Cypress Creek Basin Summary Report

Final Report

Northeast Texas Municipal Water District
P.O. Box 955
Hughes Springs, Texas 75656

Clean Rivers Program
Water Quality Division
Texas Natural Resource Conservation Commission
P.O. Box 13087, MC – 150
Austin, Texas 78753

Paul Price Associates, Inc.
3006 Bee Caves Road, Suite D-230
Austin, TX 78746
(512) 329-0155
pprice@io.com

Final Report 01/14/2000

Table of Contents

List of Tables

List of Figures

EXECUTIVE SUMMARY

Introduction

The Clean Rivers Program Water Quality Monitoring in the Cypress Creek Basin during 1998 and 1999 has taken place through a cooperative program directed by Northeast Texas Municipal Water District (NETMWD). Program participants assisting NETMWD in planning, data collection, analysis, and reporting include Paul Price Associates, Inc. (PPA), Texas Natural Resource Conservation Commission (TNRCC), the Caddo Lake Institute (CLI) and its affiliates, and the Clean Rivers Program steering committee members.

The goal of the Cypress Creek Basin Clean Rivers Program is to provide the appropriate, quality assured data to allow continuing assessment and management of water quality in the Cypress Basin. Detailed objectives of this monitoring program include:

- Establish a long-term monitoring program for the basin,
- Focus on and provide for local participation in monitoring,
- Provide reliable information to the public to enhance awareness and knowledge of water quality conditions in the basin,
- Monitor and evaluate water quality trends,
- Identify the nature and source of water quality problems that result in significant impairments,
- Evaluate the applicability of Texas Surface Water Quality Standards to specific waterbodies in the basin,
- Evaluate permit requirements with respect to water quality conditions and trends in the basins, and,
- Provide data to support the development of cost-effective water quality management programs.

Basinwide Monitoring Program

The Cypress Creek Basin monitoring program has been divided into three areas: (1) Fixed-station monitoring, (2) Systematic monitoring, and (3) Special studies monitoring. The locations of the Fixed and Systematic monitoring stations reflect the need for continued monitoring at locations that have been sampled historically. They will provide a focus on those segments that were determined to be of most concern through evaluation, procedures, and steering committee input, and to provide water quality data for analysis of the entire basin.

Fixed Station Monitoring

The primary objective of the Fixed station monitoring program is to continue and extend the long-term water quality database to follow trends and identify water quality changes in major sub-basins of the Cypress Creek system. Under the CRP, eleven stations are being sampled for biological data and/or for field parameters, conventional parameters, and metals in water and sediment by the TNRCC Region 5 staff, PPA, and CLI (Table E.X-1). The City of Marshall has participated by funding a twelfth Fixed station located on Big Cypress Creek near the City of

Marshall water intake. This station has no cost associated with CRP funds but is sampled during the quarterly Fixed station sampling events performed by the CRP Subcontractor (CLI). The Fixed station locations are designed to provide information on each of the nine classified segments (0401-0409) in the Cypress Creek Basin, and a major unclassified sub-basin (Figure EX-1, Table EX-2). This concentrates the long-term monitoring effort along the main stem of Big Cypress Creek (Segments 0401-0404), and includes the major water supply and recreational reservoirs in the basin.

Table EX-1
Cypress Creek Basin Sampling Parameters

Field Parameters	**Metals in Water**	**Sediment Samples**
Dissolved Oxygen		Aluminum, Total
Temperature (°c)	**Dissolved Metals**	Arsenic, Total
Secchi Depth (m)	Aluminum	Barium, Total
pH (s.u.)	Arsenic	Cadmium, Total
Conductivity (*um*hos)	Barium	Chromium, Total
Flow (m/s)	Cadmium	Copper, Total
Observations of ambient conditions	Chromium	Lead, Total
Fecal Coliform	Copper	Manganese, Total
Days Since Last Rainfall	Lead	Mercury, Total
	Manganese	Molybdenum, Total
Conventional Parameters	Molybdenum	Nickel, Total
TDS	Nickel	Selenium, Total
TSS	Silver	Silver, Total
Total Alkalinity	Zinc	Zinc, Total
Sulfate		TOC
Ammonia	**Total Metals**	Oil and Grease
Dissolved ortho-Phosphorus	Calcium	Total Kjeldahl Nitrogen
Total Phosphorus	Iron	Total Phosphorus
Chlorophyll-*a* / Pheophytin-*a*	Mercury, Total	% Grain Size
Chloride	Selenium, Total	% Clay
Nitrate/Nitrite		% Gravel
Hardness		% Sand
Total Kjeldahl Nitrogen		% Silt
TOC		Acid Volatile Sulfide (AVS)
Biological Data Collection (RBA)		Total Solids (% WT)

Systematic Station Monitoring

The Systematic monitoring program has two objectives: 1) screen the major non-classified streams for potential water quality problems at least every five years, and 2) support 305(b) evaluations that cover the basic water quality parameters of DO, temperature, pH, fecal coliform, chloride, sulfate, and total dissolved solids. Numerous criteria, including cost, existing TNRCC Region 5 monitoring plans, priorities set by the CRP Steering Committee, the need for Special studies to support 305 (b) assessments and TMDL development in segments 0403 and 0404, were evaluated in selecting a Watershed Approach to development of the Systematic station monitoring program. Systematic sampling is being conducted quarterly for one year in each

Figure EX-1

Table EX-2
Cypress Creek Basin

Subwatershed	Segment
James/Black Bayou	0406 0407
Big Cypress Creek	0402 0404 0408
Black Cypress Bayou	
Caddo Lake	0401
Little Cypress Creek	0409

subwatershed in the Cypress Creek Basin, so that the entire basin is sampled on a 5-year cycle. During Fiscal Year 1998, TNRCC Region 5 staff performed Systematic sampling throughout the basin, including stations within Caddo Lake (Segment 0401), Lake O' the Pines (Segment 0403), and the Tankersley Creek station (Segment 404). Stations within the Caddo Lake Watershed were the focus during Fiscal Year 1999.

Special Studies Monitoring

Four Special studies monitoring activities were addressed during Fiscal Years 1998 and 1999. These activities included a Receiving Waters Assessment (RWA) for the City of Hughes Springs, the Poultry Operations Study, the Caddo Lake Organics Study, and the Lake O' the Pines nutrient study.

Hughes Springs Receiving Waters Assessment

The Hughes Springs RWA was performed by the TNRCC Region 5 staff in June 1998 to provide supporting aquatic life use information for the City's wastewater permit renewal. This RWA showed that Hughes Creek, upstream from the discharge outfall, exhibited an "Intermediate" to "High" aquatic life-use rating when fish, macroinvertebrates, and habitat were evaluated. Data are available from the report on the TNRCC and Cypress Creek Basin wepages (NETMWD.com).

Assessment of Poultry Operations on the Water Quality in the Cypress Creek Basin

The Assessment of Poultry Operations on the Water Quality in the Cypress Creek Basin was performed at nine sites within the basin during Fiscal Year 1998. Fieldwork began in the fall of 1997 and continued into August, 1998 on a monthly basis and was conducted by TNRCC central office Surface Water Quality Monitoring (SWQM) team. Laboratory results were compiled, data was evaluated and a draft report was prepared by Paul Price Associates, Inc. and presented to TNRCC in September, 1998. The draft report was sent out for peer review, necessary revisions were made and a final report was produced on October 15, 1998. This document can be found at the Cypress Creek Basin webpage.

Nine sites within four sub-watersheds were selected for this study, two sites within areas of concentrated poultry operations (Lilly Creek and Prairie Creek) and two thought to be without significant poultry or other confined animal feeding facilities (Boggy Creek and Frazier Creek). Measurement of field parameters and the collection of conventional water samples were carried out on a monthly basis from October, 1997 to August, 1998. Metals in water samples were collected twice (February, 1998 and April, 1998) and sediment samples once (April, 1998), both by members of the TNRCC SWQM Team. Habitat and biological samples were collected once (May, 1998) using rapid bioassessment techniques.

Based on data compiled and provided by Pilgrim's Pride Corporation, the distribution and density of farms and litter application events was higher in the Lilly and Prairie Creek sub-watersheds than in those of Boggy and Frazier Creeks. Water quality in all four streams was generally similar but Lilly and Prairie Creeks tended to exhibit higher nutrient concentrations and other differences consistent with the increased loadings of sediment, oxygen demanding

materials, and nutrients expected from intensive agricultural operations. All four streams had adequate dissolved oxygen concentrations during the cooler months, but exhibited substantial oxygen depletion during the warmer months. Although total phosphorus concentrations appeared to be typical of North American sub-watersheds with agricultural development, enrichment effects were not typically evident. Nitrogen to phosphorus ratios, however, indicated that there was excess phosphorus in the system. When sub-watersheds with concentrated poultry activity (Prairie and Lilly) were compared to a similar sub-watershed with little poultry activity (Boggy) and a reference sub-watershed (Frazier), statistically significant differences ($p<0.05$) were demonstrated for certain nutrient and nutrient-related parameters. Specifically, nitrate and nitrite nitrogen (NO_3-NO_2-N) concentrations in Prairie and Lilly Creek were greater than concentrations in Frazier Creek; however, NO_3-NO_2-N concentrations represent "no concern" based on screening criteria. Total Kjeldahl nitrogen (TKN) concentrations in Lilly Creek were greater than concentrations in Frazier Creek. Total phosphorous concentrations in Prairie and Lilly Creek were greater than concentrations in Frazier Creek; however, total phosphorous and ortho-phosphorous concentrations represent "no concern" based on screening criteria. Data screening results showed that ammonia and chlorophyll *a* were of "potential concern" in Prairie, Lilly, and Boggy Creeks but were of "no concern" in Frazier Creek. All four streams were partially supporting or not supporting the aquatic life-use based on a dissolved oxygen (D.O.) screening level of 5.0 mg/l, but no significant difference was demonstrated between sub-watersheds. Although the differences in nutrients, dissolved oxygen, and related water quality parameters were not large among the four study streams, the statistical results and the stream priority showed clear parallel trends between decreasing water quality and increasing human activity in the four subwatersheds examined.

Screening for metals showed that Lilly Creek Station 2 exceeded the zinc acute criterion. The uppermost stations at Lilly and Prairie Creeks, and both stations on Boggy Creek exceeded the selenium screening levels for freshwater sediments. The fish and macroinvertebrate data show that the study streams tended to support higher levels of aquatic life-use than the habitat quality scores and the dissolved oxygen regimes would indicate. All four streams exhibited high macroinvertebrate life use, while the life use scores for fish indicated that Prairie Creek, and possibly Lilly Creek, were somewhat more impaired than the two reference streams.

Lake O' the Pines Nutrtient Study

The Lake O' the Pines Nutrient Study (Segment 0403) was developed to provide basic information about the lake, its present nutrient load, and trophic condition. The objectives of this study were to:

- Evaluate levels of available nutrients (Nitrogen and Phosphorus) in Lake O' the Pines,
- Document the distribution, abundance, and types of planktonic and rooted vegetation in Lake O' the Pines, and
- Assess the impacts of observed levels of plant production on segment standards and uses.

Eight stations were selected (four within the main lake and four within large coves) and were sampled monthly for field and nutrient parameters since August 1998. In addition, bathymetric profiling of the lake, quarterly emergent vegetation mapping, diurnal dissolved oxygen and primary productivity studies, and sediment nutrient parameter analysis have been performed

throughout the past year. Two more monthly sampling events are scheduled for July and August 1999 to complete the data acquisition.

The field study had focused on obtaining (1) the limnological data necessary to understand lake processes, (2) data on nutrient levels, and (3) biological activity in the lake over an annual cycle. A nutrient budget of sufficient accuracy to assess the relative eutrophication risk of Lake O' the Pines, and to provide a background on which to assess data collected on nutrients and productivity in the lake is currently being developed using desktop methods and the data available from the Fixed and Systematic monitoring locations, TMDL development work, and from other ongoing programs (USGS gage data, Poultry Litter Program).

Caddo Lake Organic Contaminant Study

The Caddo Lake organic contaminant study was designed as a preliminary survey of Caddo Lake waters and sediment at locations receiving runoff from the adjacent to the Longhorn Army Ammunition Plant (LHAAP) to assess the presence of specific organic compounds. The U.S. Army Corps of Engineers has identified four drainages which cross the LHAAP, two, Harrison Bayou and Goose Prairie Creek, are being significantly contaminated with these compounds. Four superfund stations were sampled within Caddo Lake, two at Harrison Bayou and two at Goose Prairie Creek, during the summer of 1998. A total of eight water samples and four sediment samples were taken and analyzed for ten organic contaminants listed in the USACE report[1]. The lab results from both the water and sediment samples indicated that all ten tested contaminants were below the minimum analytical detection limits, but recommended further organic studies within Caddo Lake surrounding the LHAAP. The Quality Assurance Project Plan and final report may be accessed through the Cypress Creek Basin webpage. As a part of further studies concerning organic contamination within Caddo Lake, TNRCC has initiated an intensive study to test for ammonium perchlorate within Caddo Lake near the LHAAP.

Geographical Information Systems

Assessments of the water quality concerns within the Cypress Creek Basin have been greatly assisted by the introduction of the use of Geographic Information Systems (GIS). This layer-based program allows for combining information from both geographic (map) and database (table) formats are then utilized within the watershed inventory to locate and track information for monitoring stations, permitted discharges, agricultural operations, and other concerns within the watersheds.

The positions of possible areas of concern are determined utilizing a Global Positioning System (GPS), which produce latitude and longitude coordinates and whose information is then incorporated into the GIS program. Additional information relating to these positions such as sampling data or discharge information is linked directly to the mapped information. The relationships of the different layers that are mapped and spatially analyzed help to establish potential interrelationships and possible influence on water quality within the watershed. An

[1] United States Army Corps of Engineers. 1999. Report to the Technical Review Committee of the Longhorn Army Ammunition Plant, 2 June 1999. United States Army Corps of Engineers: Tulsa District.

example of this use could be the relative proximity of point or non-point source contributors to areas with identified water quality concerns.

Locational data points of monitoring stations and other GPS's positions, and any associated information is provided to TNRCC in a database format for inclusion in the GIS inventory.

The Cypress Subcontractor Paul Price Associates, Inc. employs personnel GPS certified by TNRCC.

Total Maximum Daily Load

The Lake O' the Pines watershed encompasses Segments 403, 404, 405 and 408, which includes four major impoundments (Lake Cypress Springs, Lake Monticello, Lake Bob Sandlin, and Lake O' the Pines), about 50 miles of Big Cypress Creek, and numerous tributary streams. It is part of the 2,812 square mile Cypress Creek Basin, which is located in Northeast Texas between the Sulphur River basin on the north and the Sabine River basin to the west and south. Primary uses in the Lake O' the Pines watershed are recreation and public water supply, and demand for both uses is expected to continue to grow.

The 303(d) listing process has identified water quality or aquatic life impairments in Segments 403 and 404 (but not 405 and 408), and various basin stakeholders have identified additional concerns. However, the distribution of the adverse conditions, their severity, possible seasonal components, and their relationships to known or suspected sources of pollutants are poorly defined by existing data. Sources of impairments in the Lake O' the Pines watershed have not been delineated, but major candidates include poultry production and other agricultural operations, industrial and municipal wastewater discharges, urban runoff, lignite mining, and power plant operations.

Northeast Texas Municipal Water District, under the guidance of the TNRCC and U.S. Environmental Protection Agency (EPA) has initiated a coordinated series of studies intended to identify pollutants impairing surface water uses and their sources, establish pollutant discharge levels that protect water uses (the Total Maximum Daily Load, TMDL), and develop a Watershed Action Plan outlining specific corrective actions to be employed in achieving and maintaining those pollutant levels. A critical aspect of this program is the maintenance of communication with and feedback from the stakeholders; the watershed residents, businesses, industries, municipalities, utility districts and other entities interested in protecting water quality and uses.

Public Outreach

The Cypress Basin outreach and public participation efforts have been exciting this year. The summer of 1998 Cypress Basin webpage established an identity on the Internet.
The Northeast Texas Municipal Water District purchased a domain (NETMWD.COM) and devoted most of the site to the Clean Rivers Program in Cypress Basin. These were very positive events because, without its own river authority to define its boundaries, building public awareness of Cypress Basin started from scratch. To give visual identity to the Basin, a logo was designed. The Cypress Basin logo is the icon employed on the webpage for internal navigation.

It also appears on the Basin Highlights Report and other outreach literature, including an informational insert proposed for mailing to stakeholders with their utility bills.

Last year, the newly created webpage focused on explaining what the Northeast Texas Municipal Water District is and what the Clean Rivers Program does in the basin. Webpage emphasis has now shifted to providing stakeholders with meeting agendas and minutes, and to publishing water quality documents such as the "Joint Agreement and Guidelines between the Northeast Texas Municipal Water District and Pilgrim's Pride Corporation for Development of Walker Creek Project" and "Water Quality Protection and Enhancement in the Cypress Basin".

Publication of these documents on the webpage for access by stakeholders concerned with water quality issues in the basin is the most significant public outreach accomplishment, so far. By the end of this fiscal year, the webpage will have an interactive Cypress Basin map that offers public access to water quality data from links with individual monitoring stations.

Links have been established to TNRCC webpages that report Clean Rivers, CRP partners TMDL and Senate Bill One programs and policies in Cypress Basin. To attract area interest, a link has been established to the Ft. Worth District Corps of Engineers daily rainfall and reservoir elevation reports for Lake O' the Pines.

Website use statistics reflect a steady interest in the site. On the best day in July 301 hits were recorded and 163 hits during the most productive single hour. July averages were 99 hits per day and four hits per hour. The areas of highest use (in descending order) were the homepage, What's New?, Reports, the Basin Map and Workplans. Hourly use statistics indicate that the highest use period is around 3:00 PM each day.

Altavista, Excite, Net Find AOL, Yahoo, and Ask Jeeves were the most frequently used search engines. Users also came from referring pages that link to the site. Those pages were at TNRCC, TAMU, Franklin County Water District, the Sulphur River Authority and Texas Water Development Board. Webpage users were affiliated with United States commercial (64%), followed by unknown (25%), Network (5%), and United States Educational (2%) servers.

In June, visits from outside the United States included 22 from the United Kingdom, and eight from Singapore. Other visits were from Australia, Sweden, Israel, Finland, Malaysia, South Africa, Germany, Lebanon, and Canada.

Water Quality Concerns and Improvements

The Clean Water Act Section 303(d) requires the TNRCC to list water bodies, which do not meet the state's water quality standards. For the year 1999, the focus was on the Canadian River, Red River, Sulphur River, Cypress Creek, Sabine River, Sabine Pass, and Neches River basins. The TNRCC identified six water bodies in the Cypress Creek Basin, including two lakes, which are impaired or do not meet the water quality standards. These identifications were made utilizing the analysis by TNRCC of five years of collected water quality data.

Causes for impairment and priority ranking of water bodies in this basin identified as impaired are summarized in Table EX-3.

Table EX-3
Clean Water Act Section 303(d) Water Body Impairments

Name of Water Body	Impairment Cause	Overall Priority
Caddo Lake	1 Elevated concentrations of mercury in fish tissue. 2 Periodic exceedances of the pH criterion established to safeguard general water quality uses. 3 Water temperature occasionally exceeds the criterion for the segment. 4 In the middle of the lake, dissolved zinc conc. sometimes exceed the criterion established to protect aquatic life. 5 In the upper end of the lake, total mercury was exceeded in water sampling collected in 1994.	Medium
Big Cypress Creek Below Lake O' the Pines	1 Elevated levels of mercury in fish tissue November, 1995.	Medium
Lake O' the Pines	1 In the upstream 1/2 of the reservoir, conc. of dissolved zinc occasionally exceed the criterion established to protect aquatic life.	U- A project to address a listed pollutant is underway TMDL projects for dissolved oxygen and zinc are underway.
Big Cypress Creek Below Lake Bob Sandlin	1 Elevated levels of selenium in fish tissue 2 Low dissolved oxygen is an intermittent, but chronic problem	U- A project to address a listed pollutant is underway TMDL projects for dissolved oxygen and selenium are underway.
Black Bayou	1 Dissolved oxygen is sometimes lower than the standard set for optimum aquatic life conditions.	Low
Little Cypress Bayou (Creek)	1 In the lower 25 miles of this segment, concentrations of dissolved cadmium and lead sometimes exceed the criteria established to protect aquatic life.	Medium

The TNRCC ranks the impaired water bodies as Low, Medium or High priority based on the analysis of their data. These rankings determine the priority of each water body for future studies or Total Maximum Daily Load (TMDL) projects. The TMDL projects are quantitative assessments of water quality problems and their contributing pollutant sources. These projects include an implementation plan, which identifies responsible parties and prescribes specific corrective actions.

Water quality concerns were also addressed with an agreement between Pilgrims Pride Corporation, a poultry processing and production company, and the Northeast Texas Municipal Water District. The objectives of this agreement provide for a decrease in nutrient loading, nitrogen, and phosphorus, and no increase in nonpoint loading from poultry growing in either existing or new farms. Access would be provided to records, reports, and databases on water quality information possessed by Pilgrims Pride Corporation, and funding would be provided by the corporation for water quality sampling.

Implementation of this plan will insure that generic best management practices to be followed by growers until site-specific plans can be developed.

Site-specific management plans would be required prior to delivery of any birds to new facilities, and a commitment to establishing a reduction of phosphorus in chicken litter is also included. The implementation of this agreement is a positive step toward reducing water quality impacts of poultry operations within the Cypress Creek Basin.

1.0 INTRODUCTION

The Clean Rivers Program (CRP) Water Quality Monitoring in the Cypress Creek Basin during 1998 and 1999 has taken place through a cooperative program directed by the Northeast Texas Municipal Water District (NETMWD). Program participants assisting NETMWD in planning, data collection, analysis, and reporting include Paul Price Associates, Inc. (PPA), Texas Natural Resource Conservation Commission (TNRCC), the Caddo Lake Institute (CLI) and its affiliates, and the Clean Rivers Program Steering Committee members.

This document is intended to summarize and evaluate water quality conditions and issues in the Cypress Creek Basin over the past five years, and to recommend further action that can be taken to address outstanding issues. A subwatershed approach is used to identify and attribute water quality trends within a specific watershed. Subwatersheds defined and addressed as units in this document consist of one or more Segments and their associated, unclassified tributaries (Figure 3-1). These groupings reflect potentially major transitions in habitat and water quality, and use the existing Fixed and Systematic station distribution to monitor the water quality emanating from their discrete drainage basins. While data screening proceeds by Segment in Section 4, unclassified tributaries to those Segments are addressed as associated units.

The watersheds of James and Black Bayous (Segments 407 and 406, respectively), in the northeastern corner of the Cypress Creek Basin, are combined into the James/Black Bayou watershed. The basis of this association is similar soils, vegetation and land uses, the paucity of monitoring data in those drainages, and their lack of a confluence in Texas with the remaining waters of the Cypress Creek Basin.

The Black Cypress Bayou watershed lies immediately to the west of the James/Black Bayou watershed and exhibits similar soils, vegetation and land uses. Black Cypress Bayou is a major unclassified tributary to Segment 402 (Big Cypress Creek between Lake O' the Pines and Caddo Lake). No long-term data set is available for this stream, but Fixed station monitoring was initiated at a location (TNRCC station 10245) last sampled prior to 1993, and Systematic station monitoring is planned for multiple locations during FY2001.

The largest subwatershed in the Cypress Creek Basin is that of Big Cypress Creek. For the purposes of this document, the Big Cypress Creek watershed is considered to encompass the entire drainage above the Lake O' the Pines Dam, including all of Segments 403, 404, 405, and 408, and their respective unclassified tributaries. This watershed drains much of the western Cypress Creek Basin, an area vegetated primarily by an oak woodland-prairie mosaic. The watershed tends to be the site of the more intense agricultural activity as compared to the eastern basin, and contains the bulk of the Cypress Creek Basin's urban concentrations, industry, and recreational waters.

The Little Cypress Creek watershed, encompassing Segment 409 and its unclassified tributaries, lies on the southern margin of the Cypress Creek Basin, merging with Big Cypress Creek a short distance downstream of the mouth of Black Cypress Bayou. Its soils, vegetation and land use is most similar to that of the Big Cypress Creek watershed.

The Caddo Lake watershed consists of Caddo Lake (Segment 401), Segment 402 and their respective unclassified tributaries (Figure 3-1). While Caddo Lake is certainly affected by landscape factors and human activities in its immediate watershed, streamflows originating in the Black Cypress Bayou, Big Cypress Creek and Little Cypress Creek watersheds dominate the lake hydrologically, and probably have profound effects on its water quality.

The period of record used for screening and status determinations of the sampled water quality parameters encompasses the period 1994-1999. Use of this period insures that all the data employed were collected and analyzed using consistent methods and procedures documented in a Quality Assurance Project Plan (QAPP), making it appropriate for documentation of seasonal water quality characteristics, analyses of temporal trends, and comparisons of subwatersheds within the basin.

1.1 Goals and Objectives of the Clean River Program

The goal of the Cypress Creek Basin Clean Rivers Program is to provide appropriate, quality assured data and to facilitate continuing assessment and management of water quality by local individuals and interests (stakeholders) that are directly affected by these issues. Detailed objectives of the Cypress Creek Basin CRP are:

- Establish a long-term monitoring program for the basin,
- Focus on and provide for local participation in monitoring,
- Provide reliable information to the public to enhance awareness and knowledge of water quality conditions in the basin,
- Monitor and evaluate water quality trends,
- Identify the nature and source of water quality problems that result in significant impairments,
- Evaluate the applicability of Texas Surface Water Quality Standards to specific waterbodies in the basin,
- Evaluate permit requirements with respect to water quality conditions and trends in the basins, and,
- Provide data to support the development of cost-effective water quality management programs.

1.2 Public Benefits of the Clean Rivers Program

At the center of the Clean Rivers Program is the desire to maintain or improve water quality for all persons within the Cypress Creek Basin. Through monitoring efforts made by this program, close scrutiny is paid to the utilization of water within the Cypress Creek Basin, and levels of metals, volatile compounds, and other parameters are observed and recorded. The public benefits from the expertise of numerous water quality experts, who through their knowledge of water chemistry and stream dynamics understand the changes and needs of a healthy water quality system. Violations of water quality, when detected by the monitoring program are addressed in a timely manner, assuring that safe water quality levels are maintained throughout the basin.

Through this program, the public is given an opportunity to participate at a very grassroots level in determining the direction of water quality maintenance and improvement within the Cypress Creek Basin. Information about specific studies and activities within the basin are made available on the Internet on the Northeast Texas Municipal Water District webpage (NETMWD.COM). Community concerns and questions about program plans and methods are addressed in public meetings whose minutes are available by request or on the NETMWD webpage. Questions regarding water quality or basin concerns can be queried through the webpage or public meetings. All information gathered by the Clean Rivers Program from public input are taken under consideration when planning the monitoring schedules and direction of the water quality program within the basin. In this manner, the public has available to it a means of both input and a source of information about water quality within the Cypress Creek Basin.

1.3 Characteristics of the Cypress Creek Basin

The 2,812 square mile Cypress Creek Basin, shown in Figure 3-1, is located in Northeast Texas, between the Sulphur River Basin on the north, the Sabine River Basin on the west and south and the Louisiana border on the east. The basin is drained by Big Cypress Creek, which is divided into the flowing Segments 402 and 404, and the reservoir Segments; 401 (Caddo Lake), 403 (Lake O' the Pines), 408 (Lake Bob Sandlin), and 405 (Lake Cypress Springs), and its tributaries. Big Cypress Creek) is in its turn tributary to the Red River, which it joins near Shreveport, Louisiana where it is known as Twelve-Mile Bayou.

Tributaries of Big Cypress Creek in Texas include Little Cypress Creek (Segment 409) to the south and Black Cypress Bayou (unclassified) to the north. The two other major tributaries (e.g., James Bayou, Segment 407, and Black Bayou, Segment 406), which drain watersheds in the northeast quadrant of the Cypress Basin, have no confluence with Big Cypress Creek in Texas.

The four largest reservoirs in the basin (Caddo Lake, Lake O' the Pines, Lake Bob Sandlin, and Lake Cypress Springs), that are designated for use as public water supplies, are impoundments of Big Cypress Creek. Four smaller reservoirs (Monticello, Welch, Ellison Creek, and Johnson Creek) have been constructed on tributary streams to be used primarily as cooling ponds for steam-electric power plants. While shoreline development has been permitted only around Lake Cypress Springs, recreational and retirement housing construction continues within the small watersheds draining directly into Lake Bob Sandlin, Lake O' the Pines, and Caddo Lake.

Annual rainfall ranges from 35 inches per year at the western extreme of the basin to over 55 inches annually at the Louisiana border (NFIC, 1987). Temperatures average near 90 degrees Fahrenheit in the summer and winter freezes can be expected each year, but temperatures as low as zero Fahrenheit are rare. The abundant rainfall and low regional slope result in frequent floods that overflow onto floodplains for lengthy periods, leaving water-filled oxbow lakes, sloughs and other water-filled depressions behind when they recede. The floodplain habitats associated with the waterways are important dispersal highways for eastern forest dwelling animals to move beyond the forest limits, into areas such as the Blackland prairies, where upland vegetation types present a barrier to them. Regionally, upland soils tend to be acid sandy loams or sands, while bottomland soils are typically brown to dark gray, acid sandy loams to clays. The regional landscape consists of

rolling wooded hills with regional elevations of 200 to 800 feet MSL, but with limited local relief, gentle slopes, and broad, frequently flooded, densely vegetated stream bottoms.

The Cypress Creek Basin is located within the South and East Central Texas Plains Ecoregions (Ecoregions 33 and 35, Omernik, 1987). The two major vegetational areas corresponding to the South and East Central Texas Plains Ecoregions are, respectively, the post oak savannah and the pineywoods. The post oak savannah is a north-south strip in the central part of eastern Texas encompassing the western portion of the Cypress Creek Basin, while the eastern two thirds of the basin is located within the pineywoods vegetational region (TPWD, 1984). The pineywoods vegetational area is typically gently rolling to hilly-forested land in the eastern portion of the Cypress Creek Basin where rainfall tends to be increasingly more abundant and uniformly distributed. The pine-oak forest characteristic of this region of Texas is an ecotone between the eastern pine forests and the oak-hickory forest of the post oak woodlands to the west. Although post oak and blackjack oak constitute the dominant climax overstory vegetation, loblolly and shortleaf pine are generally common.

The eastern portion of the basin is about 85% forested, primarily mixed pine-hardwood, while the western portion is about half wooded and generally exhibits only scattered stands of pine. The bottomland forests, particularly along Big Cypress Creek and the major tributaries, is the most mesic habitat in eastern Texas where the dense vegetation is generally comprised of water oak, willow oak, sweet gum, black gum, and birch.

The Cypress Creek Basin includes some of the leading broiler and dairy producing counties in the state. The area around Pittsburg, including subwatersheds of the Big and Little Cypress Creeks, has experienced particularly intense development of poultry production facilities. The Poultry Farm and Litter Application Survey compiled by Pilgrim's Pride Corporation (1998) on behalf of the Cypress Basin Clean Rivers Program indicated that poultry production throughout the Cypress Creek Basin totaled approximately 99,000,000 birds during 1997, nearly 25% of statewide production. This activity generated 132,720 tons of litter, of which 114,511 tons were disposed of on 42,363 acres of disposal sites at application rates that varied from 1 to 5 tons/acre during 1997.

Timber sales factor heavily in the regional economy, particularly in the eastern portion of the basin. Truck crops (vegetables, fruit, melons), hay production and livestock are important throughout the Cypress Creek Basin, but the oak woodland-prairie mosaic characteristic of the western half appears to exhibit the most intense agricultural activity, including confined poultry feeding operations. Lignite and iron ore mining, oil and gas production, and small manufacturing facilities are scattered throughout the basin (NFIC, 1987).

The city of Mount Pleasant, in Titus County, had a population of almost 13,000 in the 1990 census, making it the largest urban concentration in the Cypress Creek Basin. The cities of Atlanta, Gilmer, Pittsburg, Winnsboro, Daingerfield, Hughes Springs, Linden and Jefferson constitute the other major population centers.

Manufacturing and electric power generation accounts for the majority of water use within the basin, with municipal water supply a distant third. Although most rural residents still depend on groundwater from the Carrizo-Wilcox and Queen City aquifers, the demand for treated surface

water by rural basin residents and by population centers outside the Cypress Creek Basin (e.g., Longview) is increasing.

1.4 Cypress Creek Basin Water Quality

The Texas Natural Resource Conservation Commission as required by the federal Clean Water Act lists Texas water bodies, which do not meet the state's water quality standards. These water bodies are compiled on the Clean Water Act Section 303(d) list. For the year 1999, the focus was on the Canadian River, Red River, Sulphur River, Cypress Creek, Sabine River, Sabine Pass, and Neches River Basins. On the basis of five years of water chemistry data, the TNRCC identified six water bodies in the Cypress Creek Basin, including two lakes, which are impaired or do not meet the water quality standards. The specific impairments in each water body are listed in Table 1-1.

The TNRCC ranks impaired water bodies as Low, Medium or High priority with respect to the priority of each water body for future studies or Total Maximum Daily Load (TMDL) projects. The TMDL projects are quantitative assessments of water quality problems and their contributing pollutant sources, which include an implementation plan identifying responsible parties and prescribing specific corrective actions. At this time, TMDL projects for dissolved oxygen and zinc, and for dissolved oxygen and selenium, are underway in Segments 403 and 404, respectively.

Table 1-1
Water Quality Impairments and their Causes in the Cypress Creek Basin

Water Body (Segment)	Impairment Cause
Caddo Lake (401)	1 Elevated concentrations of mercury in fish tissue. 2 Periodic exceedances of the pH criterion established to safeguard general water quality uses. 3 Water temperature occasionally exceeds the criterion for the segment. 4 In the middle of the lake, dissolved zinc concentration sometimes exceeds the criterion established to protect aquatic life. 5 In the upper end of the lake, total mercury was exceeded in water sampling collected in 1994.
Big Cypress Creek Below Lake O' the Pines (402)	1 Elevated levels of mercury in fish tissue in November 1995.
Lake O' the Pines (403)	1 In the lower 1/2 of the reservoir, concentrations of dissolved zinc occasionally exceeds the criterion established to protect aquatic life.
Big Cypress Creek Below Lake Bob Sandlin (404)	1 Elevated levels of selenium in fish tissue 2 Low dissolved oxygen is an intermittent, but chronic problem
Black Bayou (406)	1 Dissolved oxygen is sometimes lower than the standard set for optimum aquatic life conditions.
Little Cypress Bayou (409)	1 In the lower 25 miles of this segment, concentrations of dissolved cadmium and lead sometimes exceed the criteria established to protect aquatic life.

1.5 Water Quality Data Collection and Analysis

Water Quality Monitoring in the Cypress Creek Basin during 1998 and 1999 has taken place through a cooperative program directed by Northeast Texas Municipal Water District (NETMWD). Program participants assisting NETMWD in planning, data collection, analysis, and reporting include Paul Price Associates, Inc. (PPA), Texas Natural Resource Conservation Commission (TNRCC), the Caddo Lake Institute (CLI) and its affiliates, and the Cypress Creek Basin Steering Committee members. During 1998-1999, sample collection was accomplished by TNRCC central office and Region 5 personnel and by the CRP contractors. Chemical analyses of water and sediment samples have been conducted by the TNRCC laboratory in Houston and by Ana-Lab Inc. in Kilgore, Texas. Data analysis and reporting has been conducted by PPA and provided to NETMWD for presentation to TNRCC through the Clean Rivers Program.

Prior to 1998-1999, TNRCC Region 5 personnel were responsible for sample collection. The TNRCC laboratory conducted water and sediment analyses, and HDR Engineering, Inc. performed the data analyses on behalf of Titus County Fresh Water Supply District No. 1, the local entity directing the Cypress Creek Basin Clean Rivers Program at that time. This project has, at all times, been conducted in cooperation with the TNRCC under the authorization of the Texas Clean Rivers Act.

The monitoring program has been divided into three areas: (1) Fixed-station monitoring; (2) Systematic monitoring; and (3) Special studies monitoring. The locations of the Fixed monitoring stations reflect the need for long-term sampling at particular locations in order to monitor water quality trends in major subwatersheds or Segment reaches. Systematic monitoring is intended to provide a short-term (1-2 years) focus on Segment reaches and subwatersheds which lack sufficient data to identify and evaluate water quality concerns. The Systematic monitoring program has been designed to provide water quality data and analysis for subwatersheds throughout the entire basin on a five-year rotation. The Fixed and Systematic monitoring stations provide the primary data source for this report. Table 1-2 lists the parameters, by data set, ordinarily collected and analyzed for at the Fixed and Systematic stations.

Special studies monitoring programs, with the exception of the Poultry Operations Study, were initiated in 1998 to provide information on water bodies, or water quality issues of concern to the Basin Steering Committees. The results of the Special studies monitoring programs are presented in their respective reports, and are not specifically addressed in this summary except by reference where the results are employed in the watershed analyses and evaluations in Section 4.

Five Special studies were implemented during the study period:
A study of the water quality impacts of poultry production operations was conducted during 1997-1998 that compared water quality characteristics among nine sample locations in four tributary watersheds where sampling was conducted on a monthly basis. The methods, results and conclusions of this study are presented in detail in "Poultry Operations Study, Report to the 76th Session of the Texas Legislature", TNRCC Pub #SFR65, January 1999[3] (section pertaining to Cypress Basin available on the Cypress Basin CRP Web Page).

A Special study on Caddo Lake was initiated in response to concerns that a suite of toxic organic compounds, presumably originating at the Longhorn Army Ammunition Plant and reported to be present in Harrison Bayou sediments might be flushed into the lake during rainfall events. Water and sediments were sampled offshore of the mouth of Harrison Bayou following two rainfall events. The results of this study are reported in "Targeted Monitoring in the Cypress Basin: Study of Contaminants at Caddo Lake Associated with the Longhorn Army Ammunition Plant", Final Report submitted to TNRCC Water Quality Division July 15, 1999[4] (available on the Cypress Basin CRP Web Page).

A Special study to assess the nutrient (nitrogen and phosphorus) content, monitor seasonal changes in water column nutrient concentrations and plankton standing crop, and provide basic data on the hydrography of Lake O' the Pines was initiated in August, 1998. The study was intended to provide the preliminary information necessary to develop a nutrient budget for Lake O' the Pines, evaluate its most likely trophic status, and identify and quantify the major nutrient storage pools in Lake O' the Pines (e.g., sediments, water, biomass) as part of problem definition and model development in the TMDL program. The methods and results of this study are reported in "Targeted Monitoring in the Cypress Basin: Nutrient Study In Lake O' the Pines " October 20, 1999, Draft Report submitted to TNRCC.[7]

Intensive surveys of water quality in major point source effluents, in Big Cypress Creek, and in major tributaries to segments 403 and 404 during summer low flow conditions were conducted in August, 1998 and August-September, 1999. Data collection and analysis followed the methods and procedures outlined in the Clean Rivers Program Quality Assurance Project Plan (QAPP), although a separate QAPP for those two collections was not developed. Data from these surveys has been archived for use in the analysis of water quality responses to low flows in warm weather, characterization of point source loadings of stream baseflows, and for use as calibration and verification data sets to be used in steady state stream model development during the TMDL program. This study was funded by Pilgrim's Pride Corporation to facilitate TMDL development.

The TNRCC Region 5 staff performed a receiving water assessment (RWA) on April 21-23, 1998 to support a permit renewal for the City of Hughes Springs wastewater treatment facility. The assessment was made on Hughes Creek, upstream from the treatment facility, and was conducted in accordance with the TNRCC Surface Water Quality Monitoring Procedures. Methods, results and conclusions of this study are presented in the TNRCC file report "Hughes Springs RWA, 21-23 April, 1998" and summarized in the "Cypress Creek Basin Highlights Report"[5], (August, 1999), which is available on the Cypress Creek Basin CRP Web Page.

Appropriate, current TNRCC approved methods, as set forth in the FY1999 Quality Assurance Project Plan (QAPP) for the Cypress Basin CRP, were employed for the collection and analysis of all field measured parameters. Water and sediment samples were collected and transferred to a lab facility for physical and chemical analysis. Habitat, nekton, and benthic macroinvertebrate sampling was performed using the standard procedures and protocols established for the TNRCC Surface Water Quality Monitoring (SWQM) program and described in the 1999 SWQM Procedures Manual.

Table 1-2.
Fixed and Systematic Station Monitoring Parameters.

Field Parameters	**Storet Code**	**Metals in Water**	**Storet Code**	**Sediment Samples**	**Storet Code**
Dissolved Oxygen (Diurnal once per year*)	00300 (89857)			Aluminum, Total	01108
Temperature (°c)	00010	**Dissolved Metals**		Arsenic, Total	01003
Secchi Depth (m)	00078	Aluminum	01106	Barium, Total	01008
pH (s.u.)	00400	Arsenic	01000	Cadmium, Total	01028
Conductivity (*um*hos)	00094	Barium	01005	Chromium, Total	01029
Flow (m/s)	00061	Cadmium	01025	Copper, Total	01043
Flow Severity	01351	Chromium	01030	Lead, Total	01052
Days Since Last Rainfall	72053	Copper	01040	Manganese, Total	01053
Conventional Parameters		Lead	01049	Mercury, Total	71921
Fecal Coliform	31616	Manganese	01056	Molybdenum, Total	01063
TDS	70300	Molybdenum	01060	Nickel, Total	01068
TSS	00530	Nickel	01065	Selenium, Total	01148
Total Alkalinity	00410	Silver	01075	Silver, Total	01078
Sulfate	00945	Zinc	01090	Zinc, Total	01093
Ammonia	00610			TOC	81951
Dissolved ortho-Phosphorus	00671	**Total Metals**		Oil and Grease	00557
Total Phosphorus	00665	Calcium	00916	Total Kjeldahl Nitrogen	00603
Chlorophyll-*a*	32211	Iron	01045	Total Phosphorus	00668
Pheophytin-*a*	32218	Mercury	71900	% Grain Size	
Chloride	00940	Selenium	01147	% Clay	82009
Nitrate/Nitrite	00630			% Gravel	80256
Hardness	46570			% Sand	89991
Total Kjeldahl Nitrogen	00625			% Silt	82008
TOC	00680			Acid Volatile Sulfide (AVS)	50088
Biological Data Collection (RBA)**	-------			Total Solids (% WT)	81373

* Diurnal DO sampling will be performed once at each station during May through September and will be performed by either a person or datalogger

** Sampling in Fixed and Systematic monitoring on an annual basis.

Since 1998, all CRP field data and sample analysis results have been managed by Paul Price Associates, Inc., stored at the NETMWD headquarters, and transmitted to the TNRCC Clean Rivers Program. All data are maintained in the Paradox 7 format in accordance with CRP program requirements for input into the SWQM database. Prior to transmittal, the data undergoes quality assurance review, as described in the Cypress Creek Basin QAPP, by the CRP Quality Assurance Officer at Paul Price Associates, Inc. Water and sediment quality results generated by TNRCC Region 5 personnel from Cypress Creek Basin stations are similarly managed by them.

1.6 Coordination/Cooperation Among Basin Entities

The Sulphur River Task Group, Committee of Regions C and D was formed in 1998 by joint resolutions to address common issues in the connected river basins[1]. In January 1999 the task group selected a joint facilitator for coordinated efforts in the two basin's data and water planning assumptions to determine the regions future water needs. Paul Price Associates Inc. represented the CRP in Cypress Basin at a Senate Bill One committee meeting in the region by presenting an overview of the basin program. Representatives of and citizens from the Red River, Sulphur River, Sabine River and Cypress Basin were in attendance. Sulphur River Authority supplying support staff to Cypress Basin monitoring efforts has realized a new cooperative initiative.

1.7 Public Involvement

The Clean Rivers Program depends on public participation for effective watershed planning. Regional authorities depend on the counsel of steering committees to focus and prioritize planning initiatives. These committees represent each basin's diverse interests (including public, government, industry, business, agriculture and environmental) and they ensure that local concerns are addressed and regional solutions are recommended. Public involvement is essentially a mutual education process. The public participants learn about what is involved in putting together the program and meeting program goals, while the program sponsors learn what the grassroot issues are in the basin. Ideally, public involvement will bring together people with differing needs and values to develop a plan the communities in the basin can support. These processes require outreach and education efforts. Built into the CRP are several tools for public involvement including the steering committee, public meetings, release of technical reports, program reports of basin highlights, the annual basin summary to the public, and opportunities for volunteers in data collection programs (Texas Watch). Posting agendas, meeting minutes and program reports on the Internet at NETMWD.com has enhanced public outreach efforts. Locally, the news print press has attended many public meetings and has prepared articles including the findings of the poultry special study[2].

Another feature of the public and private outreach has been the involvement of the Caddo Lake Institute in the basin monitoring and planning meetings. Although initially the Caddo Institute has not provided the level of volunteer participation originally anticipated, future phases of this program should benefit from the early involvement of the Caddo Institute and may yet result in more volunteer participation.

1.8 Role of Steering Committee

The members of the steering committee represent private citizens, utilities, industries, corporate citizens, municipalities, county commissioners, colleges, private institutes, area government planning groups, soil and water conservation agencies, utility and navigation districts, and ecotourism interests. These members are representative of the stakeholders in this basin. Attendance at monthly steering committee meetings has been high to initiate CRP under NETMWD. The steering committee has proactively reached out to the public to request support for a prohibition of widespread use of MTBE in the Cypress Basin in anticipation of potential water quality problems relating to the use of MTBE to solve air quality problems.

The steering committee plays a vital role ensuring that the diverse basin interests engage in the program and that the program is responsive to local priorities. The Cypress Creek Basin CRP steering committee has been effective in prioritizing the data collection, reviewing progress in the basin, receiving current data and concerns for the basin, and coordinating the water quality initiatives. The steering committee has been vital in establishing the order of the segments sampled and constituents analyzed in the adopted workplans.

2.0 PUBLIC INVOLVEMENT

Cypress Creek Basin outreach and public participation efforts have been exciting and successful during FY1998 and1999. In July 1998, the Cypress Basin webpage established an identity on the Internet through the Northeast Texas Municipal Water District domain (NETMWD.com), which has devoted most of its site to the Clean Rivers Program in Cypress Creek Basin. These were very positive events because, without its own river authority to define its boundaries and provide a focus for addressing regional water issues, building public awareness of Cypress Creek Basin started from scratch. A logo was designed to give visual identity to the Basin. The Cypress Basin logo is the icon employed on the webpage for internal navigation. It also appears on the Basin Highlights Report and other outreach literature.

At first the webpage focused on introducing the Northeast Texas Municipal Water District, the Clean Rivers Program, and its potential functions in the basin. Now webpage emphasis has shifted to providing stakeholders with meeting agendas and minutes, and to publishing water quality documents. Examples of available documents include the Special study reports of Caddo Lake, Lake O' the Pines, Hughes Springs Receiving Waters Assessment, Poultry Operations Study, and other documents important to water quality issues, such as the "Joint Agreement and Guidelines between the Northeast Texas Municipal Water District and Pilgrim's Pride Corporation for Development of Walker Creek Project," and "Water Quality Protection and Enhancement in the Cypress Basin".

Publication of these documents on the webpage for access by stakeholders concerned with water quality issues in the basin is the most significant public outreach accomplishment of the CRP during the preceding year. By the end of this fiscal year, the webpage will have an interactive Cypress Basin map that offers public access to water quality data from links with individual monitoring stations.

Water quality data and station locations are currently presented in three separate reports. The Caddo Lake data is presented with station maps at http://Caddo/caddorpt.pdf, nutrient monitoring data is found at http://netmwd.com/reports/lopdata.pdf and the basin poultry report is found at http://netmwd.com/reports/poultry.pdf.

The Basin Monitoring program for the year 2000 is presented at:

- http://netmwd.com/CRP/00monpl.pdf
- http://netmwd.com/CRP/figure1.pdf
- http://netmwd.com/CRP/figure2.pdf
- http://netmwd.com/CRP/figure3.pdf

Links have been established to TNRCC webpages that report Clean Rivers, TMDL and Senate Bill One programs and policies in Cypress Basin. To attract area interest, a link has been established to the Ft. Worth District Corps of Engineers daily rainfall and reservoir elevation reports for Lake O' the Pines. Several other basins have updated their sites to reference NETMWD.com. Other sites responding to the update requests are anticipated.

Website use statistics reflect a steady interest in the site. On the best day in July 301 hits were recorded and 163 hits during the most productive hour. July averages were at 99 hits per day and four hits per hour. The areas of highest use (in descending order) were the homepage, What's New?, Reports, the Basin Map and Workplans. Hourly use statistics indicate that the highest use period is around 3:00 PM each day.

Altavista, Excite, Net Find AOL, Yahoo, and Ask Jeeves were the most frequently used search engines. Users also came from referring pages that link to the Cypress Basin webpage. Those pages were at TNRCC, TAMU, Franklin County Water District, the Sulphur River Authority and Texas Water Development Board. Webpage users were affiliated with United States commercial (64%), followed by unknown (25%), Network (5%), and United States Educational (2%) servers.

3.0 BASIN OVERVIEW

Figure 3-1 shows the major watersheds of the Cypress Creek Basin, the nine Segments into which the major streams draining the basin have been divided by TNRCC, and the locations of the major population centers and transportation corridors. Station locations, sampling frequencies and parameter sets employed in the Fixed and Systematic monitoring programs managed by the Cypress Creek Basin Clean Rivers Program are summarized in Table 3-1, while actual sampling events at all stations sampled during 1994-1999 are presented in Table 3-2. Figures 3-2 and 3-3 show the locations of Fixed and Systematic stations, respectively, from which data were collected during the study period.

The Fixed monitoring stations are supposed to provide long term data on water quality at locations draining major subwatersheds and important Segment reaches within the Cypress Creek Basin. The primary purpose of collecting comparable water quality data over a substantial period of time is to identify temporal trends in water quality and to differentiate water quality characteristics, impairments and possible causes over discrete subwatershed areas. However, Table 3-2 shows that a complete data set is available for only one station (10332), near the mouth of Little Cypress Creek (Segment 409). Three additional Fixed monitoring stations and three of the Systematic monitoring stations have results for substantial portions (at least three of five years) of the current study period (Table 3-2).

The Systematic stations are rotated through the basin on a five-year schedule to provide basic information on the water quality in streams draining smaller subwatersheds. The Systematic monitoring program is intended to efficiently utilize limited resources to detect problem reaches throughout the Cypress Creek Basin, and to help localize pollutant sources to specific drainages.

The Special studies listed in Section 1.5 were initiated to address specific water quality issues or to support other programs (i.e., TMDL development) addressing water quality issues in the Cypress Creek Basin. Although initiated in response to specific needs, these programs have provided another source of quality assured data on pollutant loadings, nutrient transport and transformation, and hydrologic characteristics of various areas in the Cypress Creek Basin.

A statewide land use map layer obtained from the Geographic Information System (GIS) maintained by TNRCC was used to prepare a map of the land uses in the major subwatersheds of the Cypress Creek Basin (Figure 3-4) and tabulation of the areas and proportions of each observed land use (Table 3-3). Basinwide, woodlands and agriculture account for about 66% and 28%, respectively, of the 1,828,762 acres (2857.4 square miles) mapped in the Cypress Creek Basin. The remaining 5.5% is occupied by urban areas and water (4.31%) and by other land uses totaling less than 1%.

Major concerns have focused on low dissolved oxygen episodes and the potential presence of excess zinc and selenium in Segments 0403 (Lake O' the Pines) and 0404 (Big Cypress Creek). Fish consumption hazards, aquatic life, and general water quality impairments have been of concern in Segment 0401 as a result of the presence of mercury in fish tissue, periodic exceedances in pH and temperature criteria, dissolved zinc and total mercury, and organic contaminants.

figure 3-1

Table 3-1

Table 3-2

Figure 3-2

Figure 3-3

Figure 3-4

Table 3-3
Land Use in the Cypress Creek Basin and Its Major Subwatersheds

Land Use Type- Cypress Creek Basin	*Acres*	*Percent*
Urban	39440	2.16
Agricultural	516310.5	28.22
Cropland and pasture	513012.9	99.3
Confined feeding operations	1873.7	0.4
Orchards, groves and vineyards	104.4	0.02
Other Agricultural land	1319.5	0.3
Rangeland	3064	0.17
Forest	1212314	66.29
Water	39317	2.15
Wetlands	10918	0.60
Rock	3531	0.19
Unknown	3834	0.21
Total Area	1828982	
Land Use by Subwatershed		
James/Black Bayou Subwatershed		
Urban	6954	1.99
Agricultural	57691	16.52
Cropland and Pasture	57278.7	99.3
Orchards, groves and vineyards	54.5	0.09
Confined Feeding Operations	92.1	0.15
Other Agricultural land	266.1	0.46
Rangeland	533	0.15
Forest	282702	80.95
Water	665	0.19
Wetlands	222	0.06
Rock	14	0.00
Transitional	393	0.11
Total Area	349210	
Black Cypress Subwatershed		
Urban	3063	1.18
Agricultural	63042	24.35
Cropland and Pasture	62740.2	99.5
Confined Feeding Operations	24.8	0.04
Other Agricultural Land	277.3	0.44
Rangeland	217	0.08
Forest	191013	73.77
Water	362	0.14
Wetlands	407	0.16
Rock	676	0.26
Transitional	120	0.05
Total Area	258932	
Big Cypress Subwatershed		
Urban	22544	3.79
Agricultural	219393	36.85
Cropland and Pasture	217816.1	99.3
Orchards, groves and vineyards	49.8	0.02
Confined Feeding Operations	1086.2	0.4
Other Agricultural Land	661.1	0.3
Rangeland	633	0.11
Forest	313516	52.65

Land Use by Subwatershed cont.	Acres	Percent
Water	31952	5.37
Wetlands	1321	0.22
Rock	2710	0.46
Transitional	3174	0.53
Total Area	595424	
Little Cypress Subwatershed		
Urban	4771	1.04
Agricultural	160025	35.03
Cropland and Pasture	159251.5	99.5
Confined Feeding Operations	658.4	0.4
Other Agricultural Land	114.9	0.07
Rangeland	867	0.19
Forest	289977	63.48
Water	846	0.19
Wetlands	79	0.02
Rock	131	0.03
Transitional	126	0.03
Total Area	456828	
Caddo Subwatershed		
Urban	2108	1.25
Agricultural	15939	9.47
Confined Feeding Operations	12	0.07
Cropland and Pastures	15926	99.92
Rangeland	814	0.48
Forest	135106	80.24
Water	5492	3.26
Wetlands	8889	5.28
Transitional	21	0.01
Total Area	168368	

Potential sources of water quality problems in Big Cypress Creek and Lake O' the Pines have been assumed to include wastewater discharges, septic tanks, and non point source runoff from poultry production facilities and urban areas. Atmospheric deposition is considered to be the primary source of mercury in east Texas reservoirs. While sampling conducted on the grounds of the Longhorn Army Ammunition Plant located adjacent to Caddo Lake gave cause to regard that property as a potential non-point source of toxic organic compounds, significant contamination from that source has not been detected at this time.

Drinking Water Quality Reports for the year 1998 are available for the following cities and communities in the Cypress Creek Basin: Jefferson, Avinger, Daingerfield, Hughes Springs, Lone Star, Northeast Texas Municipal Water District, Ore City, and Pittsburg. Water designated for the public supply use is protected by Texas Drinking Water Standards (TDWS). Primary drinking water criteria for organic and inorganic chemicals are found in Table 6 and Table 7 of the "Guidance for Screening and Assessing Texas Surface and Finished Drinking Water Quality Data", TNRCC April 21, 1998. These criteria are equivalent to the maximum contaminant levels (MCLs) for primary drinking water standards found in the following water quality reports. MCLs apply to post treatment drinking water that is sampled at the entrance to distribution systems.

The following inorganics were detected in one or more of the water supplies mentioned above: barium, fluoride, mercury, nitrate, gross beta emitters, and selenium. Two organic constituents (Xylenes and Ethylbenzene) were detected in the Pittsburg water supply. No exceedances of the MCLs were detected at any of the eight sites.

Copper and lead concentrations were also measured in each of the water supplies with the exception of Northeast Texas Municipal Water District. These measurements are screened against action levels. Action levels are the concentration of a contaminant that, if exceeded, triggers treatment or other requirements that a water system must follow. The City of Daingerfield was the only community where exceedances were detected. One exceedance each of the lead and copper action levels was detected.

The water turbidity limit for these water systems is 0.5 NTUs. Turbidity in the following water supplies exceeded the turbidity limit: Jefferson (2% of samples), Northeast Texas Municipal (1% of samples), and Pittsburg (1% of samples). Turbidity results from very small particles of material (such as clay or phytoplankton cells) suspended in the water. Bacteria and many metals and organic compounds that may be present in the water tend to be associated with suspended particles. Excessive turbidity, in addition to affecting the treatment process, may indicate a higher risk of pathogens or contaminants present in the waterbody associated with the particulate material.

4.0 TECHNICAL SUMMARY

4.1 Introduction

The technical summary provides a detailed review of water quality by subwatershed and an explanation of the types of analyses employed in the processing of the data. In addition this section will highlight the priority watersheds and provide an overview of the analyses for those areas exhibiting a significant water quality concern.

4.2 Technical process

An electronic copy of the quality assured data set for the Cypress Creek Basin for the study period (1994-1999) was obtained from TNRCC. The data set consisted of the results produced by the TNRCC Region 5 sampling program for the period, plus the results of the Fixed and Systematic monitoring conducted by the Clean Rivers Program contractor during 1998 and 1999. As a consequence, the data set is more heavily weighted with water quality data taken during 1998-1999 than the previous years.

The results of the Special studies conducted by TNRCC and the Clean Rivers Program contractor during the study period are contained in separate reports and are not reproduced in this document except as necessary to employ their results in the watershed analyses presented below in Section 4.3.[3]

For analysis and presentation, the data set obtained from TNRCC was converted from its original Paradox 7 format to Excel. The data was sorted into Segment sets, with separate worksheets for stations located on the Segment and for stations located on tributaries; the screening process was also conducted on a per segment/tributary basis. Within these sets, data were aggregated by station within parameters. Data screening was conducted according to the procedures set forth in "Guidance for Screening and Assessing Texas Surface and Finished Drinking Water Quality Data", April 21, 1998 TNRCC (referred to below as "Guidance"). Each data set was prepared for screening by averaging duplicate samples, removing sample results obtained from below the surface mixed layer, averaging dissolved oxygen concentrations over the mixed layer in profiles, and truncating profile data below the surface for other parameters except pH.

Maximum, minimum, average, first and third quartiles, and number of samples were calculated and tabulated by station and parameter to create the basic data set on which subsequent manipulations and statistical analyses were performed (Appendix 1). Following the screening and statistical analyses, Segment results were appropriately combined to characterize and evaluate water quality conditions and issues in the five major subwatersheds defined in the preceding sections.

The following discussion describes how data screening was conduced:

1)Record screening results in tables by Segment (Appendix 2).

2) Segment Criteria for Cypress Basin. These are applied only to Segment stations. Dissolved oxygen results from unclassified tributaries are screened against a criterion of 5.0 mg/l unless a different criterion has been assigned as the result of adopting a site specific standard.

- List n, number of samples for each parameter
- List criteria from Guidance Table 1
- Dissolved oxygen: list number samples (surface and mixed layer avg.) less than the criterion in **Exceeds Criterion** Column.
- pH: list number samples where any value outside criterion range occurs in surface sample or mixed surface layer profile (only one exceedance for each sample station/date).
- Temperature: list number samples exceeding criteria
- Chloride, Sulfate, TDS: Put a YES in the **Exceeds Criterion** column when the segment average value is greater than the criterion.
- For each parameter, divide the number in the **Exceeds Criterion** column by the number of samples screened (n), enter the percentage in the **% Exceeding** column.

3) Fecal Coliform Criterion Evaluate with a Contact Recreation Criterion of 400/100ml. A screening level of 200/100ml was not used because the samples were taken as grabs and not at a 30-day, 5-sample geometric mean.

4) Toxic materials in Water Criteria for primary screening for metals and organic material are given in the Guidance Tables 4 and 5. Use the freshwater acute criteria in those tables. Criteria calculated using pH and hardness values from Table 2 of the "Texas Surface Water Quality Standards" are as follows:

	Metals (Guidance table 4)	
01025	Cadmium (dissolved)	6.4 µg/l
01030	Chromium (diss., trivalent)	521.1 µg/l
01040	Copper (dissolved)	4.8 µg/l
01049	Lead (dissolved)	12.6 µg/l
01065	Nickel (dissolved)	409.0 µg/l
01090	Zinc (dissolved)	33.7 µg/l
	Organic chemicals (Guidance table 5)	
39032	Pentachlorophenol	3.3 µg/l

Continue filling out the screening table using the dissolved metal and organic data for that segment. Where exceedances of the criteria listed above are identified, a secondary screening using segment specific values for hardness or pH must be conducted.

5) Silver Values given in the database for dissolved silver must be converted to ionized silver before comparison with the criterion:
% ionic=exp(exp(1/(0.6559+(0.004489(median Chloride concentration for the segment)))))
which is calculated below for the range 10-50 mg/l Cl^-:

10	64.9	21	44.9	32	33.4	43	26.2
11	62.6	22	43.6	33	32.6	44	25.7

12	60.4	23	42.4	34	31.8	45	25.2
13	58.2	24	41.2	35	31.1	46	24.7
14	56.3	25	40.0	36	30.4	47	24.2
15	54.4	26	39.0	37	29.7	48	23.8
16	52.6	27	37.9	38	29.1	49	23.3
17	50.9	28	36.9	39	28.5	50	22.9
18	49.3	29	36.0	40	27.9		
19	47.8	30	35.1	41	27.3		
20	46.3	31	34.2	42	26.7		

Expressing the tabulated values as percentages, multiply dissolved silver concentrations by the appropriate, tabulated value (i.e., at a chloride concentration of 10 mg/l, multiply silver concentrations by 0.649).

6) Chronic Criteria for Toxic Materials Compare the average values at each station with the Chronic Criteria in Guidance Tables 4 and 5. Enter those values in the **Mean** column of the screening table. Where a chronic criterion is exceeded, enter the station Number in the **Exceeds Criterion*** column. Calculated chronic criteria are listed below:

	Metals (guidance table 4)	
01025	Cadmium (dissolved)	0.36 µg/l
01030	Chromium (diss, trivalent)	62.1 µg/l
01040	Copper (dissolved)	3.6 µg/l
01049	Lead (dissolved)	0.49 µg/l
01065	Nickel (dissolved)	45.5 µg/l
01090	Zinc (dissolved)	30.5 µg/l
	Organic chemicals (guidance table 5)	
39032	Pentachlorophenol	2.1 µg/l

*Note: in the screening table if (where) detection limits exceed the screening criteria.

7) Obtain the results of the EPA/TNRCC ambient water and sediment toxicity tests for each segment. Enter the number of tests in the **n** column, and the number of tests showing toxicity in the **Exceeds Criterion** column.

8) Fish Consumption/Human Health Compare average values at each station to the criteria listed in Table 8 of the Guidance. Column A applies to all Segments except 0404 while Column B applies to 0404. For the unclassified tributaries, multiply the tabulated values in Column B by 10 to obtain the screening criteria .

9) Nutrients and chlorophyll *a* Screening levels are given in guidance Table 9 for freshwater streams and reservoirs. Enter the number of samples, number exceeding criteria, and percentage exceeding criteria in the n, Exceeds criterion and %Exceeding columns, respectively.

10) Sediment Toxicants Screening levels for metals and organic chemicals in sediments are listed in Tables 10 and 11 of the Guidance. Enter number of samples, number exceedances, and percentages as above.

11) Metals and organic Substances in Fish Tissue This screening requires a minimum of four samples taken within five years. Compare tissue sample results to the freshwater criteria in Tables 12 and 13. Enter number of samples, number exceedances, and percentages as above.

4.3 Subwatershed Summaries

4.3.1 James and Black Bayous

The boundary between Texas and Louisiana presently limits the Cypress Creek Basin Clean Rivers Program to water quality issues in Texas. Several streams that are tributary to Big Cypress Creek have their confluences with the latter stream, (where it is called Twelve-Mile Bayou), and so do not affect its water quality here. These include the subwatersheds drained by James and Black Bayous, which occupy the northeastern one fifth of the Cypress Creek Basin, and a small, triangular area below Caddo Lake shown on Figure 3-1 which encompasses the headwaters of Paw Paw and Crass Bayous. The entire subwatershed has a total area of 349,210 acres, with land uses as shown in Figure 4-1 and tabulated in Table 3-3. The James/Black Bayou subwatershed as a whole, and the area south of Caddo lake, consists predominately of forested (81%) hills in the East Central Texas Plains Ecoregion (the pineywoods vegetational region), where landscapes typically consist of wide, flat, heavily wooded bottom lands along the major streams, and dissected, sandy clay upland hills. Post oak, blackjack oak, and loblolly and shortleaf pine constitute the dominant climax overstory vegetation in uplands, while bottom lands are dominated by water oak, willow oak, sweet gum, black gum, and birch. Agricultural land totals only 16% of the James/Black Bayou subwatershed (including the Paw Paw Bayou subwatershed south of Caddo Lake), and urban concentrations are limited to the city of Linden in the James Bayou drainage, the city of Atlanta in the Black Bayou drainage, and the city of Waskom in the Paw Paw Bayou drainage (Figures 4-1, 4-2).

Point source discharges in the James/Black Bayou subwatershed include the municipal discharges from the cities of Linden, Atlanta and Waskom. The city of Linden lies in the headwaters of James Bayou, which is monitored by a single, Fixed station (10321). Black Bayou is monitored by a single Fixed station (10314) located near the Louisiana Border. No USGS Gages are located on any of the streams draining these subwatersheds in Texas. A state superfund site (Double R Plating Company) is located in Queen City (Cass County) in the headwaters of Black Bayou, and a federal superfund site (Stewco, Inc.) is located near Waskom in the Paw Paw Bayou drainage basin, which is not monitored in Texas[6].

The James Bayou drainage exhibits less urban and agricultural development than does the Black Bayou drainage and no state or federal superfund sites or permitted hazardous waste disposal sites are known to be present. The major tributary of James Bayou, Frazier Creek, was chosen for monitoring to represent a relatively undisturbed subwatershed in the Poultry Operations Study.

Land use is not uniform across the James/Black Bayou and Paw Paw Bayou subwatersheds. Areas shown as grassland and savanna on vegetation maps, which largely correspond to

Figure 4-1

Figure 4-2

Table 4-1

Summary of Water Quality Characteristics at Stations in the James/Black Bayou Subwatershed – September 1994 – February 1999

	Black Bayou Segment 406						**James Bayou Segment 407**					
Parameter	Max	Min	Mean	Q25	Q75	n	Max	Min	Mean	Q25	Q75	n
Temperature (C)	26.7	5.4	**17.1**	12.7	21.8	12	26.8	6.7	**18.4**	13.7	23.58	16
Secchi Depth (m)	1	0.26	**1**	0	1	10	1	0.23	**1**	0.38	0.88	15
Specific Conductance (µmhos)	123	41	**73**	48	102	11	1908	39	**189**	59.75	93.25	16
Oxygen, dissolved (mg/l)	10.7	0.47	**4.8**	1.2	6.8	12	11.3	2.0	**6.7**	3.9	9.5	17
pH	6.7	6	**6.4**	6.2	6.5	12	7.2	5.4	**6.2**	6	6.525	16
Alkalinity, Total (mg/l)	48.0	2.5	**18.4**	10.8	22.8	10	370.0	2.5	**46.6**	12	30	13
Chlorophyll-*a* (µ*g/l)*	20.7	0.5	**4**	1	4	10	270	0.5	**22**	0.5	3.28	13
Pheophytin-*a* (µg/l)	21.3	0	**4.1**	0.5	4.0	10	14.7	0.5	**2.7**	0.5	2.143	12
Hardness, dissolved (mg/l)	---	---	**17**	---	---	1	32	15	**22**	15.75	26	4
Total Dissolved Solids (mg/l)	112	19	**68**	55	89	10	1000	5	**148**	50	109	13
Total Suspended Solids (mg/l)	8	3	**6**	5	7	10	40	4	**14**	8	18	13
Volatile Suspended Solids (mg/l)	15	1	**4**	1	4	10	---	---	---	---	---	---
Nitrite+Nitrate N (mg/l)	0.21	0.01	**0.10**	0.067	0.11	9	0.257	0.05	**0.14**	0.0688	0.197	4
Ammonia Nitrogen (mg/l)	0.59	0.005	**0.11**	0.01	0.12	10	0.31	0.005	**0.07**	0.0213	0.075	14
Nitrite Nitrogen (mg/l)	---	---	**0.04**	---	---	1	---	---	---	---	---	---
Nitrate Nitrogen (mg/l)	---	---	**0.005**	---	---	1	---	---	---	---	---	---
Kjeldahl Nitrogen (mg/l)	1.09	0.35	**0.7**	0.5	0.8	9	2.8	0.17	**0.8**	0.4175	0.666	12
Total Phosphorus (mg/l)	0.33	0.05	**0.11**	0.07	0.10	10	0.34	0.02	**0.09**	0.0325	0.088	14
Ortho-Phosphorus (mg/l)	0.07	0.01	**0.05**	0.03	0.07	4	0.04	0.005	**0.01**	0.005	0.015	9
Total Organic Carbon (mg/l)	14	6	**10.3**	9.0	11.8	10	26.9	3	**9.6**	6	8.55	12
Fecal Coliform (cfu/100ml)	290	40	**120**	79	125	11	---	---	---	---	---	---
Dissolved Calcium (mg/l)	---	---	**4.2**	---	---	1	6.38	2.16	**3.92**	2.69	4.8	3
Dissolved Magnesium (mg/l)	---	---	**1.5**	---	---	1	---	---	---	---	---	---
Chloride (mg/l)	12	5	**7**	6	8	9	320	4	**34**	6.61	10.65	12
Sulfate (mg/l)	8	0.5	**5.25**	4.25	6.75	10	8.34	0.381	**4.03**	1.47	6	13

agricultural areas on land use maps, are much more common in the portion of the subwatershed drained by Black Bayou than in the James Bayou drainage. The broad, heavily wooded riparian corridor so typical of regional streams is absent from Black Bayou as it flows through extensive agricultural clearing and the city of Atlanta (Figures 4-1, 4-2). In contrast, woodlands cover at least 90% of the James Bayou drainage and the riparian woodland along James Bayou is continuous and well developed. The Paw Paw Bayou subwatershed encompasses only headwater areas and doesn't exhibit riparian corridors of bottomland woodland.

The results of sampling for conventional water quality parameters over the preceding five years are summarized in Table 4 -1. Segment 406, Black Bayou, has lower average levels of chlorophyll *a* and dissolved constituents than the more westerly stream, James Bayou. Although average concentrations of chlorophyll *a*, total dissolved solids (TDS), alkalinity, chloride and specific conductance appear to differ among the two streams, the differences were the result of single, atypical values observed at the James Bayou station (see Maximum column in Table 4-2) in a water sample collected on July 10, 1998. The observations may reflect an ephemeral event or a sampling error, rather than a systematic difference between these streams.

Compared with the relatively undeveloped James Bayou drainage, Black Bayou was expected to exhibit water quality characteristics attributable to the presence of the city of Atlanta. While the lower dissolved oxygen concentrations and elevated nitrite + nitrate nitrogen levels would be consistent with this expectation, the lack of difference in other parameters that often are positively related to the amount of domestic wastewater present (i.e., chlorophyll *a*, TDS, specific conductance, chloride) argues against it.

The results of data screening on Segments 406 and 407 are detailed in Table 4-2a and 4-2b, respectively, and parameters for which Concern or Potential Concern is indicated are listed below.

	Segment 406	Segment 407
Dissolved Oxygen	C*	C*
pH	-	PC*
Dissolved Cadmium (chronic)	C	-
Total Mercury (health)	PC	-
Sediment Manganese	-	C

(* represents at least nine samples in five years, sufficient for 305(b) classification)

Low dissolved oxygen concentrations continue to be of concern in both segments, while low pH values are of potential concern in Segment 407 alone. Results for those parameters have not changed since the last data screening except that the proportion of dissolved oxygen exceedances in Segment 406 has increased. However, nutrients, which were of concern or possible concern in both segments in the 1996 report, exhibited no concerns in this data set. With respect to toxic materials, only dissolved aluminum was of possible concern in Segment 406 in the 1996 report. Dissolved aluminum did not exceed any criteria in this data set. Observed cadmium, mercury and manganese exceedances are based on the results from single samples.

Table 4-2a
Results of Data Screening: Black Bayou, Segment 406

Code	Parameter	n	Mean	Criterion	Exceeds	%
Segment and Aquatic Life Standards					**Criterion**	**Exceeding**
00300	**Dissolved Oxygen (mg/l)**	12	4.78	4	5	41.67
Toxic materials in Water (Chronic)						
01025	Cadmium (d) (ug/l)	1	5	0.36	10314	---
Fish Consumption and Human Health						
71900	Mercury (t) (ug/l)	1	0.028	0.0122	10314	---
Nutrients and Chlorophyll *a*						
00610	Ammonia (mg/l)	10	0.11	0.3	1	10.00
32211	Chlorophyll-*a* (mg/l)	10	3.81	16.5	1	10.00

Table 4-2b
Results of Data Screening: James Bayou, Segment 407

Code	Parameter	n	Mean	Criterion	Exceeds	%
Segment and Aquatic Life Standards					**Criterion**	**Exceeding**
00300	Dissolved Oxygen (mg/l)	14	6.25	4	5	35.71
00400	pH	14	6.26	6.0-8.5	3	21.43
31616	Fecal Coliform (#/ml)	8	169.88	400/100	1	12.50
Nutrients and Chlorophyll *a*						
00610	Ammonia (mg/l)	14	0.07	0.3	1	7.14
32211	Chlorophyll-*a* (µg/l)	14	22.37	16.5	1	7.14
Sediment Toxicants						
01053	Manganese (t) (mg/kg)	1	640	490	1	100

4.3.2 Black Cypress Bayou

Black Cypress Bayou, although not a designated Segment, is a major tributary of Big Cypress Creek Segment 0402, which it intersects between the city of Jefferson and Caddo Lake. It drains a 258,932 acre subwatershed that lies immediately to the west of the James/Black Bayou subwatershed (Figure 3-1.) The Black Cypress Bayou subwatershed, also within the East Central Texas Plains Ecoregion, is largely (74%) forested, but agricultural use and clearing, particularly in the northwestern portion, is greater (24 % versus 16 %) than in the James/Black Cypress subwatershed (Figures 4-3, 4-4, Table 3-3).

Urban areas within the Black Cypress Bayou subwatershed include Hughes Springs and Avinger. Permitted discharges include the municipal wastewater treatment facility at Hughes Springs. No other potential sources of pollution are known to be present in this watershed. Black Cypress Bayou water quality has been monitored at a single Fixed station (10245) for only the past year. Four Systematic monitoring stations in this watershed are scheduled for operation during Fiscal Year (FY) 2001 (Figure 3-3).

Subwatershed hydrology is monitored at USGS Gage 07346045, located at the U.S. Highway 59 bridge, 1.1 miles north of Jefferson, about five miles upstream of the mouth of Black Cypress Bayou. The drainage area above this gage is 365 mi^2 (233,600 acres), about 90% of the watershed area delineated on the GIS layer. For the 30-year period of record from October, 1968 through December, 1998, flows in Black Cypress Bayou have ranged from 0 cfs to 10,700 cfs, and averaged 360.8 cfs.

Results of conventional parameter measurements on Black Cypress Bayou collected during the past year are presented in Table 4-3. The stream at this location exhibited, like those of the James/Black Bayou Subwatershed, the soft, slightly acid water typical of the eastern, forested part of the state. Dissolved oxygen concentrations were always above 5 mg/l. Moderate to low levels of nutrients and chlorophyll *a* suggests a relatively undisturbed water quality.

Water quality results from Black Cypress Bayou (station 10245) were screened together with the data from the other Segment 402 tributary station (16253), but individual streams are identified where concerns are detected. The screening results detailed in Table 4-4 indicate that there is a potential concern with fecal coliform levels since one of the four samples taken during the past year exceeded the contact recreation criterion of 400 colony forming units/100 milliliters (cfu/100ml). Dissolved oxygen concentrations at station 10245 on Black Cypress Bayou measured more than 5.5 mg/l. No other exceedances were detected in the data from Black Cypress Bayou.

The Texas Department of Health (TDH) has drafted a Health Consultation for an oxbow lake located near Avinger in the Black Cypress Bayou subwatershed. Locally known as Pruitt Lake, the TDH refers to it as Black Cypress Bayou and recommends limiting the ingestion of fish from the lake due to excessive mercury concentrations in the fish tissue (0.242-1.910 mg/kg among eight fish species). No more than two, four-ounce meals per month should be eaten by children 3-11 years, and adults should eat no more than two, eight-ounce meals per month.

Figure 4-3

Figure 4-4

Table 4-3

Summary of Water Quality Characteristics at Stations in the Black Cypress Bayou Subwatershed
November, 1998 – April, 1999

Parameter	Max	Min	Mean	Q25	Q75	n
Temperature (C)	24.2	10.9	**16.5**	13.60	17.00	5
Secchi Depth(m)	0.78	0.51	**0.66**	0.62	0.71	4
Specific Conductance (µmhos)	51	45	**47**	46.00	48.00	5
Dissolved Oxygen (mg/l)	10.6	5.5	**7.9**	6.55	9.13	6
pH	6.7	6	**6.3**	6.00	6.40	5
Total Alkalinity (mg/l)	14	8	**10**	10.00	10.00	5
Chlorophyll *a* (µg/l)	4.77	0.5	**1.66**	0.50	1.68	5
Hardness, dissolved (mg/l)	14.3	11.3	**13.1**	12.50	14.00	3
Total Dissolved Solids (mg/l)	128	30	**69**	30.00	82.00	5
Total suspended Solids (mg/l)	124	4	**32**	4.00	16.00	5
Ammonia Nitrogen (mg/l)	0.052	0.025	**0.03**	0.03	0.04	5
Total Kjeldahl Nitrogen (mg/l)	0.96	0.4	**0.70**	0.54	0.95	5
Total Phosphorus (mg/l)	0.2	0.06	**0.1**	0.07	0.12	5
Total Organic Carbon (mg/l)	12	7	**9**	8.00	11.00	5
Fecal Coliform (cfu/100 ml)	820	28	**236**	43.75	242.50	4
Sulfate (mg/l)	6	4	**5**	5.00	6.00	5
Chloride (mg/l)	8	5	**7**	7.00	7.00	5

Table 4-4

Results of Data Screening: Black Cypress Bayou, Segment 402 Tributaries

	n	Mean	Criterion	Exceeds	%
Parameter				**Criterion**	**Exceeding**
Aquatic Life Standards					
Dissolved Oxygen (mg/l)	13	7.34	5.00	2	15
Fecal Coliform (cfu/100 ml)	4	236.75	400.00	1	25
Toxic Materials in Water (chronic)					
Copper (d) (ug/l)	1	4.45	3.60	16253	---
Nutrients and Chlorophyll *a*					
Chlorophyll *a* (ug/l)	13	6.22	16.50	1	8
Cadmium (mg/kg)	1	2.10	1.02	1	100

4.3.3 Big Cypress Creek

The Big Cypress Creek subwatershed encompasses all of the Lake O' the Pines watershed: the drainages of Segments 403 (Lake O' the Pines), 404 (Big Cypress Creek), 408 (Lake Bob Sandlin), and 405 (Lake Cypress Springs) (Figure 3-1). It extends from the East Central Texas Plains Ecoregion (the pineywoods surrounding Lake O' the Pines) into the South Central Texas Plains Ecoregion (post oak savanna), a transition marked by more extensive agricultural clearing in the western portion of the basin (Figures 3-4, 4-5). The distribution of vegetation types is shown in Figure 4-6. Although eliminated from the lake segments, the riparian woodland in Segment 404 is extensive and undisturbed relative to the adjacent uplands.

This 595,424 acre subwatershed is the most intensively developed in the Cypress Creek Basin; agricultural land uses occupy 219,393 acres and urban areas 22,544 acres. At 37% and 3.8%, respectively, these land uses are substantially more common in this subwatershed than in the other subwatersheds of the Cypress Creek Basin (Table 3-3). Agricultural land use levels (approximately 25%) are comparable between the Black Cypress Bayou subwatershed and the eastern half of the Cypress Creek Basin subwatershed (roughly, east of the Boggy and Greasy Creek subwatersheds) but reach frequencies substantially greater than 50% over large areas of the western basin.

The majority of intensive poultry operations are located near Pittsburg and Mount Pleasant. Industrial facilities (including electric power production) are present in Mount Pleasant, near Lone Star and Daingerfield (Ellison Creek Drainage), on Lake Monticello (adjacent to Lake Bob Sandlin), Welsh Lake on Swauano Creek and Johnson Creek Reservoir on Johnson Creek. Shoreline residential development is present on Lake Cypress Springs and substantial low density retirement and recreational residential development surrounds Lake O' the Pines. Significant urban concentrations occur at Mount Pleasant, Pittsburg, Daingerfield, Lone Star, and Ore City.

The thirteen largest wastewater discharges in the Big Cypress Creek subwatershed are listed in Table 4-5. A TNRCC permitted industrial hazardous waste site is present at Lone Star, and a TNRCC waste disposal permit authorizes disposal of dairy wastes by irrigation and application on land in the Prairie Creek subwatershed. The latter permit is currently inactive.

USGS streamflow gages are located at the State Highway 11 crossing of Big Cypress Creek (07344500) and below the dam at Lake O' the Pines (07346000). Peak flow values are the only streamflow data currently available from these gages. The gage below Lake O' the Pines recorded maximum, minimum, and average streamflows of 55,400, 0, and 687 cfs, respectively during the period 1924 through 1959 (before construction of Lake O' the Pines).

A single Fixed station (10296) provides two years (September, 1997 –August, 1999) of water quality data on Lake O' the Pines (Segment 403), and two Fixed stations (10308 and 13631) located on Big Cypress Creek (Segment 404) have been sampled for three and five years, respectively, during the study period (Figure 3-2, Table 3-2). Segments 405 (Lake Cypress Springs) and 408 (Lake Bob Sandlin) each have a Fixed station (10312 and 10329, respectively) that was operated during FY1999.

Table 4-5

Largest wastewater discharges in the Big Cypress Creek subwatershed

Facility	Type	Permit Vol. (MGD)	Receiving Water
Ore City WWTP	Municipal	.218	Meddlin Creek (Lake O' the Pines)
City of Lone Star WWTP	Municipal	0.44	Big Cypress Creek
Lone Star Steel WWTP	Domestic	0.5	Big Cypress Creek
Lone Star Steel	Industrial	70 (cooling, process,storm)	Ellison Creek Reservoir
Lone Star Steel	Industrial	55 (cooling)	Ellison Creek Reservoir
City of Pittsburg Sparks Branch WWTP	Municipal	0.97	Prairie Creek Tributary
City of Pittsburg Dry Creek WWTP	Municipal	0.2	Prairie Creek Tributary
Pilgrim's Pride Processing Plant WWTP	Industrial	3	Tankersley Creek
City of Mount Pleasant WWTP	Municipal	2.91	Hart Creek
City of Omaha WWTP	Municipal	0.2	Boggy Creek
City of Daingerfield WWTP	Municipal	0.7	Brutons Creek (Ellison Creek Reservoir)
Southwestern Electric power Company	Industrial	550 (cooling, other low vol.)	Johnson Creek Reservoir
Southwestern Electric power Company	Industrial	1445	Welsh Lake (Swauano Creek)

Figure 4-5

Figure 4-6

Three Systematic stations provide water quality data on Tankersley (10261 and 10264) and Hart (10266) Creeks, both of which are tributaries of Segment 404 (Table 3-5). A single Systematic station (10300) provides data on Lake O' the Pines from September, 1997 through April, 1999 (Figure 3-3, Table 3-2). Special studies have been conducted on the tributary subwatersheds drained by Prairie and Boggy Creeks (Poultry Operations Study), on Big Cypress Creek (Intensive Studies), and on Lake O' the Pines (Nutrient Study).

The results of monitoring field and conventional water chemistry parameters since 1994 are summarized by reservoir and stream segment for the Big Cypress Creek subwatershed in Table 4-6 (a through e). In evaluating this data, it must be noted that large numbers of samples have been collected in segments 0403 and 0404, relative to the other segments in the Big Cypress Creek subwatershed. The data from Segment 0408 appears to be biased toward an overestimate of its water quality because of a preponderance of cool weather samples.

Comparing the reservoir segments, Lake O' the Pines appears to exhibit some of the water quality characteristics of enrichment, relative to conditions in the upstream reservoirs, Lakes Cypress Springs and Bob Sandlin (Table 4-6a, d, and e). For example, average concentrations of chlorophyll *a*, TDS, ammonia nitrogen, Total Kjeldahl nitrogen (TKN), and total phosphorus (TP) were all higher in Lake O' the Pines than in the other two reservoirs, while average Secchi depth, dissolved oxygen concentration, and pH were all lower. Differences among the reservoirs in average values of the biologically active parameters are reflected in the increased range of individual measurements in the Lake O' the Pines data, and the occurrence of extreme values (e.g., dissolved oxygen, pH, Secchi depth).

Big Cypress Creek, Segment 0404, tends to exhibit averages and ranges in water quality parameters that are similar to those observed in Lake O' the Pines (Table 4-6b). Big Cypress Creek is the largest tributary of the Lake O' the Pines. The station that is furthest downstream within this segment (13631) is located only a few hundred yards from the more upstream station in Segment 0403.

Specific conductance and dissolved constituents in general, including nutrients and inorganic solids, tend to be present at equivalent or higher concentrations in Big Cypress Creek than in Lake O' the Pines. While the average total phosphorus level in Lake O' the Pines is approximately three times the values recorded in the upstream reservoirs, it is only one fifth the average total phosphorus concentration in Big Cypress Creek (0.5 mg/l). The Big Cypress Creek data indicate that most (88%) of the nitrogen present in the water column is present as nitrate plus nitrite, which is a result of the presence of a series of very high nitrate nitrogen values observed in samples collected at station 10308 between August, 1997 and September, 1998 (Figure 4-7). Unfortunately, this parameter was not measured at the other stations in this subwatershed, except in Lake Bob Sandlin where nitrate (and nitrite) nitrogen accounts for about 29% of total nitrogen.

Total phosphorus in Segment 0404 exhibited a behavior similar to that of nitrate nitrogen; extreme values were observed only at station 10308, and were confined to the period between August, 1997 and September, 1998 (Figure 4-8). Lower, but still high, levels of total phosphorus

Table 4-6
Summary of Water Quality Characteristics at Stations in the Big Cypress Creek Subwatershed

Table 4-6a
Segment 0403 - Lake O' the Pines

Parameter	Max	Min	Mean	25th Quartile	75th Quartile	n
Temperature (C)	32.3	7.8	**20.9**	11.8	28.3	87
Secchi Depth (m)	1.9	0.33	**1.0**	0.8	1.3	44
Specific Conductance (µhmos)	387	70	**173**	132	214.5	71
Dissolved Oxygen (mg/l)	15.1	2.3	**7.6**	5.7	9.3	48
pH	9.1	5.8	**6.9**	6.7	7.1	48
Total Alkalinity (mg/l)	62	2.5	**23**	14	28.5	16
Chlorophyll (µg/l)	33	0.5	**7**	1.2	11.2	26
Hardness (mg/l)	85.6	19.1	**42.1**	27.3	59.8	14
Total Dissolved Solids (mg/l)	220	57	**118**	76	160	14
Total Suspended Solids (mg/l)	17	2	**6**	3.75	9.25	16
Ammonia Nitrogen (mg/l)	0.12	0.005	**0.06**	0.025	0.094	26
Total Kjeldahl Nitrogen (mg/l)	1.5	0.14	**0.6**	0.4	0.6	40
Total Phosphorus (mg/l)	0.43	0	**0.10**	0.035	0.11	26
Dissolved ortho-Phosphorus (mg/l)	0.1	0.005	**0.02**	0.005	0.01	12
Total Organic Carbon (mg/l)	11	4.9	**7**	5.75	7.525	40
Fecal Coliform (cfu/100ml)	130	0.5	**25**	0.5	30	18
Sulfate (mg/l)	54	13.2	**31**	21.275	42	14
Chloride (mg/l)	36	3	**17**	11.55	21.75	14
Sediment TOC (mg/kg)	40600	3820	**27540**	21010	39400	3

Table 4-6b

Segment 0404 - Big Cypress Creek

Parameter	Max	Min	Mean	25th Quartile	75th Quartile	n
Temperature (C)	32.3	3.3	**21.8**	14.4	29	53
Secchi Depth (m)	1.1	0.08	**0.6**	0.4	0.76	37
Conductivity (µmhos)	1222	132	**430**	211	539	45
Dissolved Oxygen (mg/l)	11.3	0.8	**6.6**	5.4	8.6	43
pH	8.2	6.3	**7.0**	6.7	7.2	44
Total Alkalinity (mg/l)	100	15	**38**	26	42	29
Chlorophyll-*a* (µg/l)	76.5	0.5	**7.6**	0.5	7.75	30
Pheophytin-*a* (µg/l)	15.2	0	**2.8**	0.5	2.79	30
Hardness (mg/l)	319	41.9	**88**	57.3	88.5	17
Total Dissolved Solids (mg/l)	836	117	**276**	152	348	29
Total Suspended Solids (mg/l)	32	3	**12**	5.5	16	31
Nitrate+Nitrite (mg/l)	48.9	0.05	**7.61**	0.73	5.45	22
Oil and Grease (mg/l)	4280	512	**1949**	783	2667	3
Ammonia Nitrogen (mg/l)	0.15	0.005	**0.06**	0.0375	0.07	28

Segment 0404 - Big Cypress Creek (Continued)						
Total Kjeldahl Nitrogen (mg/l)	3.6	0.39	**0.94**	0.72	1.02	30
Total Phosphorus (mg/l)	3.62	0.02	**0.50**	0.13	0.44	29
Ortho-Phosphorus (mg/l)	0.78	0.04	**0.27**	0.10	0.40	8
Total Organic Carbon (mg/l)	12	0.5	**8**	7	9	29
Chloride (mg/l)	103	11	**30**	18	31.4	30
Sulfate (mg/l)	149	16.6	**52**	35	61.25	30
Fecal coliform (cfu/100ml)	2000	0.5	**197**	40	150	40
Sediment Total Organic Carbon (mg/kg)	33000	4930	**17825**	12500	20800	9

Table 4-6c
Segment 0404 - Big Cypress Creek Tributary Stations (Tankersley Creek, Hart Creek)

Parameter	**Max**	**Min**	**Mean**	**25th Quartile**	**75th Quartile**	**n**
Temperature (C)	29.5	3.9	**19.8**	15.775	25.125	46
Secchi Depth (m)	1	0.2	**0.5**	0.4	0.525	40
Specific conductance (µmhos)	1583	194	**711**	392.75	1149.25	46
Dissolved Oxygen (mg/l)	11.1	1.6	**6.3**	4.625	7.8	46
pH	7.7	6.4	**7.1**	6.925	7.3	46
Total Alkalinity (mg/l)	146	18	**75**	48	97	23
Chlorophyll (µg/l)	66.4	0.5	**7.6**	0.5	3.61	25
Total Dissolved Solids (mg/l)	1010	142	**465**	277	649	23
Total Suspended Solids (mg/l)	106	5	**26**	11	33	25
Ammonia Nitrogen (mg/l)	7.72	0.01	**0.71**	0.065	0.155	23
Total Kjeldahl Nitrogen (mg/l)	8.72	0.55	**2.02**	0.85	2.07	25
Total Phosphorus (mg/l)	7.12	0.07	**1.91**	0.11	3.12	25
Ortho-Phosphorus (mg/l)	4.8	0.06	**1.92**	0.11175	3.6475	10
Total Organic Carbon (mg/l)	22	0.5	**10**	8	12	25
Fecal Coliform (cfu/100ml)	2800	0.5	**470**	65.75	565	36

Table 4-6d
Segment 0405 – Lake Cypress Springs

	Max	**Min**	**Mean**	**25th Quartile**	**75th Quartile**	**n**
Temperature (C)	27	10.6	**17.4**	10.8	25	20
Secchi Depth (m)	1.35	1.25	**1.3**	1.2875	1.3125	4
Specific Conductance (µmhos)	136	120	**130**	126	134.5	4
Dissolved Oxygen (mg/l)	9.77	6.8	**7.9**	7.025	8.27	4
pH	7.5	7	**7.2**	7.075	7.275	4
Total Alkalinity (mg/l)	20	16	**18**	17	19	3
Chlorophyll (µg/l)	3.56	3.16	**3.35**	3.24	3.44	3
Hardness (mg/l)	33.3	30.7	**32.2**	31.7	33	3

Segment 0405 - Lake Cypress Springs (Continued)						
Total Dissolved solids (mg/l)	93	79	**88**	85.5	92.5	3
Total Suspended Solids (mg/l)	4	3	**3**	3	3.5	3
Ammonia Nitrogen (mg/l)	0.06	0.025	**0.037**	0.025	0.0425	3
Total Kjeldahl Nitrogen (mg/l)	0.51	0.38	**0.46**	0.43	0.495	3
Total Phosphorus (mg/l)	0.05	0.005	**0.032**	0.0225	0.045	3
TOC (mg/l)	7	5	**6**	5.5	6.5	3
Fecal Coliform (mg/l)	11	1	**4**	1.75	5.75	4
Chloride (mg/l)	14	12	**13**	12.5	13.5	3
Sulfate (mg/l)	22	16	**19**	17	20	3

Table 4-6e
Segment 408 – Lake Bob Sandlin

Parameter	**Max**	**Min**	**Mean**	**25th Quartile**	**75th Quartile**	**n**
Temperature (C)	19.9	11.5	**15.8**	12.675	12.675	10
Secchi Depth (m)	1.5	1.1	**1.3**	1.2	1.2	10
Specific Conductance (µmhos)	153	139	**148**	148.5	148.5	10
Dissolved Oxygen (mg/l)	10.6	6.5	**8.59**	7.3	7.3	10
pH	7.3	6.6	**7.1**	7	7	10
Total Alkalinity (mg/l)	62	12	**20**	14	14	10
Chlorophyll *a*	2.97	0.5	**1.3**	0.5	0.5	10
Pheophytin-*a*	3.18	0.5	**0.8**	0.5	0.5	10
Dissolved Hardness	35.4	31.7	**33.7**	32.5	32.5	9
Total Dissolved Solids (mg/l)	110	48	**89**	85.75	85.75	10
Total Suspended Solids (mg/l)	6	2	**3**	2.25	2.25	10
Volatile Suspended Solids (mg/l)	3	1	**1.5**	1	1	10
Nitrite+Nitrate Nitrogen (mg/l)	0.3	0.05	**0.20**	0.14	0.14	10
Ammonia Nitrogen	0.06	0.025	**0.028**	0.025	0.025	10
Total Kjeldahl Nitrogen	0.54	0.34	**0.45**	0.3875	0.3875	10
Total Phosphorus (mg/l)	0.06	0.005	**0.028**	0.0112	0.0112	10
Ortho-Phosphorus (mg/l)	0.005	0.005	**0.005**	0.005	0.005	1
Total Organic Carbon (mg/l)	6	5	**5**	5	5	10
Fecal Coliform (cfu/100ml)	14	0.5	**5**	1.125	1.125	10
Dissolved Calcium (mg/l)	6.7	6.25	**6.5**	6.42	6.42	9
Dissolved Magnesium (mg/l)	4.53	3.91	**4.21**	4	4	9
Chloride (mg/l)	16	12	**14**	12.5	12.5	10
Sulfate (mg/l)	28	20	**24**	22.25	22.25	10
Total Sediment Phosphorus (mg/l)	0.2	0.03	**0.05**	0.03	0.03	9

Figure 4-7

Figure 4-8

(approximately 0.4 mg/l) were observed in late October, 1998 at both Big Cypress Creek stations, and at the nearby upstream Lake O' the Pines station (10300). In the main basin of Lake O' the Pines, total phosphorus concentrations were generally at or below 0.1 mg/l during the 1997 –1999 period of monitoring, but rose to about 0.4 mg/l during December, 1998 and January, 1999 (Figure 4-9). The period of highest nutrient concentration in lower Big Cypress Creek and upper Lake O' the Pines coincides with a relatively dry year and summer period (July-August, 1998). At this time, Big Cypress Creek was not flowing into Lake O' the Pines, but into Ellison Creek reservoir to make up for evaporative cooling losses. The elevated nutrient episode ends at the same time (September, 1998) that rainfall runoff caused Big Cypress Creek to begin flowing into Lake O' the Pines again.

Nutrient levels in Lake O' the Pines during 1998-1999 were monitored as part of a Special nutrient study[7]. This study indicated that in Lake O' the Pines, TKN accounted for most of the nitrogen in the water column, and total phosphorus was present in large concentrations (>0.1 mg/l) in the main basin of the Lake only during December, 1998 and January, 1999, in agreement with the data from station 10296.

High concentrations of phosphorus, averaging 1.91 mg/l, have been observed in the two tributaries to Segment 0404 that drain the Mount Pleasant area. As both tributaries receive treated wastewater, it is assumed that nitrate nitrogen levels in these streams are assumed, at times, to be high. Intensive surveys performed on Segment 0404 during August, 1998 and 1999 indicated that the discharge into Tankersley Creek was the largest point source of nitrogen and phosphorus entering Segment 0404 at the time. However, Systematic monitoring on these tributaries did not adequately cover the time period during which an apparently large quantity of (at least) total phosphorus was transported down Big Cypress Creek and into Lake O' the Pines to assess them as possible sources. Other potential sources of nutrients are also present, including other dischargers, urban runoff from Pittsburg and other residential concentrations, leakage from on-site treatment facilities, and intensive agricultural activity, particularly in the area around Pittsburg.

The results of data screening for the Big Cypress Creek subwatershed is presented in detail in Table 4-7 (a through e) by reservoir and stream segment. The parameters presented are those in which the data exceeded the criterion and resulted in exceedances. All parameters not listed in the table were below Guidance screening levels. Concerns revealed by this analysis are summarized in Table 4-8. Occasional low dissolved oxygen concentrations and elevations of total phosphorus levels resulted in possible concerns for these parameters in Lake O' the Pines. Concern for dissolved cadmium in Lake O' the Pines, and in the other segments of the Cypress Creek Basin subwatershed, all resulted from single instances of cadmium observed at concentrations just above the detection limit (an order of magnitude higher than the criterion concentration). Except for manganese, which exhibited higher sediment concentrations than the criterion in all three samples, the concerns tabulated for sediment metals in Tables 4-7a and 4-10 in Lake O' the Pines all resulted from elevated concentrations in one of three samples.

In Lake Bob Sandlin (Segment 0408) a concern is present for dissolved cadmium (chronic criterion). The concern listed for total mercury is based on two exceedances

Figure 4-9

Table 4-7a
Results of Data Screening: Lake O' the Pines, Segment 0403

Code	Parameter	n	Mean	Criterion	Exceeds	%
					Criterion	**Exceeding**
00300	Dissolved Oxygen (mg/l)	48	7.65	5	9	18.75
00400	pH	48	6.88	6.0-8.5	3	6.25
Toxic materials in Water (Chronic)						
					Station	
01025	Cadmium (d) (ug/l)	8	0.78	0.36	10296	---
		6	0.98		10300	---
Nutrients and Chlorophyll *a*						
00610	Ammonia (mg/l)	26	0.06	0.13	1	3.85
00665	Total Phosphorus (mg/l)	26	0.1	0.2	3	11.54
Sediment Toxicants						
1008	Barium (t) (mg/kg)	3	285.67	287	1	33.33
1029	Chromium (t) (mg/kg)	3	33.97	34	1	33.33
1052	Lead (t) (mg/kg)	3	40	61.5	1	33.33
1053	Manganese (t) (mg/kg)	3	1606.67	1210	3	100.00
1068	Nickel (t) (mg/kg)	3	23.03	25.2	1	33.33
1148	Selenium (t) (mg/kg)	3	1.95	1.73	1	33.33
1093	Zinc (t) (mg/kg)	3	168.57	120	1	33.33

Table 4-7b
Results of Data Screening: Segment 0408 – Lake Bob Sandlin

Code	Parameter	n	Mean	Criterion	Exceeds	%
					Criterion	**Exceeding**
Toxic materials in Water (Chronic)						
					Station	
01025	Cadmium (d) (ug/l)	3	1.78	0.36	10329	---
		3	1.78		10330	---
		3	1.78		16158	---
71900	Mercury (t) (ug/l)	2	0.0135	0.0122	10329	---
		3	0.0303		16158	---

Table 4-7c
Results of Data Screening: Segment 0405 – Lake Cypress Springs

	Parameter	n	Mean	Criterion	Exceeds	%
					Criterion	**Exceeding**
Toxic materials in Water (Chronic)					Station	
01025	Cadmium (d) (ug/l)	3	1.79	0.36	10312	---

Table 4-7d
Results of Data Screening: Segment 0404 – Big Cypress Creek

Code	Parameter		n	Mean	Criterion	Exceeds	%
Segment and Aquatic Life Standards						**Criterion**	**Exceeding**
00300	Dissolved Oxygen (mg/l)		43	6.64	4.00	5	12
00010	Temperature (C)		53	21.84	32.19	2	4
31616	Fecal Coliform (#/100ml)		30	197.91	400	5	17
Toxic materials in Water (Chronic)							
10253	Cadmium (d) (ug/l)		14	0.52	0.36	13631	---
Ambient Water and Sediment Toxicity							
	Sediment-*C. dubia*					70 %	Affected
Nutrients and Chlorophyll *a*							
00610	**Ammonia Nitrogen (mg/l) 13631**		19	0.06	0.13	2	11
00593	Nitrate/Nitrite-Nitrogen (mg/l) 10308	Station	7	20.35	3.10	5	71
		13631	15	1.67	0.41	11	73
00671	Ortho-Phosphorus (mg/l)	10308	4	0.44	1.40	1	25
		13631	5	0.16	0.10	4	80
00665	Total Phosphorus (mg/l)	10308	10	1.09	1.60	3	30
		13631	19	0.18	0.20	5	26
32211	Chlorophyll *a* (ug/l)	13631	20	10.76	20.00	2	10
Sediment Toxicants							
	Copper (mg/kg)	13631	7	17.79	33.00	1	14
	Lead (mg/kg)	13631	7	50.76	61.50	2	29
	Manganese (mg/kg)	10308	3	455.67	490.00	2	67
	Mercury (mg/kg)	13631	7	0.21	0.160	1	14
	Zinc (mg/kg)	13631	7	246.91	120.00	6	86

Table 4-7e
Results of Data Screening: Tributaries to Big Cypress Creek, Segment 0404

	Parameter	n	Mean	Criterion	Exceeds	%
	Segment and Aquatic Life Standards				**Criterion**	**Exceeding**
00300	Dissolved Oxygen (mg/l)	46	6.27	5.00	10	22
31616	Fecal Coliform (#/100 ml)	36	470.26	400.00	12	33
	Nutrients and Chlorophyll *a*					
01000	Ammonia Nitrogen (mg/l)	23	0.71	0.30	5	22
00671	Ortho-Phosphorus (mg/l)	10	1.92	1.40	6	60
00665	Total Phosphorus (mg/l)	25	1.91	1.60	11	44
32211	Chlorophyll *a* (ug/l)	25	7.62	16.50	3	12

Table 4-8
Concerns (C) and Possible Concerns (PC) Indicated by the Data Screening for the Big Cypress Creek Subwatershed

	Segment				
Parameter	**0403**	**0408**	**0405**	**0404**	**0404**
					Tributaries
Dissolved Oxygen	PC*			PC*	PC*
Fecal Coliforms					C*
Cadmium (chronic)	C	C	C	C*	
Sediment Barium	C				
Sediment Chromium	C				
Sediment Copper				PC	
Sediment Lead	C			C	
Sediment Manganese	C			C	
Sediment Mercury				PC	
Sediment Nickel	C				
Sediment Selenium	C				
Sediment Zinc	C				
Mercury (Human Health)		C			
Ammonia Nitrogen					PC*
Nitrate+Nitrite				C*	
Ortho-Phosphorus				C*	C*
Total Phosphorus	PC*			C*	C*
Chlorophyll *a*					PC*

*Indicates at least nine samples within five years for nutrients and field parameters, five samples in five years for metals.

observed in seven samples at three stations. The exceeedances were found at stations 10329 and 16158. In Lake Cypress Springs (Segment 0405), the only concern indicated was for dissolved cadmium at chronic levels.

Depressed dissolved oxygen levels are of potential concern in both the main stem of Big Cypress Creek (Segment 0404) and its tributaries (Table 4-8), while fecal coliform concentrations are of concern only in the tributaries. In bottom sediments, copper and lead concentrations are of possible concern or concern only at station 13631, in the Lake O' the Pines headwaters. The opposite is true for manganese, which exceeded the stream sediment screening levels at station 10308, but not at station 13631, which was evaluated using the reservoir criteria, with similar concentration ranges. Sediment mercury exhibited a single high value (0.88 mg/kg) in seven samples from station 13631.

Relative to the screening results presented in the 1996 "Regional Assessment of Water Quality" for Segment 0403, Lake O' the Pines, low dissolved oxygen concentrations continued to be a possible concern. The concerns and possible concerns tabulated in 1996 for cadmium, copper lead and zinc in the water column were not detected in this screening. However, concerns are raised in the more recent data for elevated levels of a more extensive assemblage of metals, but this time in sediments (Table 4-7).

In the 1996 report, concerns in Segment 0408 were limited to episodes of low dissolved oxygen concentration. Possible concerns included low pH levels and total cadmium, copper and lead in the water column, although none of these parameters exhibit exceedances in the current data for Lake Bob Sandlin, there are now concerns over dissolved cadmium exceeding the chronic criterion, and total mercury in water exceeding the Fish Consumption and Human Health criterion for designated public water supply segments. In Segment 0405, a dissolved oxygen concern has been replaced by a dissolved cadmium (chronic) concern.

In 1996, fecal coliform numbers and ortho-phosphorus concentrations were of possible concern and concern, respectively. The current screening indicates that while fecal coliforms are no longer of possible concern in Big Cypress Creek, both ortho and total phosphorus, along with nitrate+nitrite nitrogen, is of concern. As in the other segments, sediment metals have replaced concerns and possible concerns over a variety of total and dissolved metals. Concerns and possible concerns about dissolved oxygen, fecal coliforms, nutrients and chlorophyll *a* concentrations in 1996 are still of concern in this screening.

Aquatic life uses in Segment 0404 were evaluated directly through a series Rapid Bioassessment Protocols conducted as part of two Special studies. Fish and macroinvertebrate sampling in Big Cypress Creek as part of an intensive survey in August 1988 indicated that three of four locations sampled supported a High aquatic life use based on fish community characteristics, but only Limited or Intermediate aquatic life uses based on the macroinvertebrate assemblages. Additional RBA sampling and habitat assessment was conducted at the same stations during August 1999 and the data is being processed.

RBA sampling conducted to support the Poultry Operations Study indicated that Intermediate aquatic life uses (based on fish communities) tended to predominate in tributary subwatersheds containing the highest densities of poultry production facilities, while High aquatic life uses were observed in reference streams. Assessments using macroinvertebrate community characteristics indicated that High aquatic life uses were realized in all the streams sampled.

4.3.4 Little Cypress Creek

The Little Cypress Creek subwatershed forms the southern boundary of the Cypress Creek Basin, encompassing the entire 456,828 acre drainage area of Segment 409 from its confluence with Big Cypress Creek. Agricultural land use levels (35% of subwatershed area) are similar to, but more uniformly distributed than, those in the Big Cypress Creek drainage are. Urban land uses occupy a smaller proportion (1.04%) of this subwatershed than of any other subwatershed in the Cypress Creek Basin (Figures 3-1, 4-10, Table 3-3). The distribution of vegetation types within the subwatershed is shown in Figure 4-11.

Urban areas in the Little Cypress Creek subwatershed are limited to the city of Gilmer and the northern portion of the city of Marshall, where a TNRCC permitted industrial hazardous waste site is located. The city of Gilmer operates the largest permitted wastewater discharge in this subwatershed. Poultry production facilities are concentrated in the 80,300 acre Lilly Creek subwatershed located south and west of the city of Pittsburg.

USGS Gage 07346070 located at the U.S. Highway 59 crossing 3.5 miles south of Jefferson and 6.8 miles upstream from the confluence with Big Cypress Creek (Segment 402). The 432,000 acre (675 square miles) drainage area exhibited a daily average flow of 537 cfs, and maximum and minimum flows of 32,700 and 0 cfs, respectively, during the period of record October, 1946 through December, 1998. A single Fixed station (10332) provides a full five-year water quality record for Little Cypress Creek (Figure 3-2). Three stations were studied on Lilly Creek during the Poultry Production Study as an example of a subwatershed with a high density of poultry facilities. Nine Systematic stations, including one on Lilly Creek, are scheduled to be sampled in this watershed during FY2000 (Figure 3-3).

Water quality characteristics of Segment 0409 are summarized in Table 4-9. The segment exhibits the relatively low specific conductances and dissolved solids concentrations typical of soft, eastern forest water, although the somewhat elevated nutrient levels, particularly phosphorus, and low dissolved oxygen episodes may indicate some enrichment. Long-term sample series are not available for discrete nutrient or biological parameters, but the relatively regular seasonal variation in dissolved oxygen in Segment 0409, and the recurring pattern of summer oxygen depletion that normally coincides with a period of high temperatures and low flows are shown in Figure 4-12.

Results of data screening for Little Cypress Creek are presented in Table 4-10. Low dissolved oxygen concentrations are of possible concern in this screening, whereas it was a concern (with a much higher exceedance rate) in the 1996 “Regional Assessment of Water Quality”. The current cadmium (chronic criterion) concern is based on the results from 16 samples, of which 15 were non-detects at a level an order of magnitude higher than the criterion. The mercury concern (Fish Consumption and Human Health Criterion) is based on two exceedances in eight samples, which included two non-detects at a level lower than the criterion. Concerns and possible concerns with nutrients and metals in water in the 1996 report are not evident in the current screening.

Figure 4-10

Figure 4-11

Figure 4-12

Table 4-9

Summary of Water Quality Characteristics at Stations in the Little Cypress Creek Subwatershed
Segment 409 – Little Cypress Creek

Parameter	Max	Min	Mean	Q25	Q75	n
Temperature (C)	28.5	3.0	**19.0**	13.0	24.6	35
Secchi Depth (m)	0.90	0.17	**0.56**	0.44	0.70	20
Specific Conductance (umhos)	181	85	**121**	100	134	23
Oxygen, dissolved (mg/l)	10.4	2.1	**6.4**	5.1	8.2	36
pH	8.1	6.0	**6.7**	6.3	6.9	36
Alkalinity, Total (mg/l)	30.0	8.0	**16.9**	10.0	20.0	15
Chlorophyll-*a* (ug/l)	5.1	0.5	**1.6**	0.5	2.5	14
Pheophytin-*a* (ug/l)	12.6	0.5	**3.4**	0.5	6.5	14
Hardness, dissolved (mg/l)	34	19	**25**	22	27	11
Total Dissolved Solids (mg/l)	160	86	**120**	102	135	14
Total Suspended Solids (mg/l)	23	2	**10**	6	13	14
Nitrite+Nitrate N (mg/l)	0.340	0.025	**0.124**	0.025	0.200	13
Ammonia Nitrogen (mg/l)	0.185	0.005	**0.037**	0.025	0.025	16
Nitrite Nitrogen (mg/l)	0.020	0.005	**0.007**	0.005	0.010	13
Kjeldahl Nitrogen (mg/l)	1.18	0.42	**0.63**	0.47	0.71	15
Total Phosphorus	0.200	0.005	**0.100**	0.060	0.131	15
Ortho-Phosphorus (mg/l)	0.090	0.005	**0.036**	0.020	0.050	14
Total Organic Carbon (mg/l)	16.0	7.0	**9.8**	8.0	10.5	15
Fecal Coliform (cfu/100ml)	190	16	**100**	43	158	18
Chloride (mg/l)	31	5	**17**	13	20	28
Sulfate (mg/l)	18	6	**12**	10	14	28

Table 4-10

Results of Data Screening: Little Cypress Creek, Segment 409

	Parameter	n	Mean	Criterion	Exceeds Criterion	% Exceeding
00300	Dissolved Oxygen (mg/l)	36	6.42	5.00	9	25
Toxic materials in Water (Chronic)						
01025	Cadmium (d) (ug/l)	16	0.47	0.36	10332	---
Fish Consumption and Human Health						
71900	Mercury (ug/l)	8	0.06	0.012	10322	---

4.3.5 Caddo Lake

The Caddo Lake subwatershed encompasses 168,368 acres, including Caddo Lake and the drainages tributary to it (Figures 3-1). The largest tributary is Segment 402 of Big Cypress Creek through which Caddo Lake receives runoff from all the subwatersheds discussed above, except for James/Black Bayou. Caddo Lake subwatershed exhibits little agricultural land use (9.5% of the subwatershed), almost 89% of the subwatershed consists of forest, wetland and water (Figure 4-13, 4-14, Table 3-3).

Substantial retirement and recreational development is in place in this subwatershed. Although Karnack is the only urban center actually within the Caddo Lake subwatershed, the city of Jefferson, immediately upstream on Segment 402, can also be expected to exert some effect on the Lake. A TNRCC permitted industrial hazardous waste site and a federal superfund site are located at the Longhorn Army Ammunition Plant adjacent to the city of Karnack.

A Fixed station (10283) located near the dam on the Louisiana border provides four years of water quality data on the main basin of Caddo Lake. A second Fixed station (16254) was established in August 1998 below the city of Jefferson to provide water quality data on the lower portion of Big Cypress Creek (Segment 402). Six Systematic monitoring stations have been established on Caddo Lake and the lower reach of Segment 402, and operated since August, 1998 (Figure 4-9, Table 3-5). Station 10294 on Caddo Lake has been sampled for four years, and station 10295 on Big Cypress Creek was sampled during the first three years of the study period. Three additional Systematic stations, two within the Segment 401 drainage, have been established on unclassified tributaries and operated during the period August, 1998-1999.

Water quality characteristics in Caddo Lake are summarized in Table 4-11 (a through c), segregated into Caddo Lake (Segment 0401), Big Cypress Creek (Segment 0402), and tributary stations, excluding station 10245, Black Cypress Bayou. Caddo Lake and its tributaries tend to be soft water environments like the other waters in the Cypress Creek Basin, exhibiting relatively low specific conductances, and dissolved constituent concentrations (TDS, hardness, alkalinity, chloride, sulfate) and with a predominately acid pH. Occasional, apparently unrelated, instances of unusually high values for TDS and sulfate are present in the Caddo Lake data which do not appear to reflect seasonal conditions or ephemeral events having influence beyond a single station.

The lake and stream environments in this watershed all exhibit high average (and maximum) levels of total phosphorus and chlorophyll *a*, and episodes of low dissolved oxygen concentrations. Figure 4-14 shows paired dissolved oxygen and chlorophyll *a* measurements from station 10283, near the dam. The prominent late summer 1998 peak in chlorophyll *a* concentrations was reflected in the results from the nearby Systematic station 14236, and at the stations in coves on the western shoreline. This event, which was presumably an algal bloom did not seem to affect dissolved oxygen concentrations, but coincided with unusually high pH values (7.9-8.2) and TKN concentrations (>1 mg/l). Elevations in the latter parameters result from the production of hydroxyl ions during photosynthesis (increased pH) and the accumulation of proteins and other nitrogenous compounds in phytoplankton biomass. An earlier bloom episode

Figure 4-13

Figure 4-14

Figure 4-15

Figure 4-16

Figure 4-17

Table 4 – 11a

Summary of Water Quality Characteristics at Stations in the Caddo Lake Subwatershed
Segment 401 – Caddo Lake

Parameter	Max	Min	Mean	Q25	Q75	n
Temperature (C)	34.5	7.7	**19.2**	11.5	25.3	105
Secchi Depth (m)	1.30	0.18	**0.67**	0.36	0.90	33
Specific Conductance (*um*hos)	138	74	**110**	101	119	14
Oxygen, dissolved (mg/l)	12.4	0.1	**6.0**	3.3	8.1	82
pH	8.2	4.9	**6.5**	6.1	6.7	82
Alkalinity, Total (mg/l)	40.0	5.0	**15.5**	9.8	20.0	52
Chlorophyll-*a* (ug/l)	149.0	0.5	**13.7**	0.5	12.0	54
Pheophytin-*a* (ug/l)	67.7	0.0	**6.3**	0.5	6.2	54
Hardness, dissolved (mg/l)	44	12	**24**	19	27	48
Total Dissolved Solids (mg/l)	1200	5	**112**	75	96	55
Total Suspended Solids (mg/l)	90	2	**12.2**	3.25	7.75	30
Ammonia Nitrogen (mg/l)	0.49	0.01	**0.07**	0.02	0.09	56
Nitrite Nitrogen (mg/l)	0.02	0.02	**0.02**	0.02	0.02	20
Nitrate Nitrogen (mg/l)	0.42	0.01	**0.08**	0.01	0.07	20
Kjeldahl Nitrogen (mg/l)	2.60	0.08	**0.96**	0.58	1.05	51
Total Phosphorus	0.82	0.01	**0.11**	0.05	0.10	56
Ortho-Phosphorus (mg/l)	0.03	0.01	**0.01**	0.01	0.02	21
Total Organic Carbon (mg/l)	20.6	6.0	**11.1**	8.2	12.0	51
Fecal Coliform (cfu/100ml)	130	0	**28**	1	32	20
Dissolved Calcium (mg/l)	8.7	2.1	**5.4**	4.6	6.0	7
Chloride (mg/l)	25.4	5.7	**12.5**	10.0	14.4	52
Sulfate (mg/l)	359.0	0.5	**18.8**	8.0	15.9	52

Table 4 – 11b
Tributaries – Segments 401 and 402

Parameter	Max	Min	Mean	Q25	Q75	n
Temperature (C)	28.6	13.9	**21.6**	15.5	27.4	15
Secchi Depth (m)	0.74	0.21	**0.46**	0.33	0.58	15
Specific Conductance (*um*hos)	420	66	**172**	86	265	15
Oxygen, dissolved (mg/l)	11.0	0.6	**6.8**	3.4	9.6	15
pH	7.0	5.7	**6.3**	6.0	6.7	15
Alkalinity, Total (mg/l)	84.0	9.0	**37.8**	17.3	56.0	15
Chlorophyll-*a* (ug/l)	61.0	1.0	**12.5**	1.0	10.8	16
Pheophytin-*a* (ug/l)	5.2	1.0	**1.5**	1.0	1.0	16
Hardness, dissolved (mg/l)	92	16	**49**	26	85	15
Total Dissolved Solids (mg/l)	222	74	**125**	85	185	15
Total Suspended Solids (mg/l)	50	4	**14**	6	19	15
Ammonia Nitrogen (mg/l)	0.49	0.03	**0.13**	0.06	15.2	15
Nitrite Nitrogen (mg/l)	0.79	0.01	**0.11**	0.01	0.06	10

Table 4 – 11b (Continued)						
Nitrate Nitrogen (mg/l)	0.02	0.02	**0.02**	0.02	0.02	10
Kjeldahl Nitrogen (mg/l)	6.70	0.19	**1.38**	0.59	1.45	15
Total Phosphorus	0.46	0.05	**0.14**	0.05	0.13	15
Ortho-Phosphorus (mg/l)	0.02	0.01	**0.01**	0.01	0.02	15
Total Organic Carbon (mg/l)	29.2	1.9	**10.5**	6.7	14.0	15
Fecal Coliform (cfu/100ml)	---	---	**---**	**---**	---	---
Dissolved Calcium (mg/l)	16.8	3.8	**8.6**	4.5	11.0	3
Chloride (mg/l)	35.8	6.9	**17.3**	9.4	27.4	15
Sulfate (mg/l)	43.1	0.8	**12.4**	2.0	14.4	15

Table 4 – 11c
Segment 402 – Big Cypress Creek

Parameter	**Max**	**Min**	**Mean**	**Q25**	**Q75**	**n**
Temperature (C)	32.0	8.4	**21.8**	17.2	27.8	30
Secchi Depth (m)	1.29	45.00	**0.90**	0.80	1.04	19
Specific Conductance (*um*hos)	156	72	**108**	94	122	24
Oxygen, dissolved (mg/l)	11.6	2.0	**6.8**	5.6	8.0	23
pH	7.1	5.5	**6.3**	6.0	6.6	24
Alkalinity, Total (mg/l)	20.0	6.0	**13.0**	10.0	16.0	23
Chlorophyll-*a* (ug/l)	21.0	0.5	**6.8**	1.0	9.7	22
Pheophytin-*a* (ug/l)	---	---	**---**	---	---	---
Hardness, dissolved (mg/l)	38	24	**29**	27	31	10
Total Dissolved Solids (mg/l)	185	45	**91**	77	97	22
Total Suspended Solids (mg/l)	15	3	**6**	3	7	22
Ammonia Nitrogen (mg/l)	0.36	0.01	**0.08**	0.01	0.11	23
Nitrite Nitrogen (mg/l)	0.02	0.02	**0.02**	0.02	0.02	10
Nitrate Nitrogen (mg/l)	0.20	0.01	**0.08**	0.01	0.15	10
Kjeldahl Nitrogen (mg/l)	1.70	0.33	**0.84**	0.57	0.98	22
Total Phosphorus	0.56	0.01	**0.12**	0.06	0.12	21
Ortho-Phosphorus (mg/l)	0.06	0.01	**0.02**	0.01	0.02	13
Total Organic Carbon (mg/l)	28.4	0.5	**9.9**	6.7	11.0	23
Fecal Coliform (cfu/100ml)	960	15	**112**	20	60	12
Dissolved Calcium (mg/l)	6.7	5.4	**5.9**	5.6	6.0	4
Chloride (mg/l)	14.6	7.9	**11.4**	9.1	13.2	23
Sulfate (mg/l)	24.2	8.0	**15.6**	13.0	17.8	23

during July-August, 1996 was also evident in Caddo Lake and also affected pH and TKN values (Figures 4-15 - 4-17).

Data screening results for the Caddo Lake subwatershed are presented in Table 4-12. The concerns and possible concerns revealed in this screening are summarized in Table 4-13. Note that column four in this table (Tributaries, 0402) refers to station 16253, on Haggerty Creek which was evaluated with station 10245 on Black Cypress Creek (Table 4-4).

The occurrence of episodes of low dissolved oxygen concentrations, particularly under summer conditions, is a concern or possible concern in all the components of the Caddo Lake subwatershed. Inspection of the data indicates that dissolved oxygen problems are more frequent and more severe in cove and shallow water situations (for example, compare Figures 4-14, 4-15, and 4-16).

The occurrence of pH measurements outside the criteria ranges (the segment standards) is a possible concern at Caddo Lake and Big Cypress Creek stations, but not in the tributaries of either segment. Also of concern only in Caddo Lake are excessive levels of TDS, which averaged more than the segment standard of 100 mg/l at stations 10294 (Carter Lake) and 10286 (Harrison Creek cove). A single value of 1200 mg/l measured at station 10294 in March, 1997 resulted in the segment mean of 112 mg/l.

Concerns for excessive nitrogen and possible concerns for total phosphorus concentrations in Caddo Lake resulted from exceedances of the criteria that all occurred in the most recent data set (1998 and 1999). The fewest exceedances of nutrient and chlorophyll *a* criteria occurred at station 10294, Carter Lake, and the high levels of chlorophyll *a* in Caddo Lake were all associated with the blooms discussed above.

Of the stations in Segment 0402, station 15022 at Caddo Lake State Park was evaluated as a reservoir station as it is within the ordinary Caddo Lake backwater. As a result, two ammonia nitrogen exceedances in five samples were observed, instead of the one in five that would have resulted from comparison with the stream criteria. Had the remaining stations been screened using the reservoir nutrient criteria, only two additional ammonia nitrogen exceedances would have been observed. With respect to possible concerns for total phosphorus concentrations in Big Cypress Creek, station 10295 which is located immediately below Lake O' the Pines Dam, exhibited the least quantities of total phosphorus (average 0.06 mg/l), while all the other stations exhibited rather high phosphorus concentrations, averaging 0.16 – 0.22 mg/l.

With respect to dissolved metals, both copper and lead exceedances (acute copper-PC, chronic copper and lead-C) were detected in Caddo Lake at the two stations located near the dam, while lead was also present in concentrations exceeding the chronic criterion at station 15275 (Goose Prairie). Mercury concentrations in excess of the Fish Consumption and Human Health Criterion were also observed at the latter station.

Metals in sediments were sampled on various schedules. Barium, cadmium, manganese, nickel, silver, and zinc were all sampled for repeatedly at station 10294 during the three-year period 1996 – 1998, while the remaining Caddo Lake stations have been sampled for those parameters

Table 4 –12a

Results of Data Screening: Caddo Lake, Segment 401-S

Code	Parameter	n	Mean	Criterion	Exceeds	%
Segment and Aquatic Life Standards					**Criterion**	**Exceeding**
00300	Dissolved Oxygen (mg/l)	82	5.96	5.00	29	35
00400	pH	82	6.47	6.0-8.5	13	16
00010	Temperature (C)	105	19.17	32.19	1	1
70300	Total Dissolved Solids (mg/l)	55	111.65	100.00	YES	---
Toxic Materials in Water (Acute)						
01040	Copper (d) (ug/l)	10	4.92	4.80	2	20
Toxic Materials in Water (Chronic)						
01040	Copper (d) (ug/l)	1	24.40	3.60	14236	---
01049	Lead (d) (ug/l)	3	1.21	0.49	10286	---
		3	1.51	0.49	14236	---
		2	0.62	0.49	15275	---
Fish Consumption and Human Health						
71900	Mercury (ug/l)	2	0.080	0.0122	15275	---
Nutrients and Chlorophyll *a*						
00610	Ammonia Nitrogen (mg/l)	56	0.07	0.13	15	27
00665	Total Phosphorus (mg/l)	56	0.11	0.20	8	14
32211	Chlorophyll *a* (ug/l)	54	13.74	20.00	11	20
Sediment Toxicants						
01008	Barium (mg/kg)	15	290.13	287.00	8	53
01028	Cadmium (mg/kg)	15	1.40	2.000	3	20
01053	Manganese (mg/kg)	15	1125.80	1210.00	8	53
71921	Mercury (mg/kg)	32	0.350	0.16	25	78
01068	Nickel (mg/kg)	15	26.93	25.20	9	60
01148	Selenium (mg/kg)	32	1.91	1.73	11	34
01078	Silver (mg/kg)	15	0.908	1.60	2	13
01093	Zinc (mg/kg)	15	166.19	120.00	11	73

Table 4-12b

Results of Data Screening: Segment 401-Tributaries Harrison and Kitchens Creeks

Code	Parameter	n	Mean	Criterion	Exceeds	%
Segment and Aquatic Life Standards					**Criterion**	**Exceeding**
300	Dissolved Oxygen (mg/l)	10	6.96	5.00	3	30
Toxic materials in Water (Acute)						
01049	Lead (d) (ug/l)	1	1.14	0.49	14998	---
Nutrients and Chlorophyll *a*						
00610	Ammonia Nitrogen (mg/l)	10	0.14	0.30	1	10
32211	Chlorophyll *a* (ug/l)	10	12.22	16.50	2	20

Table 4-12b (Continued)						
Sediment Toxicants						
01028	Cadmium (mg/kg)	2	0.65	1.02	1	50
01053	Manganese (mg/kg)	2	385.50	490.00	1	50
71921	Mercury (mg/kg)	2	0.220	0.12	1	50

Table 4-12c
Results of Data Screening: Big Cypress Creek, Segment 402-S

Code	**Parameter**	**n**	**Mean**	**Criterion**	**Exceeds**	**%**
Segment and Aquatic Life Standards					**Criterion**	**Exceeding**
00300	Dissolved Oxygen (mg/l)	29	7.12	5.00	5	17
00400	pH	30	6.36	6.0-8.5	5	17
31616	Fecal Coliform (#/ml)	16	117.30	400.00	2	13
Toxic materials in Water (Acute)						
01040	Copper (d) (ug/l)	8	2.21	4.80	1	13
Toxic materials in Water (Chronic)						
					Station	
01040	Copper (d) (ug/l)	4	3.80	3.60	16254	---
Fish Consumption and Human Health					---	---
71900	Mercury (ug/l)	1	0.16	0.0122	10295	---
		4	0.02	0.0122	15511	---
Nutrients and Chlorophyll *a*	Station					
00610	Ammonia Nitrogen (mg/l) 15022	5	0.15	0.13	2	40
00665	Total Phosphorus (mg/l) 15022	5	0.22	0.20	1	20
Sediment Toxicants						
01028	Cadmium (mg/kg)	1	2.90	2.00	1	100

Table 4-13

The following parameters are those which express concern or potential concern within the watershed: (* represents at least nine samples in five years).

	Segment 0402	Segment 0401	Tributaries, 0401	Tributaries, 0402
Dissolved Oxygen	PC*	C*	C*	PC*
pH	PC*	PC*	---	---
Fecal Coliform	---	---	---	PC
Total Dissolved Solids	---	C*	---	---
Dissolved Copper (acute)	PC	PC*	---	---
Dissolved Cadmium (chronic)	---	---	---	C
Dissolved Copper (chronic)	C	C*	---	C
Dissolved Lead (chronic)	---	C*	C	---
Dissolved Lead (human health)	---	C*	---	---
Dissolved Mercury (human health)	C*	---	---	---
Ammonia Nitrogen	C*	C*	---	---
Total Phosphorus	PC*	PC*	---	---
Chlorophyll *a*	---	PC*	PC*	---
Total Barium (Sediment)	---	C*	---	---
Total Cadmium (Sediment)	C	PC*	C	C
Total Manganese (Sediment)	---	C*	C	---
Total Mercury (Sediment)	---	C*	C	---
Total Nickel (Sediment)	---	C*	---	---
Total Selenium (Sediment)	---	C*	---	---
Total Silver (Sediment)	---	PC*	---	---
Total Zinc (Sediment)	---	C*	---	---

only once, during October, 1998. Barium, manganese, nickel, and zinc were consistently found to exceed the criteria for sediments at station 10294 in Carter Lake, while nickel and zinc exceedances were also detected at station 14236 near the dam. Mercury and selenium were sampled far more extensively, with only one sample representing station 15275. Substantial exceedances of the sediment criterion for mercury were observed at all the Caddo Lake stations. The data for selenium and silver is somewhat unusual in that the results are all reported as either non-detects or as exceedances, and all stations except 15275 exhibited at least one selenium exceedance.

Metals have been sampled for once in the two tributary streams to Caddo Lake. The dissolved lead acute criterion exceedance occurred at station 14998 (Kitchens Creek), while the metal concentrations exceeding sediment criteria occurred at station 15507, Harrison Creek.

The Caddo Lake organic contaminant study was designed as a preliminary survey of Caddo Lake to assess the presence of specific organic compounds in waters and sediment adjacent to the Longhorn Army Ammunition Plant (LHAAP). The U.S. Army Corps of Engineers has identified four drainages that cross the LHAAP, two, Harrison Bayou and Goose Prairie Creek, being significantly contaminated with these compounds. Four stations were sampled within Caddo

Lake, two at Harrison Bayou and two at Goose Prairie Creek, during the summer of 1998. A total of eight water samples and four sediment samples were taken and analyzed for ten organic contaminants listed in the USACE report. The lab results from both the water and sediment samples indicated that all ten tested contaminants were below the minimum analytical detection limits. The report recommended further organic studies within Caddo Lake surrounding the LHAAP. As a part of further studies concerning organic contamination within Caddo Lake, TNRCC has initiated an intensive study to test for ammonium perchlorate within Caddo Lake near the LHAAP. This study will be performed by the TNRCC Region 5 staff and should begin in late 1999. The Quality Assurance Project Plan and final report may be accessed through the Cypress Creek Basin webpage.

---

[1] Brad Keller and Herald Banner Staff. 1999. Water groups move ahead to secure plans. May 1999.
[2] Glenn Evans. 1998. Cypress Basin group gets look at water study, early results show no threats to aquatic life. Longview Journal, News. September 6, 1999.
[3] 1999. Poultry Operations Study, Report to the 76th Session of the Texas Legislature, Publication #SFR-65. TNRCC, Office of Water Resource Management. Austin, Texas.
[4]1999. Targeted Monitoring in the Cypress Basin: Study of Contaminants at Caddo Lake Associated with the Longhorn Army Ammunition Plant. Submitted to TNRCC, Austin, Texas by Northeast Texas Municipal Water District, Hughes Springs, Texas.
[5]1998. Hughes Springs Receiving Water Assessment. Submitted to TNRCC Field Operations Division by TNRCC Region 5, June 8, 1998.
[6] ftp://ftp.tnrcc.state.tx.us/pub/AdministrativeServices/InformationResources/Ge…/suprfund.e00 10/18/1999.
[7] Targeted Monitoring in the Cypress Basin: Nutrient Study in Lake O' the Pines. Draft Report submitted to TNRCC October, 1999 by Northeast Texas Municipal Water District and Paul Price Associates, Inc., Austin, Texas.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Preliminary Basin Action Plan

A Preliminary Basin Action Plan has been developed for the Cypress Creek Basin Clean Rivers Program by incorporating information provided by the Clean Water Act Section 303(d) list, observations made as part of the current CRP monitoring programs, and through coordination with the Cypress Creek Basin CRP steering committee. Table 5-1 summarizes significant water quality issues in the Cypress Creek Basin, lists the monitoring or remediation actions now ongoing or planned for the immediate future, and identifies their respective funding sources and participants.

The monitoring activities presently conducted by TNRCC and Cypress Creek Basin CRP were scheduled in a comprehensive 5-year plan to provide additional data to support the TMDL program that was initiated in Fiscal Year 1998. In addition to data collected in Fixed and Systematic sampling programs during the past five years, several Special Studies have been completed (or currently being performed) by TNRCC and the Cypress Creek Basin CRP. Actions taken to date include routine and intensive monitoring of Caddo Lake, a Poultry Operations Study to assess the existing and potential water quality impacts of the poultry production industry, intensive surveys of Big Cypress Creek during summer low flow periods, and additional nutrient and dissolved oxygen sampling in Lake O' the Pines. Personnel from TNRCC, NETMWD, and Caddo Lake Institute have conducted all these studies. Additional monitoring at the four downstream stations sampled during the Poultry Operations Study, plus a station established to monitor newly constructed facilities will be conducted during FY 2000.

During 1999, an agreement between the Northeast Texas Municipal Water District and Pilgrim's Pride Corporation was signed that will allow inspection/monitoring and complaint response system for poultry operations within the Cypress Creek Basin. In addition, the Pilgrim's Pride Corporation has initiated a Best Management Practices program for its corporate and contract operations.

Segments exhibiting problems considered to be less serious or less urgent (402, 405, 406, 407, 408, and 409) are being monitored through TNRCC and Cypress Basin CRP routine and intensive monitoring programs. These segments will be monitored through the five-year cycle initiated by the Cypress Creek Basin CRP Steering Committee during the 1998 fiscal year.

5.2 Conclusions

Water quality problems in the Cypress Creek Basin tend to be concentrated on the main stem of Big Cypress Creek, particularly in the two reservoirs, Lake O' the Pines and Caddo Lake that intercept drainage from the most developed (including industry, poultry production, and urban concentrations) areas in the watershed. With respect to toxic materials in water and sediments, metals seem to be the only potential problems indicated. Since the 1996 data screening, concerns over metals in the water column has abated substantially, with metals in sediments becoming the most prevalent toxic concerns, particularly in Lake O' the Pines and Caddo Lake. However, at most sampling locations, only one or a very few metals samples have been

collected, and some of the results (e.g., cadmium) may be an artifact of insufficient sensitivity and discrimination in the analytical techniques. It is evident that in the Cypress Creek Basin we are still in the process of defining the severity and extent of the problem.

In contrast to the toxicants, concerns over low dissolved oxygen concentrations, excessive nutrient levels, and other factors related to the biological functions of these water bodies expressed as a result of the 1996 data screening continues to be a concern in at least local areas of all the major subwatersheds of the Cypress Creek Basin. Excessive quantities of phosphorus, and possibly nitrogen are commonly found throughout the basin. The lower portions of Little Cypress Creek and Segment 0402 of Big Cypress Creek experience regular summer episodes of dissolved oxygen depletion. Conditions in Caddo Lake with respect to levels of nutrients, chlorophyll *a*, and dissolved oxygen, indicate that it is exhibiting evidence of more advanced eutrophication than the other main stem reservoirs in the basin.

5.3 Recommendations

The preliminary Basin Action Plan should be evaluated in the light of the findings of this report. In particular, we may consider the necessity to employ somewhat different analytical techniques where (for example) metal sampling does not seem to produce consistent results. More focus should be put onto investigations of the metal occurrences, to determine their distributions and to begin to make some progress towards identifying the sources of the problems delineated.

A Total Maximum Daily Load (TMDL) program has been initiated in the Lake O' the Pines watershed (corresponding to the Big Cypress Creek subwatershed of this report) to address low dissolved oxygen and nutrient issues. Although not cited on the state's 303(d) list for dissolved oxygen, nutrients, or other parameters related to eutrophication, data collected during the past five years indicates that the shallower portions (primarily) of Caddo Lake exhibit repeated episodes of depressed pH and dissolved oxygen, elevated nutrient and chlorophyll α concentrations, and the presence of toxic metals in water and fish tissue samples. These phenomena are all driven by biological activity in the water and sediments, and to address the impairments resulting from them will likely require consideration of the ongoing eutrophication of Caddo Lake. We anticipate that the TMDL process, and specifically experience and insight gained during the Lake O' the Pines watershed TMDL, will serve as the primary guidance for water quality management in the Caddo Lake watershed

Table 5-1.

Preliminary Basin Action Plan for Cypress Creek Basin During FY 2000.

Watershed Waterbody	Impaired Use	Cause	Potential Source	Actions Taken	Recommended Action	Rank	Funding Source	Active Participants
Caddo Lake Watershed (Segment 0401)								
Caddo Lake	Fish Consumption	Mercury in Tissue	Atmospheric Deposition	Monitoring by TNRCC	Fish tissue sampling once during FY 2000 by TNRCC in Caddo Lake at Station 14236	M	Clean Rivers Program, TNRCC, and Caddo Lake Institute	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Caddo Lake	General Water Quality Uses	Periodic exceedance in pH and Temperature Criterion	Non-point source -natural occurrence	Fixed and Systematic Monitoring by TNRCC, CRP, and CLI	Continued Monitoring by CRP and TNRCC.	L	Clean Rivers Program, TNRCC, and Caddo Lake Institute	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Caddo Lake	Aquatic Life	Dissolved Zinc in Middle Portion of Lake	Non-point source -natural occurrence and Possibly Longhorn Army Ammunition Plant	Fixed and Systematic Monitoring by TNRCC, CRP, and CLI	Continued Monitoring by CRP and TNRCC.	M	Clean Rivers Program, TNRCC, and Caddo Lake Institute	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Caddo Lake	Aquatic Life	Total Mercury Occasionally Exceeds Criterion in Upper End of Lake	Atmospheric Deposition and Possibly Longhorn Army Ammunition Plant	Fixed and Systematic Monitoring by TNRCC, CRP, and CLI	Continued Monitoring by CRP and TNRCC.	L	Clean Rivers Program, TNRCC, and Caddo Lake Institute	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Harrison Bayou	Aquatic Life and General Water Quality Conditions	Organic Pollutants	Longhorn Army Ammunition Plant	Clean Rivers Program Special Study	TNRCC has initiated Continued Monitoring for ammonium perchlorate within Caddo Lake near	H	Clean Rivers Program, TNRCC, and Caddo Lake Institute	Clean Rivers Program, TNRCC, and Caddo Lake Institute

				During FY 1999	Harrison Bayou Bay			
Goose Prairie Creek	Aquatic Life and General Water Quality Conditions	Organic Pollutants	Longhorn Army Ammunition Plant	Clean Rivers Program Special Study During FY 1999	TNRCC has initiated Continued Monitoring for ammonium perchlorate within Caddo Lake near Goose Prairie Bay	H	Clean Rivers Program, TNRCC, and Caddo Lake Institute	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Big Cypress Creek Between Lake O' the Pines and Caddo Lake (Segment 0402)								
Big Cypress Creek	Fish Consumption	Mercury in Tissue	Non-point sources	Fixed Station Monitoring by TNRCC, CRP, and the City of Marshall	Monitoring through TNRCC and CRP Fixed, Systematic monitoring, and Special studies	M	Clean Rivers Program, TNRCC, Caddo Lake Institute, and the City of Marshall	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Lake O' the Pines (Segment 0403)								
Lake O' the Pines	Aquatic Life	Dissolved Zinc and Dissolved Oxygen	Non-point sources -Poultry operations Point source -9 WWTP Permits watershed	Fixed, Systematic, and Special studies performed within segment 0403	Continued Monitoring through Fixed and Systematic stations as well as continuation of TMDL study	U	EPA, TNRCC, and Clean Rivers Program	Clean Rivers Program, TNRCC, and Caddo Lake Institute
Big Cypress Creek Below Lake Bob Sandlin (Segment 0404)								
Welsh Reservoir	Fish Consumption	Selenium in Fish Tissue	Water used for cooling at power plant	TMDL underway	Monitoring of selenium in fish tissue under the TMDL study	H/U	EPA, TNRCC, and Clean Rivers Program	TNRCC and Clean Rivers Program
Big Cypress Creek Below Bob Sandlin (Including tributaries Tankersley Creek, Hart Creek,	Aquatic Life Use	Intermittent but Chronic Low Dissolved Oxygen	Non-point sources - natural occurrence -Poultry operations in	Fixed, Systematic, and Special studies performed within	Development of a TMDL program to determine the nutrient loading from point and non-point sources within the watershed.	H/U	EPA, TNRCC, Clean Rivers Program, and Pilgrim's Pride Corporation	TNRCC, Clean Rivers Program, and Pilgrim's Pride Corporation

Swuanano Creek, Boggy Creek, Walker Creek, Dry Creek, Greasy Creek, Prairie Creek)			upper basin -Leaking septic systems in watershed Point source - 5 WWTP Permits in Segment 0404 watershed	segment 0404 watershed Also, a TMDL has been initiated within the watershed	Agreement between NETMWD and Pilgrim's Pride Corporation to monitor poultry production and litter disposal within the watershed. FY 2000 Special Study sampling to continue the lower-most stations sampled during the TNRCC Poultry Operations Study.			

Watershed Waterbody	Impaired Use	Cause	Potential Source	Actions Taken	Recommended Action	Rank	Funding Source	Active Participants
Big Cypress Creek	Aquatic Life Use	TPWD Reported Lack of Mussels in Segment 404	Point and Non-point sources and Altered flow regime	Fixed and Systematic monitoring. Regular monitoring has found some mussels within this segment.	Monitoring through CRP and TMDL programs. Possible mussel study associated with the TMDL program.	M	EPA, TNRCC, and Clean Rivers Program	TNRCC and Clean Rivers Program
Lake Cypress Springs (Segment 0405)								
Lake Cypress Springs	Aquatic Vegetation	Nutrients	Non-point Sources -Leaking septic systems	Fixed station Monitoring by TNRCC and CRP. Monitoring by Franklin County Water District	Continued Monitoring through Fixed and Systematic stations. Franklin County Water District Monitoring	L	TNRCC, Clean Rivers Program, and Franklin County Water District	TNRCC, Clean Rivers Program, and Franklin County Water District
Lake Cypress Springs	General Water Quality Conditions	Fecal Coliform and MTBE*	Non-point Sources -Leaking septic systems and gasoline additives	Franklin County Water District has tested for both with negative results	Continued Monitoring through Fixed and Systematic stations. Franklin County Water District Monitoring	L	TNRCC, Clean Rivers Program, and Franklin County Water District	TNRCC, Clean Rivers Program, and Franklin County Water District

* Methyl Tertiary Butyl Ether (MTBE) is a concern throughout the entire Cypress Creek Basin as discussed by the steering committee. The Franklin County Water District has tested for this substance in Lake Cypress Springs with negative results.

Watershed Waterbody	Impaired Use	Cause	Potential Source	Actions Taken	Recommended Action	Rank	Funding Source	Active Participants
Black Bayou (Segment 0406)								
Black Bayou	Aquatic Life Use	Low Dissolved Oxygen	Natural Occurrence	Fixed station monitoring under CRP. Systematic station monitoring during FY 2000	Continued monitoring through CRP and TNRCC Fixed and Systematic station monitoring.	L	TNRCC and Clean Rivers Program	TNRCC and Clean Rivers Program
James Bayou (Segment 0407)								
James Bayou	Aquatic Life Use	Low Dissolved Oxygen	Natural Occurrence	CRP Fixed station Monitoring	Continued monitoring through CRP Fixed station monitoring.	L	Clean Rivers Program	Clean Rivers Program
Little Cypress Creek (Segment 0409)								
Little Cypress Creek	Aquatic Life Use	Dissolved Cadmium and Lead in Lower 25 miles of creek sometimes exceed criteria	Non-point source	CRP Fixed station monitoring. Systematic station monitoring during FY 2000	Continued monitoring through Fixed and Systematic station sampling.	M	TNRCC and Clean Rivers Program	TNRCC and Clean Rivers Program

APPENDICES