

CYPRESS CREEK BASIN HIGHLIGHTS REPORT

Texas Clean Rivers Program



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This report was prepared by Water Monitoring Solutions, Inc. for the Northeast Texas Municipal Water District in cooperation with the Texas Commission on Environmental Quality Clean Rivers Program.

EXECUTIVE SUMMARY

The Clean Rivers Program (CRP) was created by the Texas Legislature in 1991 under the Texas Clean Rivers Act. The Clean Rivers Program (CRP) is a water quality monitoring, reporting, planning and coordinating program administered by the Texas Commission on Environmental Quality (TCEQ) and funded by state collected fees. The Northeast Texas Municipal Water District (NETMWD) coordinates the CRP for the Cypress Creek Basin.

The Basin Highlights Report is required under the CRP to provide a concise overview of water quality conditions and issues throughout the Cypress Creek Basin for years between publications of the Basin Summary Report. As a participant in the CRP, the NETMWD submits the Cypress Creek Basin Highlights Report to the TCEQ. This report is used to assist the TCEQ and CRP partners to develop and prioritize programs that will:

- Protect the quality of healthy waterbodies and
- Improve the quality of impaired waterbodies

Under the CRP, biologists and field staff collect surface water samples and field parameters, conduct special projects, and measure flow at sites throughout the Cypress Creek Basin. Other entities participating in the Cypress Creek Basin CRP include the following:

- Caddo Lake Institute
- Pilgrim's Pride Corporation
- Texas Parks and Wildlife Department
- East Texas Baptist University
- U.S. Steel Tubular Products, Inc.
- AEP SWEPCO
- City of Longview
- Northeast Texas Community College
- Titus Co. Fresh Water Supply District #1
- United States Geological Survey
- Franklin County Water District
- City of Marshall
- Luminant
- Texas Forest Services

The majority of this report focuses on the 2014 *Texas Integrated Report of Surface Water Quality* and updates to listings and concerns in the Cypress Creek Basin. Efforts of the stakeholders to combat invasive species are also discussed.

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We would like to thank Tim Bister with the Texas Parks and Wildlife Department for providing information about invasive species and measures being taken to control them in the Cypress Creek Basin.

We also want to recognize Lucas Gregory with Texas A&M Agrilife, Texas Water Resources Institute for writing the Lake O' the Pines National Water Quality Initiative (NWQI) update.

CYPRESS CREEK BASIN

A basin, also called a drainage area, catchment, or watershed, is an area of land that drains its surface and subsurface water to a common point. For the Cypress Creek Basin, that common point is Caddo Lake. All of the land area within the Cypress Creek Basin drains primarily from the northwest to the southeast and eventually feeds into Caddo Lake. Note that before entering Caddo Lake, some surface water first enters from smaller sub-watersheds through tributaries, or streams at the upstream end of the basin. The major tributaries that drain into Caddo Lake include Big Cypress Creek, Little Cypress Creek, James Bayou, Harrison Bayou, Kitchen Creek, and Black Cypress Bayou.

The 6,000 square-mile Cypress Creek watershed extends upstream from Caddo Lake at the Texas-Louisiana state border, to the westernmost extreme of the Cypress Creek Basin, near Winnsboro. This watershed, which includes several reservoirs, originates in the southern part of Hopkins and Franklin counties, and flows south eastwardly into Camp, Titus, Morris, Marion, and Harrison Counties. Big Cypress Creek serves as the boundary line that separates Camp County from Titus and Morris counties, in addition to dividing Upshur from Morris County.

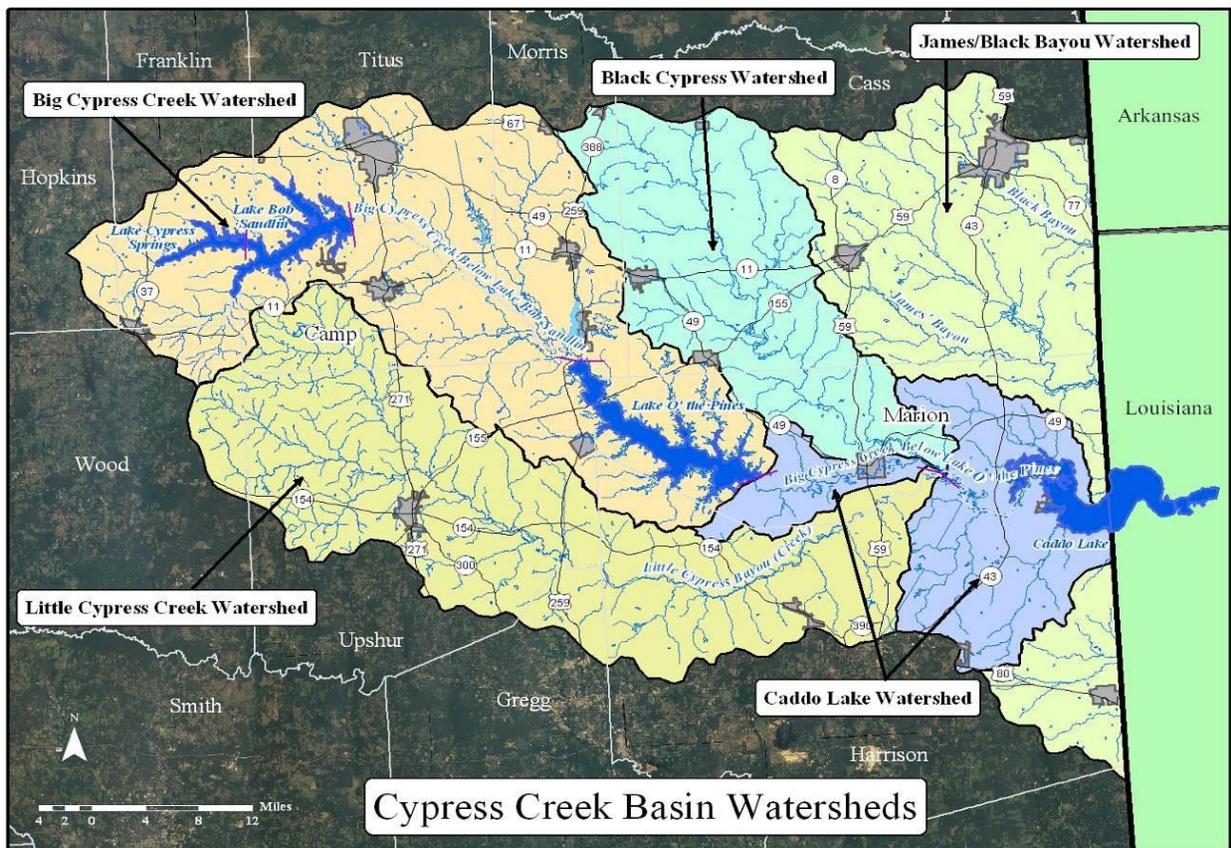


Figure 1: Map of the Cypress Creek Basin Watersheds

The Cypress Creek Basin has a diverse ecology. Big Cypress Creek, above Lake O' the Pines, is intermittent in its headwaters. The stream runs through flat to rolling terrain surfaced by sandy and clay loams that support water-tolerant hardwoods, conifers, and grasses. Big Cypress Bayou flows into Caddo Lake through a jungle-like bottomland where cypress trees are common. The navigable waters of Big Cypress Bayou contributed to the rise of the City of Jefferson as a commercial center prior to the railroads. Between 1842 and 1872, the town was a principal port in Texas, serving as a distribution point for much of North and East Texas. Once the railroads arrived in the early 1870s, river traffic declined. Since World War II, Big Cypress Creek has been dammed to form a series of reservoirs including Lake Cypress Springs, Lake Bob Sandlin, Monticello Reservoir, and Lake O' the Pines.

LAKE O' THE PINES NATIONAL WATER QUALITY INITIATIVE PHASE I UPDATE

In 2014, the Lake O' the Pines National Water Quality Initiative (NWQI) entered Phase 1 of the project managed by Texas A&M Agrilife Research and Texas Water Resources Institute. The goals of the project are to assess water quality improvements resulting from implementation of conservation practices throughout the Lake O' the Pines NWQI. There are 11 sites in the study area (3 sub-basin, 4 farm scale, and 4 field scale) to assess nutrient, sediment, and bacteria impacts resulting from Best Management Practices (BMP) implemented in the watershed. This project is in response to the Lake O' the Pines TMDL Implementation Plan as well as USDA Natural Resources Conservation Service recommendations to help improve water quality in this impaired segment through BMP implementation. The study will focus on three test farms and field plots with one control for each scale. Several nutrient management scenarios that affect nutrient, bacteria, and sediment concentrations in run off as well as runoff volume will be monitored. Currently, the sampling stations are being completed, and data collection will commence in Q2 of FY 2016. The data collected in 2016 will serve as a baseline for the project. The results from this study will not only help those within the Lake O' the Pines and Cypress Creek Basin, but also may assist those in other basins in East Texas.

INVASIVE SPECIES

The effects of invasive species on the water quality and aesthetics of Cypress Creek Basin were the primary topics of presentations and discussion at the 2015 CRP Stakeholder Meeting. Invasive species have been a primary concern for stakeholders over the years, especially in Caddo Lake. Professionals, volunteers, and researchers have worked tirelessly to reduce populations and prevent the spread of invasive species throughout the basin.

WHAT ARE INVASIVE SPECIES?

Non-native plants, animals, and even pathogens can cause drastic changes in existing ecosystems that result in millions of dollars of damage. Once identified as a problem species, the offending organism is labeled as an invasive species. Across the state of Texas, invasive species are a large problem for resource management, including our water resources.

The invasive species that are of the greatest concern in the basin are:

- Giant Salvinia
- Alligatorweed
- Water Hyacinth
- Hydrilla
- Zebra Mussels

Four of the five statewide aquatic invasive species of greatest concern, as determined by the TCEQ, are found within the Cypress Creek basin.

Giant Salvinia (*Salvinia molesta*) forms chains or groups of oblong and flat or semi-cupped leaves connected with a thread-like leaf that hangs under water (Texasinvasives.org). These chains form very dense floating mats that significantly reduce light penetration and oxygen levels in the water. These floating mats can also become a great hindrance for fishing and boating activities.



Figure 2: *Salvinia molesta*
Source: TPWD



Figure 3: *Alternanthera philoxeroides*

Source: <http://aquaplant.tamu.edu/>

Alligatorweed (*Alternanthera philoxeroides*) has been identified in reservoirs in the basin. It is distinguished by its pointed, opposite facing leaves, and small white flowers on short head-like spikes occurring in floating mats. Alligatorweed is a concern because the thick mats it forms crowd out native species of vegetation, slow water flow, lower dissolved oxygen levels, and increase sedimentation (Texasinvasives.org). All of the above can lead to increased flooding during high flow events due to impeded drainage within the basin.



Figure 4: *Eichhornia crassipes*

Source: <http://aquaplant.tamu.edu/>

Water Hyacinth (*Eichhornia crassipes*) is a free-floating plant with wavy, up-pointed leaves, and tall (up to 3 feet) light blue or violet flower spike (aquaplant.tamu.edu). These plants may look beautiful, but if left uncontrolled, can cover the entire surface of a lake leading to decreased oxygen levels that may lead to fish kills. This plant may also impact navigation and fishing activities.

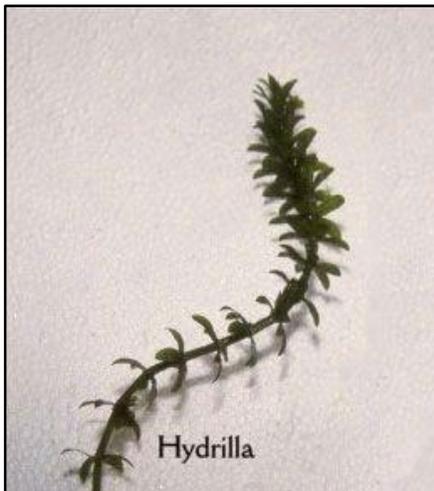


Figure 5: *Hydrilla verticillata*

Source: <http://aquaplant.tamu.edu/>

Hydrilla (*Hydrilla verticillata*) are related to several popular aquarium and nursery plants. Hydrilla forms towering plants under water with opposite facing long narrow leaves. It can grow with surprising speed, up to 1 inch per day, and a total length of 30 feet. This high speed of growth causes intense demand on the aquatic system, raising the pH while lowering the dissolved oxygen concentration of the water. Hydrilla makes good cover for small fish, hence the popularity with aquariums, but can be detrimental to the larger fish and also promotes mosquito habitation.

Zebra mussels (*Dreissena polymorpha*) have not been found in any of the lakes in the Cypress Creek Basin; however, zebra mussel DNA has been detected in both Caddo Lake and Lake Bob Sandlin. Current literature suggests that the chemical makeup of the water in the basin will not sustain large populations of zebra mussels. According to the USGS, these organisms require a minimum of 10 mg/L of calcium for initial shell growth and 25 mg/L for sustainable populations. Zebra mussel larval survival rates are highest in waters with pH 6.6 – 8.5 with optimal growth at 8.4, while adult mortality rates are lowest at pH 7.4 – 8.0.



Figure 6: Colony of Zebra Mussels

The average calcium concentration for reservoirs in the Cypress Creek Basin is 7.0 mg/L while the median pH ranges from 6.6 in Caddo Lake to 7.6 in Lake Bob Sandlin. Based upon historical data, the water quality of reservoirs in the Cypress Creek Basin is likely not conducive to support large populations of zebra mussels. However, it was once widely believed that zebra mussels were limited to the cold waters of northern lakes and would never be a concern in the south. The best course of action is to prevent the introduction of zebra mussels into the Cypress Creek Basin watersheds.

ZEBRA MUSSEL DOGS?

In January 2016, Working Dogs for Conservation (WDC), worked at boat ramps around Texas to detect the presence of zebra mussels on boats and trailers as a trial run for two events in May 2016. In May, WDC made demonstrations at the KYKX Bass Tournament held on Lake O' the Pines and at the Toyota Big Bass Classic on Lake Ray Roberts. At the Toyota Bass Classic, the WDC teams worked at the boat ramps while another team provided public education and demonstrations at



Figure 7: WDC Dog Checks for Zebra Mussels

the Expo in Frisco. Funding for this project is through a U.S. Fish and Wildlife Service grant.

Working Dogs for Conservation is a non-profit organization that trains and uses dogs to detect species of concern all over the world. They are used to detect invasive species, search for State and Federal Threatened and Endangered species in the U.S., and work in many countries in Africa and Asia checking for contraband including ivory and Rhino horn.

WHAT CAN YOU DO?

Water bodies in the Cypress Creek Basin are among the most beautiful in Texas, attracting boaters and recreational users to its reservoirs throughout the year. Unfortunately, boats are one of the most common ways invasive aquatic plants are spread from one reservoir to another. Once an invasive plant enters a new ecosystem that is suitable for its growth, the plant spreads rapidly and out-competes local, native vegetation which can lead to disastrous consequences.

Everyone has the ability to limit or stop the spread of invasive species into watersheds. Under Texas law, owners are required to remove harmful plants and animals from boats, watercraft, and trailers before leaving the vicinity of a waterbody. TPWD provides useful resources on their website with topics ranging from how to properly clean your recreational equipment to a complete list of prohibited aquatic organisms available at:

www.tpwd.texas.gov
and www.texasinvasives.org

ZEBRA MUSSELS

HIDE HERE



**DON'T BE A CARRIER.
TAKE ACTION AND STOP THE SPREAD!**

CLEAN your boat, trailer and gear by removing all plants, animals and foreign objects. Adult zebra mussels attach to any hard surface.

DRAIN all water from the boat, including the motor, bilge, livewells and bait buckets. Zebra mussels' microscopic larvae can hide in the water in your boat.

DRY the boat and trailer for a week or more. If unable to dry it that long, wash it with hot (140-degree), high-pressure, soapy water.

IT'S THE LAW. Boaters are **REQUIRED** to drain all water from their vessel, including live wells, bilges, motors, and any other receptacles or water intake systems before leaving or approaching public waters. This applies to ALL types and sizes of boats.

Possession or transportation of zebra mussels is illegal - The first offense is a class C misdemeanor, punishable with a fine of up to \$500. A second offense is a Class B misdemeanor, punishable with a fine up to \$2,000, a jail sentence of up to 180 days or both.



Zebra mussels hurt aquatic life, damage boats - even affect your water supply. Already in several North and Central Texas lakes, they could spread throughout the state on boats and trailers like yours.



texasinvasives.org/zebramussels

Figure 8: TPWD Boat Inspection Campaign Advertisement

INVASIVE SPECIES CONTROL ACTIVITIES IN 2015

Generally there are three methods of controlling invasive plants: biological, chemical, and mechanical. Biological measures involve the introduction of another species (plant or animal) to act as a controlling species; one example is the use of the Giant Salvinia Weevil to control the spread of Giant Salvinia by eating its leaves. Chemical control involves the use of pesticides or herbicides to kill populations of invasive plants. Mechanical refers to the manual removal of plants/animals using either machines and/or people.

Caddo Lake is the only reservoir in the basin with an established population of Giant Salvinia. Texas Parks and Wildlife Department (TPWD) does a vegetation survey each August on the area reservoirs. Their survey in August 2015 showed 2,850 acres of Giant Salvinia. In response to this problem, TPWD contractors treated 4,200 acres with herbicides in 2015. The Giant Salvinia Weevil has been successful as a bio-control on a number of water bodies in south Louisiana and southeastern Texas. TPWD released over 132,000 adult weevils on Caddo Lake in 2015. The Caddo Biocontrol Alliance (CBA) operates a greenhouse on Caddo Lake, and they have released an additional 129,000 adult weevils to combat this plant. Crested floating heart has also been monitored and effectively treated with herbicides in 2015. Monitoring and control of invasive plants will continue in 2016.

Lake O' the Pines has both Water Hyacinth and Alligatorweed in the upper section of the reservoir, primarily in the reach between U.S. 259 and Highway 155. In 2015, the NETMWD and U. S. Army Corps of Engineers (USACE) combined to treat about 250 acres with herbicides. USACE has also released the Alligatorweed Flea Beetle on some stands of Alligatorweed. The beetle has shown success in retarding the growth of the plant. The USACE is also actively monitoring boat ramps and boat trailers to prevent the introduction of Giant Salvinia.

Lake Bob Sandlin has both Alligatorweed and Hydrilla. Homeowners in some areas, permitted by TPWD, sprayed herbicides in their neighborhoods to treat these species. TPWD worked with the homeowners to ensure that the correct chemicals were applied properly. Additionally, TPWD released Alligatorweed Flea Beetles in the spring of 2015. The Titus County Freshwater District #1 physically removed all visible water hyacinth plants after being alerted of their presence by TPWD in 2015. These efforts to remove water hyacinth will continue into the 2016 growing season as they are observed.

Lake Cypress Springs has successfully eliminated Hydrilla from the reservoir for several years since the introduction of triploid grass carp. Alligatorweed is present and continues to be monitored to prevent the plant from becoming established in the reservoir.



Figure 9: Herbicide Application in Caddo Lake

FISH CONSUMPTION ADVISORIES

The Texas Department of State Health Services monitors fish in the state for the presence of contaminants and alerts the public through bans or advisories when consumption may pose a threat to human health. These warnings are based on the collection and analysis of fish samples for long lasting contaminants found in fish tissue, such as PCBs, pesticides, and/or heavy metals (e.g., mercury). Fish consumption advisories and bans are issued where tissue testing indicates a potential threat to public health. All fish consumption advisories remain in effect until rescinded or modified in writing regardless of the effective date.

Lake Daingerfield

The Texas Department of State Health Services issued a fish consumption advisor in 2002 for Lake Daingerfield due to mercury levels in fish tissue. The consumption advisory is for largemouth bass: adults should limit consumption to no more than 2 8-ounce meals per month, and children should limit consumption to no more than two 4-ounce meals per month. There is no advisory for catfish consumption. The DSHS also continues to monitor mercury levels in fish from Lake Daingerfield.

Caddo Lake and Big Cypress Creek

In 1995, the Texas Department of State Health Services issued a fish consumption advisory for Caddo Lake and Big Cypress Creek in Marion County due to mercury in fish tissue. The consumption advisory is for largemouth bass and freshwater drum: adults should limit consumption to no more than two 8-ounce meals per month, and children should limit to no more than two 4-ounce meals per month for combined both species. This is a Category 5c water body, so additional data are being collected prior to scheduling a TMDL.



Figure 10: Fish Consumption Advisory Sign

Ellison Creek Reservoir

In December, 2005, a fish consumption advisory was issued for all fish species taken from Ellison Creek Reservoir due to high levels of PCBs. The DSHS recommends that no fish should be consumed from this reservoir. A DSHS risk characterization conducted in August 2007 based, were based on ten additional crappie samples obtained in November 2006. The samples yielded the resulting addendum, one half to one meal per week consumption of crappie. The DSHS has decided to maintain the “no consumption advisory for all species of

fish in Ellison Creek Reservoir. Other States with similar results have interpreted data to support a fish consumption advisory of two meals per month for specific fish species.

RECORD RAINFALL IN CYPRESS CREEK BASIN

An important part of the hydrological cycle is precipitation, and 2015 was a landmark year for precipitation and releases from Lake Bob Sandlin. Precipitation records at Ft. Sherman Dam began in 1979 (Figure 11). The 36-year average rainfall at this site was 51.8 inches. In 2015, 74.9 inches of rain was measured, making it the second wettest year during this period of record. The record amount of rainfall led to the first discharges from Lake Bob Sandlin in nearly five years along with the greatest amount of releases on record at 280,283 acre-feet. These releases surpassed the previous record set in 2001 by 23,965 acre-feet.

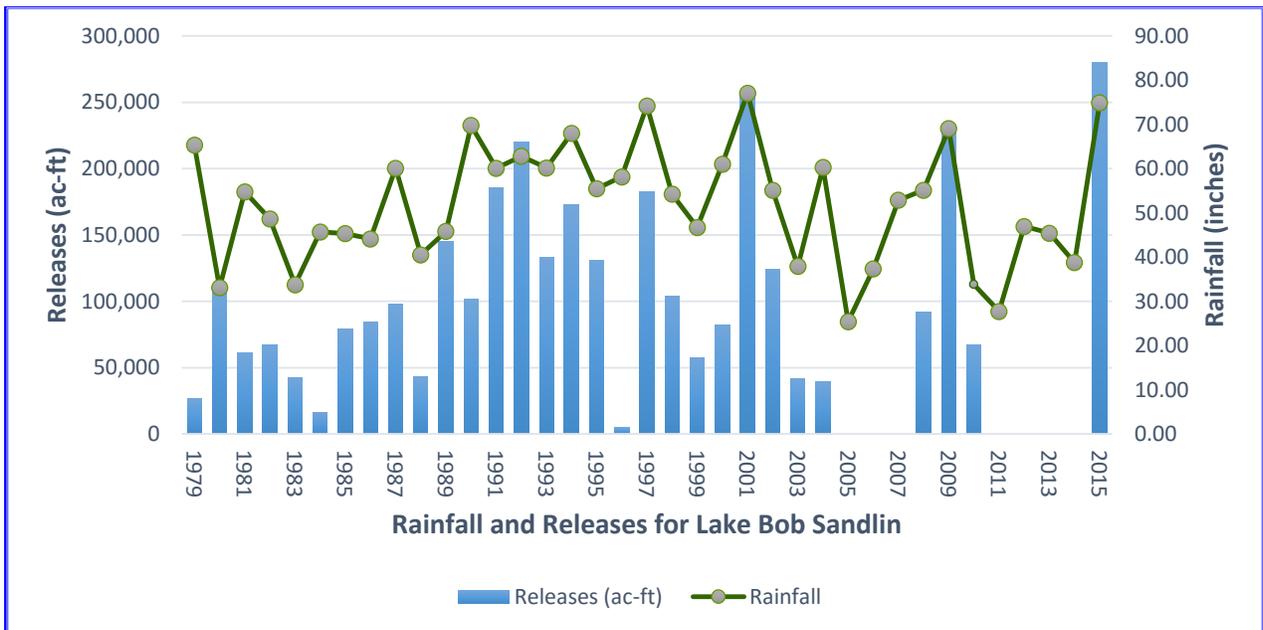


Figure 11: Rainfall and Releases for Lake Bob Sandlin

WATER QUALITY

Monitoring, data collection, and analysis are the basis for maintaining good water quality within the Cypress Creek Basin. These activities are coordinated by the NETMWD through the TCEQ CRP. Other entities participating in monitoring within the Cypress Creek Basin include Water Monitoring Solutions, Inc. (WMS), Caddo Lake Institute (CLI), Franklin County Water District (FCWS), Titus County Freshwater Supply District #1, City of Marshall, Texas Parks and Wildlife Department (TPWD), the Jeffersonian Institute, Northeast Texas Community College, and the United States Geological Survey (USGS).

WATER QUALITY PARAMETERS

Field Parameters generally include those parameters collected using a multi-parameter sonde such as dissolved oxygen, conductivity, pH, and temperature. Stream flow and water transparency are measured while field observations are recorded. Photographic records are maintained for future reference. These data provide information about the physical and chemical water quality characteristics at the site that are used to evaluate water quality.

Dissolved Oxygen (DO) indicates the amount of oxygen available to organisms in the water. Factors such as higher water temperature and the presence of organic materials can reduce the dissolved oxygen concentration. All aerobic aquatic organisms require a minimum dissolved oxygen concentration to survive.

pH is a measure of the acidity or basicity of a solution. Different species of fish can tolerate a variety of pH ranges, but pH levels below 4 (acidity of orange juice) or above 12 (basicity of ammonia) are lethal to all fish.

Conductivity is a measure of the capability of water to pass an electric current which serves as an indicator of the concentration of dissolved ions in the water. The Cypress Creek Basin watersheds tends to have a low conductance, so significant increases in conductivity may serve as an indicator that polluting discharges have entered the water.

Conventional parameters are chemical components in water that typically require laboratory analysis. These parameters generally include nutrients, chlorophyll, solids, hardness, alkalinity, and chlorides.

Nutrients include nitrate, nitrite, ammonia, and phosphorus. High concentrations of nutrients can cause excessive algal growth, taste and odor problems in drinking water, and human health issues. When algae die, bacteria consume oxygen while decomposing organic matter. During this process, oxygen concentrations can decrease below the levels required for fish survival, resulting in the occurrence of fish kills. Elevated ammonia concentrations adversely affect fish and invertebrate reproductive capacity and can become toxic. High levels of nitrates and nitrites can produce Nitrite Toxicity, or “brown blood disease” in fish. This disease reduces the ability of blood to transport oxygen throughout the body. High concentrations of dissolved solids suspended in the water column and may affect the aesthetic quality of the water.

Bacteria - *Escherichia coli* (*E. coli*) are used as an indicator of recent fecal matter contamination and that pathogens dangerous to human beings may potentially be present in the water.

Stream Flow is a measurement of the volume of water flowing through a cross-section of the stream. Flow is reported in cubic-feet per second and is commonly measured in wadeable streams using an acoustic Doppler velocity meter. Flow may also be reported from a nearby USGS gage.

HOW DATA ARE USED

The State of Texas classifies segments into designated “use” categories: Aquatic Life Use, Contact Recreation, Public Water Supply, Fish Consumption, and General Use. A water body may have multiple designated uses. Standards have been established which include criteria to ensure that surface water bodies meet their designated use(s). Water bodies designated for contact recreation have criteria to protect the public from waterborne pathogens. Surface water designated for public water supply have standards to ensure the water body is suitable as a source for public water supply. Similarly, standards assigned for fish consumption are designated to protect the public from consumption of toxins that may be stored in fish tissue. The State has developed physical, chemical, and bacteriological standards and screening levels to determine if a segment meets its designated uses. Below are lists of parameters used to evaluate water quality:

Standards Criteria

Dissolved Oxygen
Temperature
Chloride
pH
Total Dissolved Solids
E. coli

Screening Levels

Ammonia-Nitrogen
Nitrate – Nitrogen
Total Phosphorus
Chlorophyll *a*

Data collected are used to compile the *Texas Integrated Report of Surface Water Quality* (IR). The IR is an evaluation of the quality of surface water throughout Texas. Prepared in even-number years, the report identifies water bodies which do not meet water quality criteria and/or screening levels. The report is a tool used for decision making, planning, reporting, and coordinating monitoring efforts. The *2014 Texas Integrated Report of Surface Water Quality* has been approved by the EPA and can be accessed at:

http://www.tceq.texas.gov/waterquality/assessment/305_303.html.

New listings for the Cypress Creek basin include Segment 0404 for Sulfate; 0405A for depressed Dissolved Oxygen; and 0407 for impaired fish and benthic communities. Bacteria has been removed from the *2014 Texas 303 (d) List* for Segment 0406 Assessment Unit 01; however, bacteria remained on the list for Assessment Unit 02. A complete listing of impairments in the Cypress Creek Basin are shown in Figures 12 and 13.

2014 Texas 303(d) List				
Segment	Parameter	Assessment Unit	Category	Listed
0401	Depressed Dissolved Oxygen	02, 03, 05, 07	5C	2000
	Mercury in Edible Tissue	01, 02, 03, 05, 07	5C	1996
	pH	03	5C	1996
0401A	Depressed Dissolved Oxygen	01	5C	2000
0402	Depressed Dissolved Oxygen	02	5C	2010
	Mercury in Edible Tissue	01, 02, 03, 04	5C	1998
	pH	01	5C	2000
0404	Bacteria	02	5B	2002
	Sulfate	01, 02	5C	2014
0404A	PCB in Edible Tissue	01	5A	2006
	Toxicity in Sediment	01	5C	2006
0404B	Bacteria	01	5B	2000
0404C	Bacteria	01	5B	2006
0404N	Mercury in Edible Tissue	01	5C	2002
0405	pH	02, 03	5C	2012
0405A	Depressed Dissolved Oxygen	01	5C	2014
0406	Bacteria	02	5C	2006
	Depressed Dissolved Oxygen	01, 02	5C	2002
0407	Bacteria	02	5C	2006
	Depressed Dissolved Oxygen	01, 02	5C	2000
	Impaired Fish Community	01	5C	2014
	Impaired Macrobenthic Community	01	5C	2014
	pH	01	5C	2008
0409	Bacteria	02, 04	5C	2006
	Depressed Dissolved Oxygen	01, 02, 03	5C	2000
0409B	Bacteria	01	5C	2006
0402A/ 0410	Copper in water	01, 03	5C	2010
	Depressed Dissolved Oxygen	01, 02, 03, 05	5C	2000
	Mercury in Edible Tissue	03	5C	2000

Figure 12: Table of Impairments from the 2014 Texas Integrated Report for the Cypress Creek Basin

2014 Texas Integrated Report - Table of Concerns										
Segment	Assessment Unit(s)	Bacteria	Benthics	Depressed DO	Metals	Chl. <i>a</i>	NH ₃	NO ₃	Total P	Habitat
0401	01, 03, 05, 07			CS						
0401	01				CS*					
0401	07								CS	
0401A	01	CN								
0402	02			CS						
0402	03		CN							
0402A/0410	05	CN								
0402A/0410	01, 03				CN**					
0402A/0410	03, 04			CS						
0403	02, 03					CS				
0403	04			CS				CS		
0404	01			CN		CS				
0404	02							CS	CS	
0404A	01				CS* ¹					
0404B	01						CS		CS	CS
0404C	01							CS		
0404E	01							CS		
0404J	01			CN						
0404N	01				CS* ²					
0405	02, 03					CS				
0405A	01	CN		CS						
0405B	01									CS
0406	01			CS						
0406	02			CS		CS				
0407	01	CN								CS
0407	02		CN							
0407B	02			CS						
0408C	01									CS
0409	02			CN						

FIGURE 13: Table of Concerns from the 2014 Texas Integrated Report for the Cypress Creek Basin

CN - Concern for near-nonattainment of the TSWQS based on numeric criteria

CS - Concern for water quality based on screening levels

* iron in sediment

*¹ Cd, Fe, Pb, Mn, Ni, Zn in sediment

** copper in water

*² mercury in edible tissue

The following maps show the stations being monitored by the NETMWD and CLI during FY 2016, followed by a map of the TCEQ monitoring stations. These stations were selected to meet data needs through the CRP Coordinated Monitoring process.

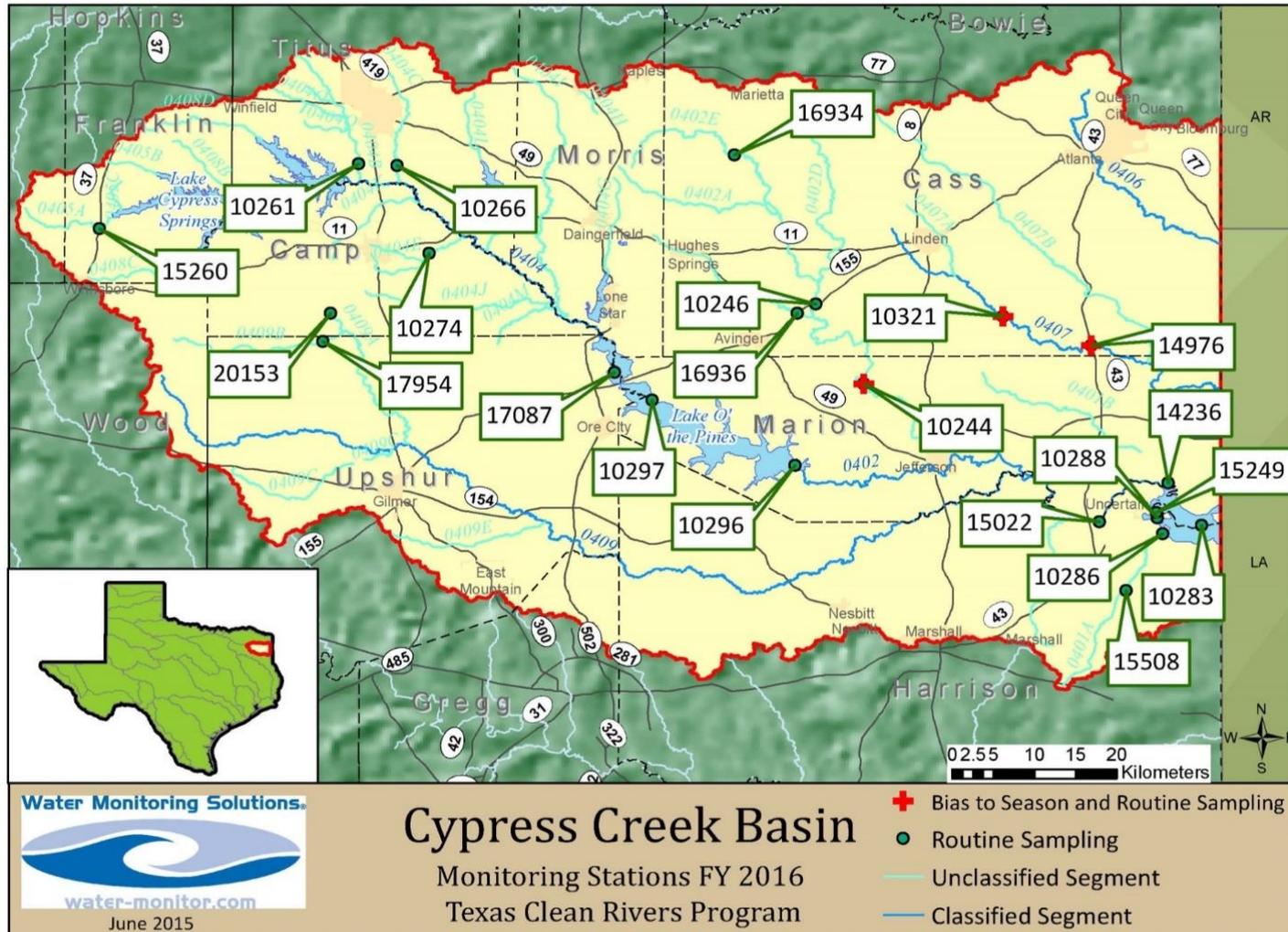


FIGURE 14: Map of the FY 2016 Cypress Creek Clean Rivers Program Monitoring Stations

2016 Cypress Creek Basin Highlights Report

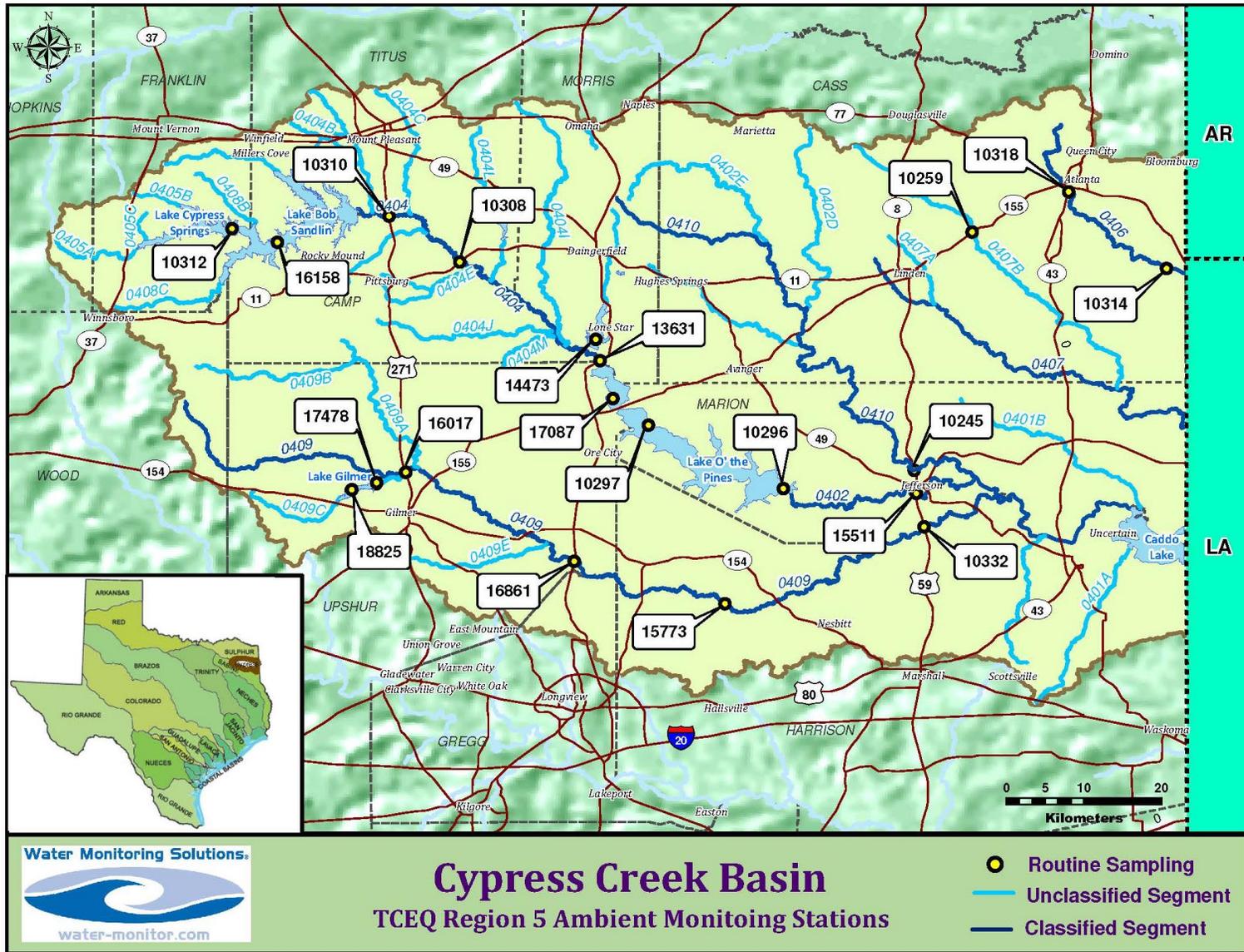


FIGURE 15: Map of the FY 2016 TCEQ Region 5 Ambient Monitoring Stations

ASSESSMENT DISCUSSION

0401 – CADDO LAKE

Caddo Lake is impounded by Caddo Dam in Caddo Parish, Louisiana and extends into Harrison and Marion Counties in Texas. Caddo Lake receives runoff primarily from Little Cypress Creek, Black Cypress Bayou, and Big Cypress Creek watersheds. The Caddo Lake watershed is approximately 330 square miles and includes Caddo Lake and the segment of Big Cypress Creek below Lake O' the Pines Ferrell's Bridge Dam (Segment 0402).



Figure 16: Caddo Lake at the Turtle Shell Station (15249)

This watershed consists

mainly of forested hills with limited urban development. Thought to have been formed behind a log jam in the Red River, Caddo Lake was one of the largest natural lakes in the South before it was dammed in 1914. The upper half of Caddo Lake is shallow and swamp-like and these characteristics have helped to produce a diverse ecosystem.

Caddo Lake remains on the *2014 Texas 303(d) List* for low dissolved oxygen levels and mercury in edible fish tissues throughout the lake, and low pH in the Goose Prairie arm. There are concerns for iron in sediment and total phosphorus. The concern for ammonia from previous years has been removed since laboratory analysis showed low concentrations over the course of several years. Five stations are being monitored in Segment 0401 in FY 2016: 10286, 10288, 14236, 10283, and 15249. CLI monitors these stations monthly for field parameters. Quarterly conventional samples are collected at 10283 and 15249. No metals in sediment sampling is presently scheduled.

0401A – HARRISON BAYOU

Harrison Bayou (Segment 0401A) is a tributary of Caddo Lake. The segment extends parallel to SH 134 and to the Louisiana border. Harrison Bayou remains on the *2014 Texas 303(d) List* for low dissolved oxygen, although it is possibly indicative of natural conditions. Bacteria have been added to the *2014 Texas Integrated Report* as a concern for non-attainment of standards. Station 15508 is sampled quarterly for conventional parameters, field parameters, and bacteria. Bacteria sampling was added in FY 2016 in response to this concern.

0401B – KITCHEN CREEK

Kitchen Creek is an unclassified water body and a tributary of Caddo Lake. The stream crosses SH 49 near Smithland and drains into Clinton Lake east of Goat Island. There were no impairments or concerns for this tributary. Since there are no impairments or concerns, no stations are being monitored in this segment in FY 2016.



Figure 17: Big Cypress Creek at Skeeter's Marina (20635)

0402 - BIG CYPRESS CREEK BELOW LAKE O' THE PINES

This portion of Big Cypress Creek is generally deep, wide, and supports heavy recreational use including boating and camping activities. The Texas Parks and Wildlife Department has placed this segment within the target area for the recovery of the state-threatened paddlefish, and identified an area of over five thousand acres east of the City of Jefferson as containing priority bottomland hardwood forest dominated by cypress-tupelo swamps.

Parameters on the *2014 Texas 303(d) List* include low pH, mercury in edible tissue, and depressed dissolved oxygen. Station 15511 is sampled quarterly by TCEQ Region 5 for conventional, bacteria, field parameters, and flow. CLI monitors monthly for field parameters and flow on Big Cypress Creek at Caddo Lake State Park (Station 15022).

Note: *Black Cypress Bayou (formerly Segment 0402A) is now designated as Segment 0410 and is discussed at the end of this section.*

0402B – 0402E

Segments 0402B – 0402E are tributaries to Black Cypress Bayou and include Hughes Creek (0402B), Haggerty Creek (0402C), Flat Creek (0402D), and Kelley Creek (0402E). No concerns or impairments were shown for these segments. Station 16936 (Hughes Creek at SH 155) and station 16934 (Kelley Creek at FM 250) are being sampled quarterly for field parameters and stream flow. Note that Segment 0402D was not assessed in the *2014 Texas Integrated Report*.

0403 – LAKE O’ THE PINES

Lake O’ the Pines provides water for eight cities and towns, numerous rural water districts, a steel manufacturer, and electricity generators. The reservoir is an important resource to the timber industry as well as to agricultural enterprises such as the poultry, dairy, and cattle operations. Boating and fishing for trophy bass, catfish, and crappie lure large numbers of recreational users to the watershed each year.

Lake O’ the Pines was listed on the *Texas §303(d) List* in 2000 for depressed dissolved oxygen. The TCEQ adopted “*One Total Maximum Daily Load for Dissolved Oxygen in Lake O’ the Pines, Segment 0403*” and the TMDL was approved by the EPA on June 7, 2006. It was determined that the low dissolved oxygen in Lake O’ the Pines resulted from high nutrient levels. Phosphorus was identified as the limiting factor in the reservoir, so the Lake O’ the Pines Implementation Plan (I-Plan) was developed to reduce phosphorus loading into Lake O’ the Pines and was approved on July 9, 2008.

Stakeholder meetings composed of citizens, local, county, and state entities, local industries, etc. were held throughout the project. All milestones were developed by individuals with an interest in improving water quality based on the information available at the time. The I-Plan detailed priority controls in the Lake O’ the Pines watershed that include descriptions of the control measures, responsible parties were identified, and a schedule was created. Also included were the goals to measure, track, evaluate, and report progress. The scope of the I-Plan included an adaptive approach to phosphorus reduction allowing for updates that may later be identified in the project.

Watershed stakeholders specified actions to reduce non-point source contributions, like stormwater runoff. Technical and financial programs were created for agricultural producers; and local/county programs were created for on-site sewage facilities, marine sanitation, and education. Loading from point sources were addressed through the limitation of phosphorus in discharges from wastewater facilities. Phosphorus reduction is being accomplished by using a Total



Figure 18: View from the Dam at Lake O’ the Pines

Phosphorus Load Agreement (TPLA) between NETMWD and the entities who have WWTP outfalls in the Lake O’ the Pines watershed.

Project workgroups, facilitated by Texas A&M AgriLife met in January 2013 at the NETMWD headquarters in Hughes Springs. The groups assessed the I-Plan status as of November 2012. Changes may be proposed based upon feedback from those meetings to ensure project resources remain focused toward improving the water quality in Lake O' the Pines. Sampling in Lake O' the Pines will continue in FY 2016 with four stations monitored quarterly for conventional, bacteria, and field parameters.

0404 – BIG CYPRESS CREEK

Urban populations in this segment include Mount Pleasant, Pittsburg, Daingerfield, and Hughes Springs. A majority of the intensive poultry operations within the Cypress Creek Basin are located within this watershed. Big Cypress Creek drains much of the western Cypress Creek Basin, a predominantly rural watershed of rolling wooded hills. Stream flow in Big Cypress Creek is influenced directly by releases from Lake Bob Sandlin.

Segment 0404 is listed as impaired for bacteria and sulfate. Sulfate was added to the *Texas 303(d) List* in 2014. Concerns for screening levels for chlorophyll *a*, nitrate, and total phosphorus are shown in the IR. TCEQ Region 5 monitors stations 10308 (Big Cypress Creek at SH 11) and 10310 (Big Cypress Creek at US 271) each month for conventional, bacteria, flow, and field parameters. Station 13631 (Big Cypress Creek at US 259) is monitored quarterly for conventional, bacteria, and field parameters.



Figure 19: Big Cypress Creek at SH 11 (10308)

0404A – ELLISON CREEK RESERVOIR

Ellison Creek Reservoir is on the *2014 Texas 303(d) List* for PCBs in fish tissue and sediment toxicity. The Texas Department of State Health Services has issued a fish consumption advisory for PCBs in fish tissue for all species of fish within the reservoir. The *2014 Texas Integrated Report* lists Ellison Reservoir with concerns for screening levels for cadmium, iron, lead, manganese, nickel, and zinc all in sediment. TCEQ Region 5 monitors Station 14473, located at the dam, quarterly for metals in water and field parameters quarterly.

0404B – TANKERSLEY CREEK

Tankersley Creek arises in Titus County northwest of the city of Mount Pleasant. The stream flows in a southeasterly direction for approximated two miles before it enters Tankersley Lake, which impounds Tankersley Creek. Downstream of the impoundment, the stream flows for a distance of about eight miles to the confluence of Tankersley Creek with Big Cypress Creek at the Titus-Camp county line. Tankersley Creek is an unclassified water body in the Cypress Creek Basin and is the major tributary to Big Cypress Creek in the study area.

Tankersley Creek is listed as impaired for bacteria. An intensive bacteria monitoring study was performed in 2009 - 2011 through the *Assessment of Contact Recreation Use Impairments and Watershed Planning for Big Cypress Creek and Tributaries*. For more information, please go to: <http://www.tsswcb.texas.gov/en/managementprogram/bgcybac>.

There are concerns for screening levels for ammonia and total phosphorous. Samples are being collected quarterly for conventional, field parameters, flow, and bacteria at Station 10261 (Tankersley Creek at FM 3417).

0404C – HART CREEK

Hart Creek, an unclassified water body, rises 4.5 miles north of Mount Pleasant and runs southeast for twelve miles to its confluence with Big Cypress Creek. It receives surface drainage from Hayes Creek and Evans Creek, small tributaries east of Mount Pleasant. The soils are sandy along the stream's upper reaches and loamy along its middle and lower reaches. The area was originally heavily wooded, with pines and various hardwoods predominating. The City of Mt. Pleasant WWTP outfall on Hart Creek is located below SH 49 and above County Road 4550.

Hart Creek remains listed as impaired for bacteria. This stream was also intensively monitored in the study previously discussed. There are concerns for nitrate shown in the *2014 Texas Integrated Report*. Samples are being collected quarterly for conventional, field parameters, flow, and bacteria at Station 10266 (Hart Creek at County Road 4550).

0404D – WELSH RESERVOIR

Welsh Creek extends from the Titus County Dam up to normal pool level located between Mt. Pleasant and Daingerfield. Welsh Reservoir impounds Swauano and Justiss Creeks. No concerns were identified for this segment.

0404E – DRY CREEK

Dry Creek enters Big Cypress Creek from the west bank, flowing past Pittsburg in northeast Camp County. The *2014 Texas Integrated Report* lists this stream as a concern for screening levels for nitrate. Station 10274 (Dry Creek at McMinn Road) was added to the monitoring schedule in FY 2016. Quarterly samples are collected for conventionals, bacteria, field parameters, and flow.

0404F – SPARKS BRANCH

Sparks Branch was not assessed in the *2014 Texas Integrated Report*. In 2006 and 2012, it was assessed for dissolved oxygen grab sample minimum and criterion with no concerns being identified. The assessment was based on limited data and sampling may be considered in the future.

0404J – PRAIRIE CREEK

Prairie Creek flows on the southern border of Camp Count before its confluence with Big Cypress Creek near US 259. The stream remains on the *2014 Texas Integrated Report* with a concern for non-attainment of the 24-hour dissolved oxygen average and minimum criteria. No changes are proposed for Prairie Creek in the current assessment; however, the Lake O' the Pines I-Plan workgroup identified this watershed for possible monitoring to determine any potential impacts on loading into the reservoir. The Texas Water Resources Institute has recently begun a study in this watershed and will be collecting samples on a monthly basis.

0404K – WALKERS CREEK

Walkers Creek is located in Camp County, about 3 miles north of Pittsburg. There are no concerns or impairments in *2014 Texas Integrated Report*.

0404N – LAKE DAINGERFIELD

Lake Dangerfield is an eighty-acre reservoir which was completed in 1935 as a Civilian Conservation Corps project. This segment is listed on the *Texas 303(d) List* for non-support and concern for the screening level of mercury in fish tissue. DSHS has issued a fish consumption advisory for mercury.

0404O – DRAGOO CREEK

Dragoo Creek was not assessed in the *2014 Texas Integrated Report*. One site was sampled as part of the *Assessment of Contact Recreation Use Impairments and Watershed Planning for Cypress Creek and Tributaries*. During assessment, these data were determined not to be temporally representative of the stream, so no impairments or concerns could be accurately determined.

0405 – LAKE CYPRESS SPRINGS



Figure 20: View of the South Shore of Lake Cypress Springs

Lake Cypress Springs is located near the headwaters of Big Cypress Creek in the northwestern portion of the Cypress Creek Basin. The reservoir is located in Franklin County, south of the City of Mount Vernon. Lake Cypress Springs is regulated by the Franklin County Water District and is a popular recreational reservoir with many new homes constructed on the lakefront in recent years. The watershed is primarily rural with some agricultural activity including dairy, poultry, cow/calf operations, and hay meadows.

Lake Cypress Springs is listed as impaired for pH and has concerns for chlorophyll a . TCEQ Region 5 samples quarterly for conventional, bacteria, and field parameters at three locations in the reservoir.

0405A – BIG CYPRESS CREEK ABOVE LAKE CYPRESS SPRINGS

Big Cypress Creek was added to the *2014 Texas 303(d) List* for depressed dissolved oxygen. The *2014 Texas Integrated Report* also shows a concern for bacteria. A concern for impaired habitat found in previous reports has been removed. Sampling at Station 15260 (Big Cypress Creek at SH 37) continues in FY 2016 for conventional, bacteria, field parameters, and flow.

0405B – PANTHER CREEK

Panther Creek rises near Purley in Franklin County. The stream, which is intermittent in its upper reaches, originally ran southeast for 6.5 miles to its confluence with Big Cypress Creek before Lake Cypress Springs was impounded in 1970. Panther Creek is listed in the *2014 Texas Integrated Report* with a concern for impaired habitat.

0406 – BLACK BAYOU

The Black Bayou Watershed is located in the piney-woods region of East Texas in Cass and Marion counties. The watershed is predominately forested hills. The area typically consists of wide, flat, heavily wooded bottom lands along the major streams, with sandy clay upland hills that are dissected by small intermitted streams. The soils of the Black Bayou watershed floodplain are fine, sandy loam soil that are considered moderately to slowly permeable.

The upper assessment unit of Black Bayou is on the *2014 Texas 303(d) List* for bacteria while the entire segment is listed for depressed dissolved oxygen. The lower assessment unit meets standards and was removed from the 303(d) list in the most recent assessment. There is also a concern for chlorophyll *a* in the upper portion of the segment. Quarterly sampling for conventionals, bacteria, field parameters, and flow is being conducted by the TCEQ Region 5 at stations 10314 (Black Bayou at Cass CR 4659) and 10318 (Black Bayou at SH 43).

0407 – JAMES' BAYOU

Continuous and well developed riparian woodlands cover a large portion of James' Bayou. The watershed consists predominately of forested hills with wide, flat, heavily wooded bottom lands along the major streams. James' Bayou is listed for bacteria, depressed Dissolved Oxygen, pH, impaired fish community, and impaired macrobenthic community. There is also a concern for screening level for an impaired Habitat in the lower Assessment Unit. Samples for 24-hour dissolved oxygen, bacteria, field parameters and flow are being collected by WMS. Biological monitoring at station 14976 (Jims Bayou at SH 43) is scheduled during FY 2016 in response to the new biological listings and the habitat concern.

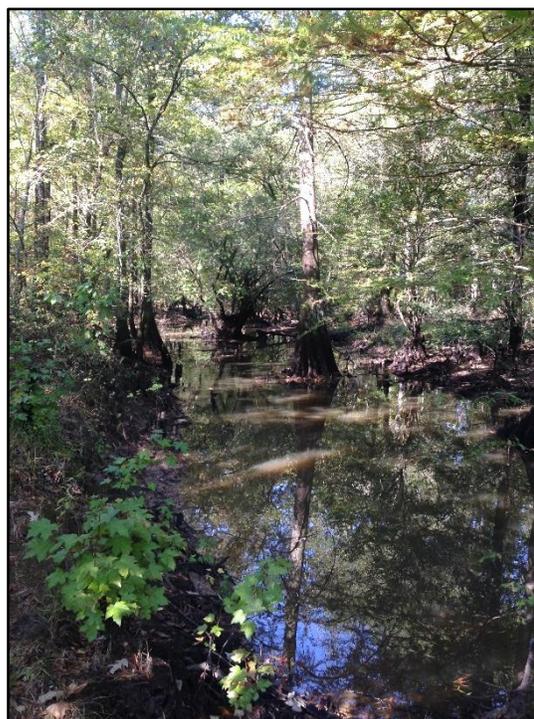


Figure 21: James Bayou at SH 43 (14976)

0407B – FRAZIER CREEK

Frazier Creek, an unclassified tributary to James' Bayou, serves as an ecoregion reference stream in this watershed since it has a relatively low level of human disturbance. Frazier Creek water is soft, with low levels of dissolved solids, alkalinity, and hardness. There is a concern for screening level of dissolved oxygen in Frazier Creek in the *2014 Texas Integrated Report*. TCEQ monitors Station 10259 (Frazier Creek at US 59) quarterly for bacteria, and flow.

0408 – LAKE BOB SANDLIN

Lake Bob Sandlin is located immediately below Lake Cypress Springs and Lake Monticello. The reservoir is a popular recreational and fishing lake. The reservoir is regulated by the Titus County Freshwater Supply District #1. In recent years, many new homes have been constructed along the lakefront. No impairments or concerns were identified in the 2014 *Texas Integrated Report*. Quarterly samples are being collected at three stations by TCEQ Region 5 in FY 2016.

0408A – LAKE MONTICELLO

Lake Monticello is approximately eight miles southwest of Mount Pleasant in Titus County. There are no concerns or impairments shown in the 2014 *Texas Integrated Report*. No sampling is scheduled for FY 2016.

0408C – BRUSHY CREEK

Brushy Creek originates north of Winnsboro in Franklin County and is joined by the South Fork of Brushy Creek, which rises six miles southeast of Winnsboro in Wood County. The South Fork runs northeast for six miles, briefly forming part of the Wood-Franklin county line. The 2014 *Texas Integrated Report* shows a concern for screening level for an impaired Habitat.

0409 – LITTLE CYPRESS BAYOU (CREEK)

The Little Cypress Creek watershed is located south of Lake O' the Pines, forms much of the southern boundary of the Cypress Creek Basin, and joins Big Cypress Creek east of Jefferson. The majority of land use within the watershed consists of forest, wetland, and a small amount of agricultural land. Little Cypress Creek tends to exhibit long periods of low flow interrupted by runoff events that result in flooding of its broad, heavily wooded floodplain.

This segment is included in the *2014 Texas 303(d) List* for low dissolved oxygen and elevated bacteria counts. Sampling in the segment is conducted by the TCEQ Region 5. Quarterly conventional, bacteria, field parameters, and flow are scheduled to be collected at 4 stations in FY 2016 at Stations 10332, 15773, 16017, and 16861.

0409A – LILLY CREEK

Lilly Creek originates two miles west of Pine in Camp County and flows southeast for nine miles to its confluence with Little Cypress Creek. Concerns for depressed DO and bacteria are shown in the *2014 Texas Integrated Report*. Quarterly sampling is being conducted at Station 20153 (Lilly Creek at FM 556) in FY 2016 for conventional, bacteria, and field parameters.

0409B – SOUTH LILLY CREEK

South Lilly Creek is a tributary of Lilly Creek and extends from its confluence with Lilly Creek to approximately two miles west of FM 1647 in Upshur County. South Lilly Creek has a Nonsupport in the *2014 Texas 303(d) List* for bacteria. WMS collects quarterly samples at Station 17954 (South Lilly Creek at FM 2425) for bacteria, field parameters, and flow (when the stream is wadeable).

0409D – LAKE GILMER

Lake Gilmer is located in central Upshur County and has no concerns or impairments. Quarterly monitoring is conducted by TCEQ Region 5 at stations 17478 and 18825 for conventionals, bacteria, and field parameters.

0409E – CLEAR CREEK

Clear Creek is a small stream located in Upshur County and is a tributary to Little Cypress Creek. The *2014 Texas Integrated Report* shows a concern for non-attainment for impaired benthic community along with a concern for screening level of an impaired Habitat.

0410 – BLACK CYPRESS CREEK (BAYOU) / FORMERLY 0402A

Black Cypress Bayou is an unclassified water body with segment boundary beginning at the confluence with Big Cypress Creek up to FM 250. This segment is designated as 0402A in the *2014 Texas Integrated Report* as an unclassified water body. Beginning with the next Integrated Report, the stream will become a classified water body, and the segment number will change to 0410.

Black Cypress Bayou is listed as impaired for low dissolved oxygen, bacteria, copper in water, and mercury in edible fish tissue. Four diel monitoring events are scheduled at Station 10245 (Black Cypress Creek at US 59) in FY 2016 by WMS. Quarterly samples for conventional, bacteria, field parameters, and flow are being collected by TCEQ Region 5.



Figure 22: Black Cypress Bayou at US 59 (10245)

GET INVOLVED IN YOUR WATERSHED

The Cypress Creek Basin encourages public involvement in basin activities. Your involvement is important to the development and support of the program. Gathering recommendations and concerns from the public is an important aspect of the CRP. You can get involved through steering committee meetings and volunteer activities.

If you are already a member of the CRP Steering Committee, it is important that you attend the annual CRP Steering Committee meeting and participate in the open exchange of information about the basin. If you are interested in participating on the CRP Steering Committee, Caddo Lake Watershed Protection Plan, or are interested in receiving information about surface water quality issues within the Cypress Creek Basin, please contact the Northeast Texas Municipal Water District at 903-639-7538 or visit their web site: www.netmwd.com. Our goal is to provide readily accessible information about local environmental issues to the public, which we hope will encourage citizens of our basin to get involved.

Interested in becoming a stakeholder and attending meetings and program updates?

Northeast Texas Municipal Water District
PO Box 955
Hughes Springs, TX 75656
903-639-7538
info@netmwd.com



Figure 23: Giant Salvinia Warning Sign

REFERENCES

Flores, Miguel I. *Letter to Ms. L'Oreal Stepney, P.E., Deputy Director Office of Water (MC-IS8) Texas Commission on Environmental Quality* 29 June 2011. Environmental Protection Agency, Region 6, Dallas, Texas.

Moring, Bruce J. *Baseline Assessment of Physical Characteristics, Fish, and Mussels at the Mesohabitat Scale at Proposed Monitoring Sites in Big Cypress Creek, Black Cypress Bayou, and Little Cypress Creek – Summary of Findings* USGS Texas Water Science Center. October 15, 2012.

TCEQ. 2014. *Total Maximum Daily Load and Implementation Plan for Lake O' the Pines* <http://www.tceq.texas.gov/waterquality/tmdl/nav/19-lakepines/19-pinelakes-tmdlplan> (Accessed December 17, 2015).

TCEQ. *Surface Water Quality Monitoring Procedures. Volume One and Two* https://www.tceq.texas.gov/waterquality/monitoring/swqm_guides.html (Accessed December 17, 2015).

TCEQ. 2014. *Surface Water Quality Monitoring Data Management Reference Guide* Texas Commission on Environmental Quality, Austin, Texas.

TCEQ. *Texas Clean Rivers Program: Guidance, FY 2016-2017* <http://www.tceq.texas.gov/waterquality/clean-rivers/guidance/index.html> (Accessed December 17, 2015).

TCEQ. *Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)* http://www.tceq.texas.gov/waterquality/assessment/305_303.html (Accessed December 17, 2015).

TDSHS. *Fishing advisories, Bans, and FAQs about Bodies of Water – Seafood and Aquatic Life* <http://www.dshs.state.tx.us/seafood/advisories-bans.aspx> (Last updated July 15, 2015).

TDSHS. *Fish and Shellfish Consumption Advisory, ADV-12* (November 2, 1995).

TDSHS. *Fish and Shellfish Consumption Advisory, ADV-22* (March 13, 2002).

TDSHS. *Fish and Shellfish Consumption Advisory, ADV-29* (December 28, 2005)

Texas State Historical Association. *The Handbook of Texas Online* <http://www.tshaonline.org/handbook> (Accessed January 3, 2016).