2020 CYPRESS CREEK BASIN HIGHLIGHTS REPORT

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Cover photo: View of Big Cypress Bayou at SH 43 above Caddo Lake

FOREWORD

The Clean Rivers Program (CRP) is a water quality monitoring, assessment, and public outreach program administered by the TCEQ and funded by state collected fees. The Northeast Texas Municipal Water District (NETMWD) coordinates the CRP for the Cypress Creek Basin. As a participant in the Clean Rivers Program, NETMWD submits its Basin Summary Report to the TCEQ and CRP partners.

This report and others submitted throughout the State are used 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 water quality and biological samples, field parameters and measure flow at sites throughout the Cypress Creek Basin.

Monitoring and analysis are the basis for maintaining good water quality within the Cypress Creek Basin. Within a cooperative program directed by the Northeast Texas Municipal Water District (NETMWD) these activities are an integral part of the State's Clean Rivers Program. Cypress Creek Basin CRP stakeholders include:

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

NETMWD contracts with Water Monitoring Solutions, Inc. (WMS) to fulfill the sampling and reporting requirements of the CRP.

GET INVOLVED!

Each spring, NETMWD provides a venue for local stakeholders to learn about water quality issues affecting their region and to provide input on projects in their communities. The Cypress Creek Steering Committee meetings allow stakeholders to have input on addressing water quality concerns and to prioritize water quality monitoring within the Cypress Creek Basin. NETMWD and its Clean Rivers Program partners continue to reach out to the public to educate and help resolve local water quality issues. Members of the public, water supply corporations, permitted dischargers, councils of government, and city and county officials are invited annually to become steering committee members. A CRP Steering Committee meeting was held in April 2019 at the NETMWD executive offices in Hughes Springs. Topics included cyanotoxin study in Caddo Lake by the US Geological Survey, an invasive species update from Texas Parks and Wildlife Department (TPWD), Total Phosphorus Load Agreement, and a discussion of the Cypress Creek Basin Summary Report.

NETMWD plans and coordinates monitoring efforts with other basin entities, the TCEQ monitoring staff, CLI, and other interested participants annually within the Cypress Creek Basin. All entities collecting water quality data in the Cypress Creek Basin are encouraged to coordinate their efforts with the NETMWD and participate under the NETMWD QAPP. Currently, the CLI monitors Caddo Lake on a monthly basis under the NETWMD QAPP.

Visit NETMWD to join the Clean Rivers Program Steering Committee or contact Robert Speight at 903-639-7538 or rspeightnetmwd@aol.com.

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LIST OF ACRONYMS AND ABBREVIATIONS

AU	Assessment Unit
cfs	Cubic feet per second (measurement of stream flow)
CLI	Caddo Lake Institute
CMS	Coordinated Monitoring Schedule
CR	County Road
CRP	Clean Rivers Program
DO	Dissolved Oxygen
DSHS	Department of State Health Services
FM	Farm-to-Market Road
FY	Fiscal Year
I-Plan	TMDL Implementation Plan
mg/L	milligrams per liter
MPN/100 mL	Most Probable Number per 100 milliliters (bacteria measurement units)
NETMWD	Northeast Texas Municipal Water District
PCB	Polychlorinated biphenyls
QAPP	Quality Assurance Project Plan
RUAA	Recreational Use Attainability Analysis
SH	State Highway
s.u.	standard units (measurement of pH)
TCEQ	Texas Commission on Environmental Quality
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TNFH	Tishomingo National Fish Hatchery
TPLA	Total Phosphorus Load Agreement
TPWD	Texas Parks and Wildlife Department
USFWS	United States Fish and Wildlife Service
WMS	Water Monitoring Solutions, Inc.
WWTP	Wastewater Treatment Plant
§303(d) List	Impaired water bodies in Section §303(d) of the Federal Clean Water Act
µg/L	micrograms per liter

The Texas Clean Rivers Program (CRP) is a statewide water quality monitoring and assessment program that provides funding and resources for regional watershed protection efforts. The program is administered by the Texas Commission on Environmental Quality (TCEQ) in partnership with river authorities and other regional governments with the goal of maintaining and improving water quality in each river basin in the state.

As the coordinating agency in the Cypress Creek basin, the Northeast Texas Municipal Water District (NETMWD) works with federal and state agencies, municipalities, water suppliers, and private companies to accomplish water quality monitoring and watershed protection objectives. Monitoring priorities are established through stakeholder input and coordination with other organizations working in the basin. Coordinating entities in attendance often include the TCEQ, Caddo Lake Institute (CLI), Texas Parks and Wildlife Department, U. S. Geological Survey, Texas State Soil and Water Conservation Board, and Texas A&M University – Agrilife/ Texas Water Resources Institute.

Figure 1: Clean Rivers Program Steering Committee Meeting, March 2018

INTRODUCTION

The Texas Clean Rivers Program (CRP) is a statewide water quality monitoring and assessment program that provides funding and resources for regional watershed protection efforts. The program is administered by the Texas Commission on Environmental Quality (TCEQ) in partnership with river authorities and other regional governments with the goal of maintaining and improving water quality in each river basin in the state.

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Most years, a Basin Highlight Report is authored, presented at stakeholder meetings, and posted to the NETMWD website. The report is typically of a non-technical nature intended to provide a high-level overview of issues that may affect water quality within the basin.

THE CYPRESS CREEK BASIN

The Cypress Creek watershed encompasses approximately 6,000 square miles. Its major tributaries – Big Cypress Creek, Little Cypress Creek, James' Bayou, Harrison Bayou, and Black Cypress Bayou – drain into Caddo Lake on the Texas/Louisiana border. The watershed has a diverse ecology. The headwaters of Big Cypress Creek, above Lake Cypress Springs, is intermittent. Releases into Big Cypress Creek from Lake Bob Sandlin runs through flat to rolling terrain surfaced by sandy and clay loams that support water-tolerant hardwoods, conifers, and grasses before entering Lake O' the Pines. Below Lake O' the Pines, Big Cypress Creek (Bayou) flows into Caddo Lake through bottomland thick with hardwood and cypress trees.

The watershed originates in the southern portions of Hopkins and Franklin Counties. Headwaters flow south eastwardly into Camp, Titus, Morris, Cass, Marion, and Harrison Counties. Reservoirs in the basin include: Monticello Reservoir, Lake Cypress Springs, Lake Bob Sandlin, Lake Gilmer, Lake Daingerfield, Ellison Creek Reservoir, Lake O' the Pines, and Caddo Lake. The major tributaries of Caddo Lake include Big Cypress Creek, Little Cypress Creek (Bayou), Black Cypress Bayou, James Bayou, and Harrison Bayou.

The basin experienced a pervasive drought that began around 1999 and extended through 2014. During this period, the drought was punctuated with large rainfall events. In 2011 and 2012, the drought reached comparable levels with the drought of record from the 1950's. This was followed by near-historic flooding in 2015 and 2016 which ended the pervasive drought.

Rainfall records at the Fort Sherman Dam, located in the upper portion of the basin, have been maintained since its completion in 1978. Over the forty-year period, precipitation has averaged around 52 inches annually. However, from 1979 to 1998, the average was 54 inches per year, as compared to 50 inches from 1999 to 2018. During the 1999 - 2014 drought, an annual average of 48 inches of rain was reported. At slightly over 25 inches of precipitation, 2005 was the driest year on record and was also the first year that no water was released from Lake Bob Sandlin.

Releases from Lake Bob Sandlin play an important role in the water quality of Big Cypress Creek and Lake O' the Pines. There are no instream flow requirements in Big Cypress Creek, so water is only released by the Titus County Freshwater Supply District #1 to maintain freeboard of the Fort Sherman Dam. From 2000 through 2014, a combined total of 939,956 acre-feet of water was released from the reservoir. As a result of pervasive drought, there were zero releases

during seven out of those fifteen years. No releases occurred in 2005 through 2007 and again from 2011 through 2014.

A record amount of water was released from the Fort Sherman Dam in 2015, at over 280,000 acre-feet. An additional 150,000 acre-feet was released by the end of April 2016. This amount of water could fill Lake Bob Sandlin more than twice. A total of 677,968 acre-feet was released in 2015 through 2018, or about 60% of the combined releases of the previous fifteen years.

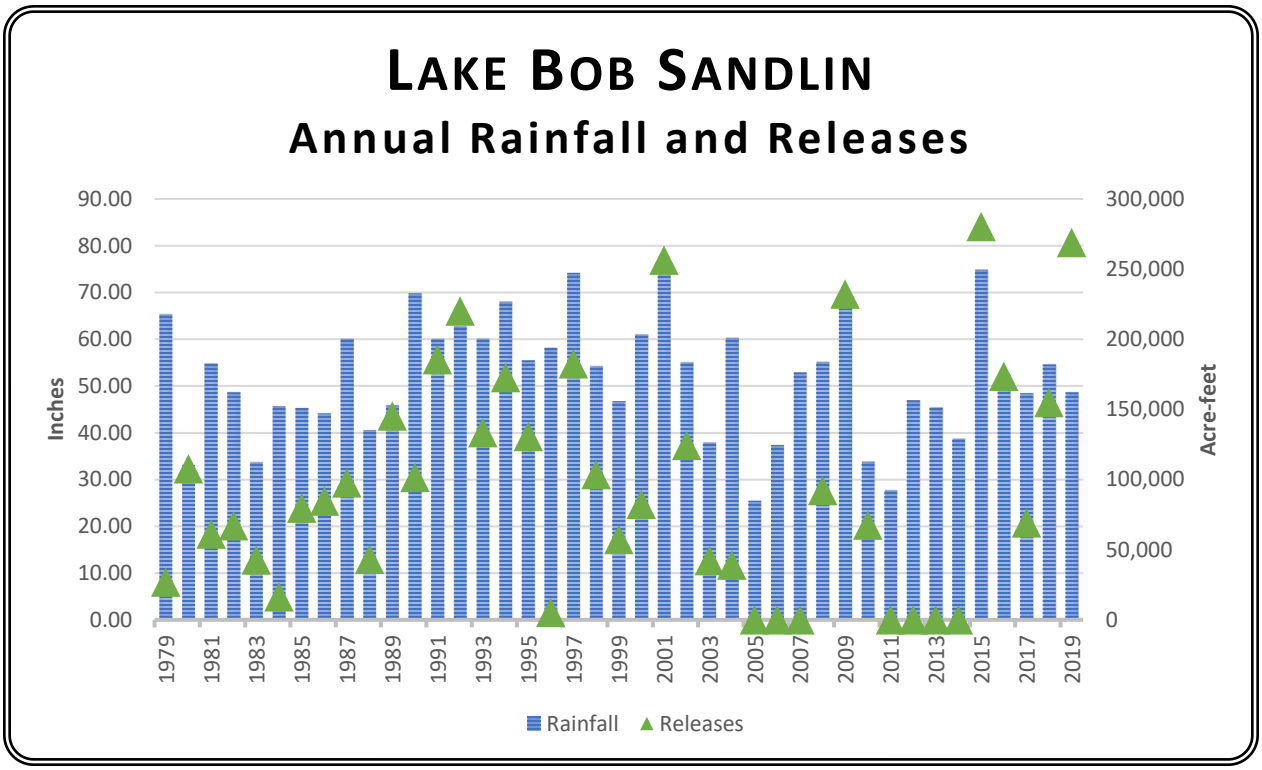

Figure 2: Graph of annual rainfall and releases form Lake Bob Sandlin

Similarly, Caddo Lake surpassed its flood stage of 172.0 feet seven times over the past 46 months. Further, during the thirteen-month period of March 2015 to April 2016, Caddo Lake reached flood stage five times including the fourth highest water level ever recorded at 179.95 feet. For a perspective of the magnitude of the recent flooding, during the 93-year period of 1921 to 2014, the Caddo Lake spillway reached its flood stage 29 times for an average of once per every 3.2 years. Over sixty percent of these record events occurred prior to the impoundment of Big Cypress Bayou that created Lake O' the Pines, which was constructed as a flood control structure in response to the historic flooding of Jefferson in 1945. The only other decades that Caddo Lake reached flood stage five times was during the 1930's and 1940's, prior to the construction of Lake O' the Pines.

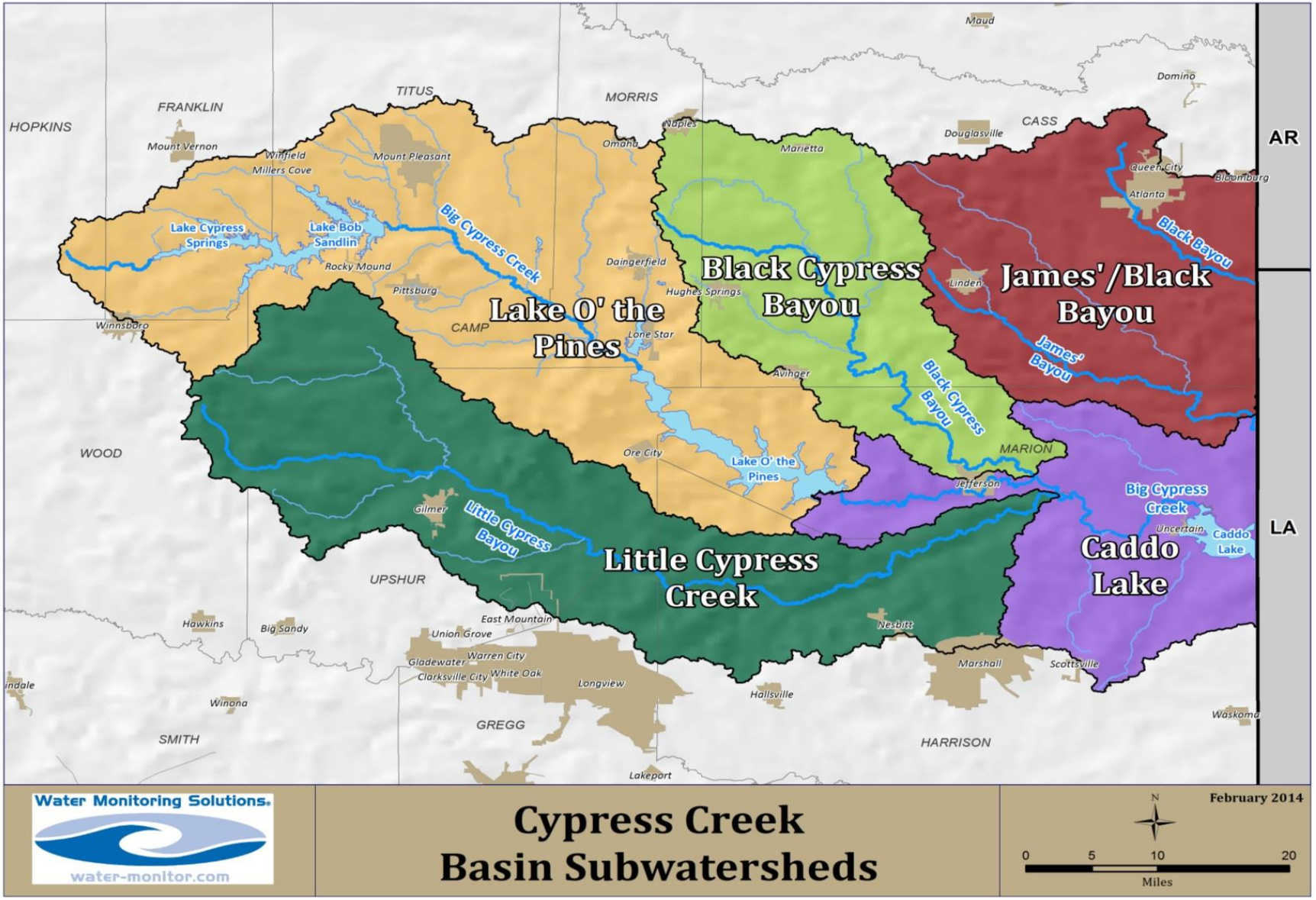

Figure 3: Map of the Cypress Creek Basin watersheds

WATER QUALITY MONITORING

Water quality monitoring and reporting is the heart of the CRP program. NETMWD / Water Monitoring Solutions, Inc. (WMS), TCEQ Region 5 – Tyler (R5), and the Caddo Lake Institute (CLI) routinely collect water quality data. Monitoring is conducted at 54 sites located in ten designated segments and 26 sub-segments within the Cypress Creek basin. The Coordinated Monitoring Schedule (CMS) is presented at the end of each segment discussion.

Clean Rivers Program partners collect monitoring data following a TCEQ-approved Quality Assurance Project Plan (QAPP). The QAPP references procedures and methods for sample collection and handling. The TCEQ Surface Water Quality Monitoring team have produced two procedures manuals that detail the methods for collecting water, sediment, and biological samples. All CRP partners follow these methods of data collection and quality assurance.

The resulting data are submitted to the TCEQ for inclusion in the state water quality database - Surface Water Quality Monitoring Information Systems. After a thorough review and approval by TCEQ, these data are made available for public access via the NETMWD and TCEQ websites. These data are used by the TCEQ to assess the basin.

Physical and chemical measurements of water quality are typically made at each station. Common parameters include dissolved oxygen, pH, suspended sediments, nutrients, bacteria, and stream flow or lake level. Biological assessments include the collection of fish, aquatic insects, and habitat assessments to assess the overall health of streams. Water quality monitoring is often described in the general terms of field parameters, conventional laboratory parameters, diel studies (data collected over a 24-hour period), stream flow, and biological sampling.

During the most recent assessment, the TCEQ evaluated 36 classified and unclassified water bodies in the basin. The results reported in the *2020 Texas Integrated Report* indicated that over half of the water bodies evaluated did not meet surface water quality standards for one or more parameters. Figure 4 details the segments and parameters shown on the *2020 Texas §303(d) List*. The §303(d) List identified nine classified and ten unclassified water bodies that were non-supporting of water quality criteria. Low concentrations of dissolved oxygen, high levels of bacteria, and mercury in fish tissue were the most common impairments. Details about these impairments and water quality concerns are discussed within the segment narratives that follow this section of the report.

The *2020 Texas §303(d) List* for the Cypress Creek Basin includes the impairments shown in the table below:

Segment ID	Description	Parameter
0401	Caddo Lake (entire)	Mercury in fish tissue
		DO
0401A	Harrison Bayou	DO
0402	Big Cypress Creek below Lake O' the Pines	Mercury in fish tissue
		DO
0402B	Hughes Creek	DO
0403	Lake O' the Pines	High pH, DO
0404	Big Cypress Creek below Lake Bob Sandlin	*E. coli*
0404A	Ellison Creek Reservoir	Sediment Toxicity (LOE)
		Dioxin in fish tissue
		PCBs in fish tissue
0404B	Tankersley Creek	*E. coli*
0404C	Hart Creek	*E. coli*
0404E	Dry Creek	*E. coli*
0404J	Prairie Creek	DO
0404N	Lake Daingerfield	Mercury in fish tissue
0405	Lake Cypress Springs	High pH
		Nutrient Reservoir Criteria
0405A	Big Cypress Creek	DO, *E. coli*
0406	Black Bayou	DO, *E. coli*
0407	James' Bayou	DO, *E. coli*
0409	Little Cypress Bayou	DO, *E. coli*
0409A	Lilly Creek	*E. coli*
0409B	South Lilly Creek	*E. coli*
0410	Black Cypress Bayou	Mercury in fish tissue
		Copper, Lead in water
		DO
0410A	Black Cypress Creek	*E. coli*

Figure 4: Table of Impairments

The water bodies shown in Figure 5 met water quality standards for the parameters shown during the most recent assessment period and were removed from the *2020 Texas §303(d) List*.

Segment Description	Parameter
Big Cypress Creek below Lake Bob Sandlin (Segment 0404)	Sulfate
James Bayou (Segment 0407_02)	*E. coli*
Little Cypress Creek (Segment 0409_03)	*E. coli*
Black Cypress Bayou (Segment 0410_03)	DO, Copper
Black Cypress Bayou (Segment 0410_04)	*E. coli*
Black Cypress Bayou (Segment 0410A_01)	DO

Figure 5: Water bodies removed from Texas §303(d) List

The water bodies shown in Figure 6 were newly added to the *2020 Texas §303(d) List* for the parameters shown.

Segment Description	Parameter
Hughes Creek (Segment 0402B)	DO
Dry Creek (Segment 0404E)	*E. coli*
Prairie Creek (Segment 0404J)	DO
Black Cypress Bayou (Segment 0410)	Lead in water

Figure 6: Water bodies added to the Texas §303(d) List

The following discussion provides definitions of the common field and conventional laboratory parameters.

FIELD PARAMETERS

Field parameters include those obtained using a water quality sonde such as temperature, dissolved oxygen, pH, specific conductance (sometimes referred to as "temperature-compensated conductivity"), and salinity. Other field parameters include transparency, stream flow, air temperature, and general field observations.

Temperature – Water temperature affects the oxygen content of the water, with warmer water unable to hold as much oxygen. When water temperature is too cold, cold-blooded organisms may either die or become weaker and more susceptible to other stresses, such as disease or parasites. Colder water can be caused by reservoir releases. Warmer water can be caused by removing trees from the riparian zone, soil erosion, or use of water to cool manufacturing equipment.

Dissolved Oxygen (DO) – The concentration of dissolved oxygen is a characteristic of water that correlates with the occurrence and diversity of aquatic life. A water body that can support diverse, abundant aquatic life is a good indication of high water quality since all aerobic aquatic organisms require oxygen to live. Modifications to the riparian zone, decreases in stream flow, increases in water temperature, increases in organic matter, bacteria, and over abundant algae may lead to lower DO concentrations in water.

Specific Conductance – Conductivity is a measure of the water body's ability to conduct electricity and indicates the approximate levels of dissolved salts, such as chloride, sulfate, and sodium in the stream. Elevated concentrations of dissolved salts can impact the water as a drinking water source and as suitable aquatic habitat.

Salinity – Salinity is commonly calculated by the water quality sonde using an algorithm based upon conductivity and temperature, and is typically only recorded at coastal and tidally influenced stations. Salinity plays a role in determining estuarine sites and the composition of saline water diluted by freshwater from streams and rivers.

pH – is a measure of the acidity or basicity of a solution. The pH scale is a logarithmic (base 10) scale. A change of one pH unit means that the water has become ten times more acidic or basic. Most aquatic life is adapted to live within a relatively narrow pH range, but tolerant

species can adjust to varying pH ranges. However, pH levels below 4 (acidity of orange juice) or above 12 (basicity of ammonia) are lethal to most fish species. Industrial and wastewater discharge, runoff from quarry operations, and accidental spills are examples of factors that can change the pH composition of a water body. For many water bodies in East Texas, the pH tends to be naturally low (acidic) due to soil composition.

Transparency – Transparency is a measure of the depth to which light is transmitted through the water column and thus the depth at which aquatic plants can grow. Transparency is measured using a secchi disk. Transparency is an important secondary parameter for assessing eutrophication, the natural aging process in reservoirs and lakes, and for determining trends in water clarity.

Stream Flow – Flow is an important parameter affecting water quality. Low flow conditions, common in the warm summer months, create critical conditions for aquatic organisms. At low flows, the stream has a lower assimilative capacity for waste inputs from point and non-point sources. Streams have critical low flows calculated by TCEQ. When stream flows drop below these (known as 7Q2) calculations, some water quality standards do not apply. For example, low DO is often a result of low flows. As a result, flow is often evaluated in conjunction with DO by the assessors to determine if a site is meeting its Aquatic Life Use designation.

CONVENTIONAL LABORATORY PARAMETERS

Laboratory analysis of “conventional” parameters generally includes solids, salts, nutrients, and bacteria. Conventional parameters analyzed by a laboratory include:

Solids: Total Suspended Solids and Total Dissolved Solids – High solids may affect the aesthetic quality of the water, interfere with washing clothes, and corrode plumbing fixtures. High total dissolved solids in the environment can also affect the permeability of ions in aquatic organisms. Mineral springs, carbonate deposits, salt deposits, and sea water intrusion are sources for natural occurring high concentration solids levels. Other sources can be attributed to oil and gas exploration, drinking water treatment chemicals, storm water and agricultural runoff, and point/non-point wastewater discharges. Elevated levels of dissolved solids such as chloride and sulfate can cause water to be unusable, or simply too costly to treat for drinking water uses. Changes in dissolved solids concentrations also affect the quality of habitat for aquatic life.

Total Hardness – Hardness is a composite measure of ions in the water, and is primarily composed of calcium and magnesium. The hardness of the water is critical due to its effect on the toxicity of certain metals. Higher hardness concentrations in the receiving stream can result in reduced toxicity of heavy metals.

Chloride – Chloride is an essential element for maintaining normal physiological functions in all organisms. Elevated chloride concentrations can disrupt osmotic pressure, water balance, and acid/base balances in aquatic organisms which can adversely affect survival, growth, and/or reproduction. Natural weathering and leaching of sedimentary rocks, soils, and salt deposits can release chloride into the environment. Other sources can be attributed to oil and gas exploration and storage, wastewater discharges, landfill run off, and saltwater intrusion.

Sulfate – Effects of high sulfate levels in the environment have not been fully documented; however, sulfate contamination may contribute to the decline of native plants by altering chemical conditions in the sediment. Due to abundance of elemental and organic sulfur and sulfide mineral, soluble sulfate occurs in almost all natural water. Other sources are the burning of sulfur-containing fossil fuels, steel mills, wastewater treatment plant discharges, and fertilizers.

E. coli **(Bacteria) –** Occurring naturally in the digestive system of warm blooded animals, *Escherichia coli* (*E. coli*) bacteria are commonly found in surface water. Although not all bacteria are harmful to human beings, the presence of is an indication of recent fecal matter contamination, and that other pathogens dangerous to human beings may be present. Bacteria are measured to determine the relative risk of contact with pathogens through swimming or other contact recreation activities. Sources may include inadequately treated sewage; waste from livestock, pets, waterfowl, and wildlife; or malfunctioning/failing septic systems.

Chlorophyll *a* – High levels of chlorophyll can indicate algal blooms, decrease water clarity, and cause swings in pH and dissolved oxygen concentrations due to photosynthesis and respiration processes. An increase in nutrients can lead to excessive algal production. Chlorophyll *a* concentrations are used as an indication of eutrophication in lakes and reservoirs.

Nutrients (Ammonia, Nitrate, Phosphorus) – Nutrients are essential for life. However, elevated concentrations of nutrients can cause excessive growth in aquatic vegetation and may lead to algal blooms. Bloom conditions may cause wide variations in pH and dissolved oxygen within a water body. Common sources of nutrient pollution are treated effluent, malfunctioning septic

systems, and agricultural non-point sources. Soil erosion and runoff from farms, lawns, and gardens can add nutrients to the water. Some nutrient loading may also occur naturally through biotic decomposition. In aquatic systems, when plants and algae die, the bacteria that decompose them use oxygen, thereby reducing the amount of dissolved oxygen in the water column which may lead to fish kills and decreased species diversity.

Elevated amounts of nitrogen in the environment can adversely affect fish and invertebrate reproductive capacity and reduce the growth of young. High levels of nitrates and nitrites can produce nitrite toxicity, or "brown blood disease." It can contribute to Blue Baby Syndrome in humans, a disease which reduces the ability of blood to transport oxygen throughout the body.

Ammonia is excreted by animals and is produced during the decomposition of organic matter. Municipal and industrial wastewater treatment plant discharge is another common source of ammonia.

Phosphorus is one of the most abundant elements on the planet; however, most natural phosphate compounds are very insoluble and not biologically available. Most water bodies are phosphorus-limited, meaning that algal production is limited to the amount of soluble phosphorus available in the water column. Common contributors of soluble phosphorus are non-point sources such as human and animal waste as well as commercial fertilizers. Commercial fertilizers are a more soluble form that can readily be used by plants, but this property also makes the phosphorus more susceptible to runoff.

Metals - High concentrations of metals such as cadmium, mercury, and lead pose a threat to drinking water supplies and human health. Eating fish contaminated with metals can cause these toxic substances to accumulate in human tissue, posing a long-term significant health threat. Bioaccumulation of mercury in the edible tissues of many fish species to the point of becoming a human health concern has prompted the Department of State Health Services (DSHS) to issue fish consumption advisories around the basin. Mercury in edible fish tissue has been identified in fish tissue in water bodies throughout East Texas.

Organics - Toxic substances from pesticides and industrial chemicals pose the same concerns as metals. PCBs, for example, are industrial chemicals that are toxic and probably carcinogenic. Although banned in the United States in 1977, PCBs remain in the environment, and they accumulate in fish and human tissues when consumed.

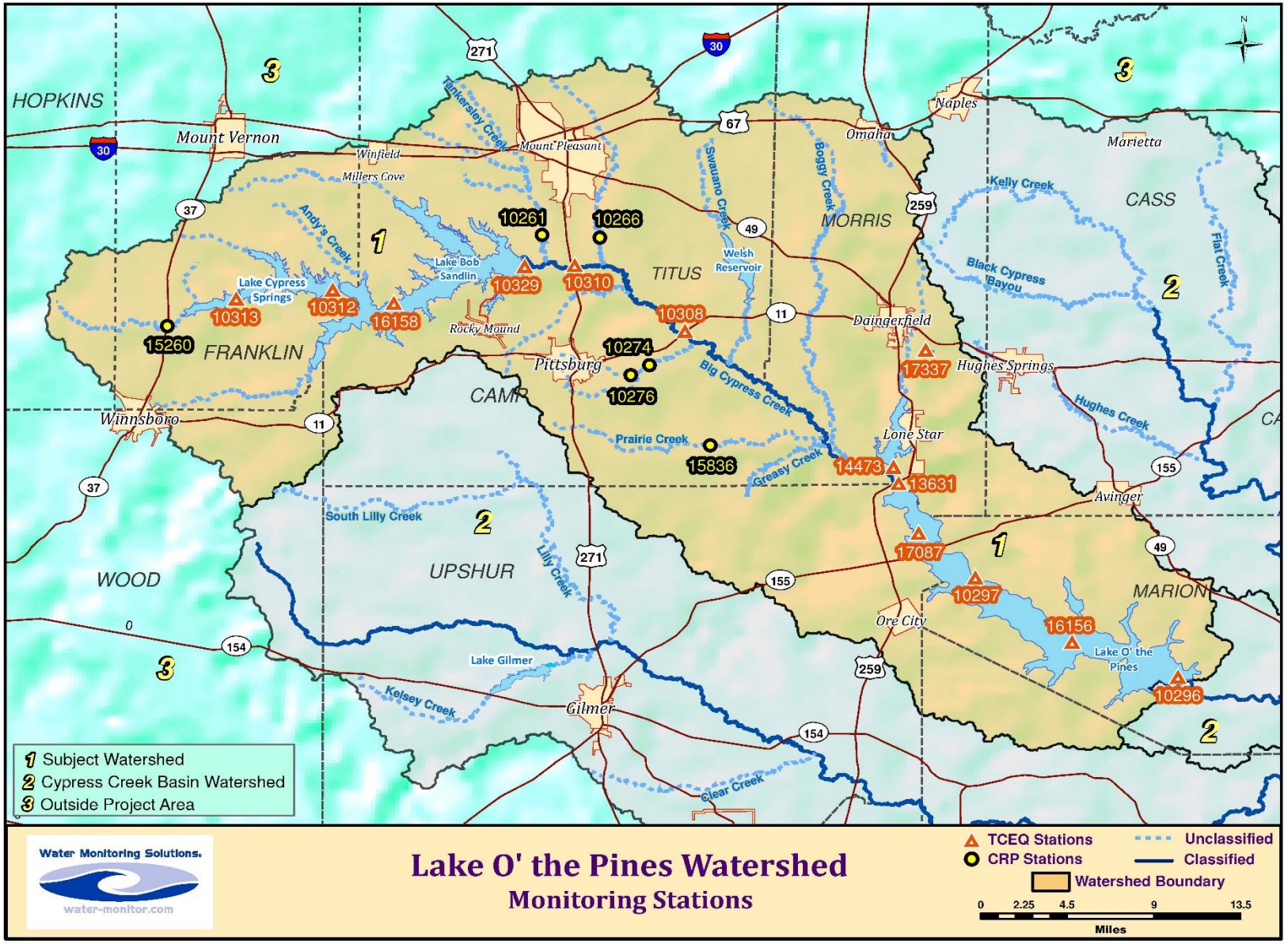

Figure 7: Map of the Lake O' the Pines watershed

LAKE O' THE PINES WATERSHED

Segment narratives for the Lake O' the Pines watershed begins in the headwaters of Big Cypress Creek and follows the waterway into Lake O' the Pines. Population centers include Mt. Pleasant (pop. 16,273), Pittsburg (pop. 4,707), Daingerfield (pop. 2,460), and Ore City (pop. 1,204).

The watershed is composed of four primary segments:

- Segment 0405 Lake Cypress Springs
- Segment 0408 Lake Bob Sandlin
- Segment 0404 Big Cypress Creek below Lake Bob Sandlin
- Segment 0403 Lake O' the Pines

Major tributaries to Lake O' the Pines include Big Cypress Creek (0404), Tankersley Creek (0404B), Hart Creek (0404C), Dry Creek (0404E), Sparks Branch (0404F), and Prairie Creek (0404J). Reservoirs in the Lake 'O the Pines Watershed include Lake 'O the Pines (0403), Ellison Creek Reservoir (0404A), Welsh Reservoir (0404D), Lake Dangerfield (0404N), Lake Monticello (0408A), Lake Cypress Springs (0405), and Lake Bob Sandlin (0408).

Figure 8: Stream flow measurement at station 15260 in Segment 0405A

SEGMENT 0405 – LAKE CYPRESS SPRINGS

Segment 0405 includes the uppermost reach of Big Cypress Creek and Lake Cypress Springs. The riparian zone of the headwaters of Big Cypress Creek is primarily agricultural including dairy, poultry, cow/calf operations, and hay meadows.

SEGMENT 0405A – BIG CYPRESS CREEK

Big Cypress Creek originates in Hopkins County near the Franklin County line and flows southeast into Lake Cypress Springs. Station 15260, located on SH 37 between Mount Vernon and Winnsboro, was the only station used for the evaluation of this reach of the stream. Regular sampling at station 15260 began in Fiscal Year (FY) 2009. Segment 0405A was listed in the *2020 Texas §303(d) List* for bacteria and dissolved oxygen. The geometric mean of the samples collected during the assessment period was 576 MPN/100 mL, well over the 126 MPN/100 mL geometric mean criterion. About 15% of the dissolved grab samples fell below the 2 mg/L criterion with an average of 1.05 mg/L.

The *2020 Texas Integrated Report* also included concerns for screening level for dissolved oxygen and chlorophyll *a*. Approximately one-quarter of the dissolved oxygen grab samples were below the 3.0 mg/L screening level while all but one of the chlorophyll *a* results exceeded the screening level of 14.1 µg/L.

Due to the typically low flow at the location, low dissolved oxygen values were often obtained during low flow. Stream flow under 1 cfs was reported for over a one-third of the site visits, and less than 2 cfs were measured at nearly half. Discussions about the representativeness of station 15260 were held at coordinated monitoring meetings. The group decided to move diel DO sampling upstream to a site that had more representative conditions to address the DO impairment. TCEQ continues monthly bacteria sampling at station 15270, but diel monitoring is being conducted at station 22151 located on County Road 3170 by NETMWD/WMS in 2020.

SEGMENT 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 it confluence with Big Cypress Creek before Lake Cypress Springs was impounded in 1970. The *2020 Texas Integrated Report* showed a concern for impaired habitat. No sampling has been conducted in this stream since 2002, and none is presently scheduled.

SEGMENT 0405 – LAKE CYPRESS SPRINGS

Lake Cypress Springs is located in Franklin County, south of the City of Mount Vernon. The popular recreational reservoir is managed by the Franklin County Water District. The watershed is primarily rural, though many new homes have been constructed along the shoreline over the past decade. The Franklin County Dam has a fixed spillway structure so water is discharged only when the lake level exceeds the normal conservation pool of 378 feet mean sea level. Water exiting the spillway flows directly into Lake Bob Sandlin.

Figure 9: Photo of Lake Cypress Springs

All assessment units (AU) were included on the *2020 Texas §303(d) List* for high pH and excessive algal growth. Over twenty percent of the surface pH measurements made at all stations in Lake Cypress Springs during the assessment period exceeded the 8.5 s.u. criterion with a median value of 9.0 s.u. Almost all high pH values were obtained during the warm months of the year. Current data indicate that the high pH impairment will continue into future assessments.

The *2020 Texas Integrated Report* classified Lake Cypress Springs as eutrophic, and ranked the reservoir in the top forty percent of reservoirs statewide for chlorophyll *a* despite having relatively low phosphorus concentrations. Values for chlorophyll *a* exceeded the 26.7 µg/L screening level in over forty percent of all samples and had a mean concentration slightly below the screening level at 26.5 µg/L.

In eutrophic reservoirs, algae and other primary producers consume the available carbon dioxide (CO_2) during the process of photosynthesis. Once the available carbon dioxide is exhausted, a CO_2 molecule will be broken away from the weak covalent bond of carbonic acid, thereby increasing the pH in the water column. After sunlight is no longer available for photosynthesis, CO_2 released through respiration, will bond with hydrogen to form carbonic acid, thereby decreasing pH. This pH cycling phenomenon can be assumed in Lake Cypress Springs since all of the grab samples were collected between 10 AM and 2 PM, the peak hours of primary productivity. However, without diel data, pH cycling cannot be demonstrated, nor the pH range calculated. The pH cycle is especially pronounced in waters with low alkalinity, such as that of Lake Cypress Springs and other reservoirs within the Cypress Creek Basin.

While DO concentration (mg/L) is used for assessment purposes, DO percent saturation is a more useful indicator of phytoplankton productivity. DO percent saturation values were compared with the high pH readings. In all but one of the high pH measurements coincided with dissolved oxygen saturation values above 100%. The correlation coefficient between pH and DO percent saturation was very high at 0.81 for all samples collected during this time period.

TCEQ Region 5 is scheduled to collect bacteria, conventionals, and field parameters on a quarterly basis at stations 10312 (dam) and 10313 (FM 115) in 2020.

SEGMENT 0408 – LAKE BOB SANDLIN

Lake Bob Sandlin is located immediately below Lake Cypress Springs and Lake Monticello, located in the upper reaches of the reservoir. Completed in 1977, the Fort Sherman Dam impounds over 8,700 surface acres with a capacity of almost 191,000 acre-feet of water. The reservoir is a popular recreational and fishing lake and is regulated by the Titus County Freshwater Supply District #1. In recent years, many new homes have been constructed along the shoreline.

The *2020 Integrated Report* showed that Lake Bob Sandlin was one of the least polluted reservoirs in the state. The reservoir ranked in the top 8% for the least amount of phosphorus, top 15% for the highest water clarity, and top 30% for the lowest concentration of chlorophyll *a*.

There were no impairments or concerns for Lake Bob Sandlin shown in the *2020Texas Integrated Report*. Despite low chlorophyll concentrations across the reservoir, pH was recorded above the criterion on several occasions since 2009. Over twenty percent of the surface pH values collected during the assessment period were reported above the 8.5 s.u. criterion.

Similar to Lake Cypress Springs, the correlation between pH and DO percent saturation was very high at 0.72, and all high pH values were associated with super-saturated DO. These high pH readings and strong correlation with DO percent saturation may be an indicator of eutrophication.

Unlike Lake Cypress Springs, chlorophyll *a* concentrations were typically low with only a few samples reported above the screening level. However, pH cycling may still be the cause of increasing pH in the assessment unit. The mean of the chlorophyll *a* samples collected at station 16158 over the past decade was 13.9 µg/L with only two samples exceeding the screening level.

Quarterly samples for bacteria, conventionals, and field parameters are scheduled to be collected by TCEQ Region 5 at stations 16158 (FM 21) and 10329 (dam) in 2020.

Figure 10: Water being released from the Fort Sherman Dam at Lake Bob Sandlin

Water is released from Lake Bob Sandlin into Big Cypress Creek, and these releases highly influence the water quality in the receiving stream. Since there are no in-stream flow requirements below the reservoir, water is released only to maintain freeboard. As discussed in the introduction, a total of 939,956 acre-feet of water was released from the reservoir from 2000 through 2014. Due to the pervasive drought, there were zero releases during seven of those fifteen years causing the stream flow of Big Cypress Creek to become dominated by effluent flows. As a result of flooding, a record amount of water was released from the Fort Sherman Dam in 2015 at more than 280,000 acre-feet. An additional 150,000 acre-feet was released by the end of April 2016. This amount of water could fill Lake Bob Sandlin more than twice. Combining the releases for 2015 through 2018, a total of 677,968 acre-feet was released, or about 60% of the total releases for the previous fifteen years combined.

SEGMENT 0404 – BIG CYPRESS CREEK BELOW LAKE BOB SANDLIN

Segment 0404 is the most urban-influenced segment in the Cypress Creek basin. Population centers include Mount Pleasant, Pittsburg, and Daingerfield. The segment begins at the release from Fort Sherman Dam on Lake Bob Sandlin and continues about 60 kilometers (38 miles) to the headwaters of Lake O' the Pines. Stream flow in this reach of Big Cypress Creek is highly influenced by releases from Lake Bob Sandlin. During periods of drought or low flow, the stream flow is primarily composed of treated municipal and industrial wastewater effluent.

There are eight permitted wastewater treatment plants in the Lake O' the Pines watershed, with the half of the plants located in Segment 0404. The two largest plants are the City of Mount Pleasant and Pilgrim's Pride, permitted at 3.0 million gallons per day each. Both plants are located near the City of Mount Pleasant. Pilgrim's Pride discharges into Segment 0404B – Tankersley Creek and the City of Mount Pleasant discharges into Segment 0404C – Hart Creek. The City of Pittsburg operates two plants with one on Segment 0404E - Dry Creek and another on Segment 0404F - Sparks Branch. The remaining plants in the Lake O' the Pines watershed include the cities of Daingerfield, Lone Star, Omaha, and Ore City.

LAKE O' THE PINES TMDL IMPLEMENTATION

Monitoring data indicated that the low dissolved oxygen in Lake O' the Pines resulted from high nutrient levels, and phosphorus was identified as the limiting factor in the reservoir. The Lake O' the Pines I-Plan was developed to reduce phosphorus loading into Lake O' the Pines which was approved on July 9, 2008.

Stakeholder meetings were held throughout the basin. As a result, milestones were developed by individuals with an interest in improving water quality. The I-Plan detailed priority controls that included descriptions of the control measures, responsible parties, and timeline along with 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.

Stakeholders specified voluntary actions aimed at reducing 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 through a Total Phosphorus Load Agreement (TPLA) between NETMWD and entities operating permitted waste water treatment plants within the Lake O' the Pines watershed. In 2014, a multi-million dollar upgrade to the Pilgrim's Pride WWTP was initiated in order to reduce its contribution of phosphorus into the watershed. In 2018, the plant discharged only 17% of its annual phosphorus allocation. For all systems combined in 2018, about 31% of the total annual allocation was discharged into the Lake O' the Pines watershed. Since the TPLA program began in 2015, the total amount of phosphorus discharged was less than 92,000 pounds, or about 40% of the annual allocations combined. The table below shows the total pounds of phosphorus discharged by each wastewater treatment plant in 2018 versus its annual allocation.

WWTP	Annual Allocation	Actual Discharge	Difference
Daingerfield	510	805	295
Lone Star	450	1,505	1,055
Mt. Pleasant	2,180	4,457	2,277
Omaha	260	544	284
Ore City	1,000	726	(274)
Pilgrim's Pride	53,200	9,544	(43,656)
Pittsburg/Dry Creek	570	209	(361)
Pittsburg/Sparks Branch	1,780	1,351	(429)
Total	**59,950**	**19,141**	**(40,809)**

Figure 11:Table of TPLA Total Phosphorus Tracking

The table below details impairments (NS), concerns for near non-attainment (CN), and concerns for screening level (CS) for Segment 0404 as shown in the *2020 Integrated Report*.

Segment AU	Description	Parameter	Support
0404_01	From Lake O' the Pines upstream 24 km	Chlorophyll *a*	CS
		Nitrate	CS
0404_02	From the confluence with an unnamed tributary upstream 37.2 km	*E. coli*	**NS**
		Nitrate	CS
		Total Phosphorus	CS
0404A	Ellison Creek Reservoir	Sediment Toxicity (LOE)	**NS**
		Cadmium, Iron, Lead	CS
		Manganese, Nickel, Zinc	CS
		dioxin in fish tissue	**NS**
		PCBs in fish tissue	**NS**
0404B	Tankersley Creek	Habitat	CS
		E. coli	**NS**
		Nitrate	CS
		Total Phosphorus	CS
0404C	Hart Creek	*E. coli*	**NS**
		Nitrate	CS
0404E	Dry Creek	*E. coli*	CN
		Nitrate	CS
0404F	Sparks Branch	*E. coli*	CN
		Nitrate	CS
0404J	Prairie Creek	DO 24-HR Avg.	**NS**
		DO 24-HR Min.	**NS**
0404K	Walkers Creek	*E. coli*	CN
0404N	Lake Daingerfield	Mercury in tissue	**NS**, CS
0404O	Dragoo Creek	*E. coli*	CN
0404S	Unnamed Trib. To BCC	DO Grab	CS
		E. coli	CN
0404T	Prairie Branch	DO Grab	CN, CS
		E. coli	CN
0404U	Evans Creek	*E. coli*	CN
0404V	Hayes Creek	DO Grab	CS
		E. coli	CN

Figure 12: Table of the 2020 Texas Integrated Report for Segment 0404

Station 10310 at US 271 and station 10308 at SH 11 are routinely monitored in the upper assessment unit of Big Cypress Creek while station 13631 at US 259 represents the lower assessment unit. Station 10310 is located downstream of the confluence with Tankersley Creek while Station 10308 is after the confluence with Hart Creek and Walkers Creek.

The bacteria impairment in the upper assessment unit of Segment 0404 was first listed in 2002. The geometric mean of the *E. coli* samples collected during the assessment period was 203 MPN/100 mL exceeding the 126 MPN/100 mL geometric mean criterion.

Figure 13: Photo of Big Cypress Creek at station 10308

The sulfate impairment was removed from both assessment units in the *2020 Texas §303(d) List* since no sulfate samples collected during the assessment period exceeded the 100 mg/L criterion. A review of the data indicated that sulfate concentration was inversely related to stream flow due to the lowest values being obtained during high flow and release periods while the highest concentrations were observed during low flow and drought periods.

Nutrients and chlorophyll *a* were included as concerns in this segment in the *2020 Integrated Report*. High nitrate was a concern in both assessment units. Total phosphorus was a concern

only in the upper reach while chlorophyll *a* was a concern in the lower reach. The screening levels for both total phosphorus and nitrate were exceeded at both stations.

Since the Pilgrim's Pride wastewater treatment plant upgrade was completed in early 2015, the phosphorus results have noticeably declined with most results falling below the screening level of 0.69 mg/L. Similar to sulfate, the highest concentrations of nitrate were collected at lower stream flows indicating that point sources were the likely contributors of the excess nutrient. Nitrate samples exceeded the screening level at both stations. The mean sample result collected in the upper assessment unit was 22.14 mg/L, or over eleven times the screening value of 1.95 mg/L. Nitrate was significantly lower at station 13631, however, over forty percent of the samples exceeded the screening level.

The high nutrient concentrations in Big Cypress Creek resulted in a concern for chlorophyll *a* in the lower assessment unit. Over one-third of the samples collected during the assessment period exceeded the 14.7 µg/L screening level with an average of the exceedances at 32.73 µg/L. The excessive nutrients continued into Lake O' the Pines and have also degraded its water quality. These effects are discussed in further detail in Lake O' the Pines section of the report.

In 2020, TCEQ Region 5 is scheduled to monitor eight times at stations 10308 (SH 11) and 13631 (US 259) for flow, bacteria, and for field and conventional laboratory parameters. NETMWD/WMS has begun a special study of sulfate and nitrate in Tankersley Creek and at station 10310. Water quality and stream flow are scheduled to be collected on a monthly basis.

SEGMENT 0404B – TANKERSLEY CREEK

Tankersley Creek arises in Titus County northwest of the city of Mount Pleasant. The stream flows in a southeasterly direction for approximately two miles before it enters Tankersley Lake. Downstream of the impoundment, the stream flows about eight miles to its confluence with Big Cypress Creek at the Titus-Camp county line. Tankersley Creek is the receiving water for the Pilgrim's Pride wastewater treatment plant, located on FM 127, west of Mount Pleasant.

Tankersley Creek was first listed as impaired for bacteria in 2000 which has continued in the *2020 Integrated Report*. The geometric mean was 270 MPN/100 mL, more than double the criterion of 126 MPN/100 mL. Due to the impairment, a bacteria study, *The Assessment of Contact Recreation Use Impairments and Watershed Planning for Big Cypress Creek and Tributaries (Hart and Tankersley Creeks)*, was funded by the Texas State Soil and Water

Conservation Board. The study was conducted from 2009 through 2011 and included a Recreation Use Attainability Analysis (RUAA). The purpose of the RUAA was to determine if primary contact recreation was the appropriate use designation of the stream. The results were submitted to the TCEQ which will be used to determine the best strategy to address the impairment.

Figure 14: Photo of Tankersley Creek at station 10261

Concerns for screening levels of nitrate and total phosphorous were identified in the *2020 Integrated Report*. Routine conventionals sampling began at Station 10261 (FM 3417) in FY 2013 since only a few samples had been collected in this reach.

Prior to upgrading the Pilgrim's Pride wastewater treatment plant, phosphorus results regularly exceeded the 0.69 mg/L screening level with an average concentration of 3.37 mg/L, or about five times the screening level. Since the plant upgrades were completed in the spring of 2015, the mean result was 0.31 mg/L with no samples exceeding the screening level.

Similar to Segment 0404, sulfate is another parameter of interest. The maximum sulfate value collected in Tankersley Creek was 508 mg/L collected in July 2013 while the mean was 138 mg/L. Since the plant upgrades were completed, the average sulfate concentration declined to 82 mg/L. Since the region began receiving higher rainfall in 2015 than in previous years, the

decline in sulfate values may be a result of dilution due to higher stream flows or a combination of higher flows along with the plant upgrades.

Due to the high nitrate and sulfate results, special studies of these parameters were funded by CRP. Monthly samples for sulfate, ammonia, nitrite, nitrate, Total Kjeldahl Nitrogen (TKN), and total phosphorus were collected at three stations in Tankersley Creek in order to identify potential sources. The nitrate special study monitoring began in July 2018 and was completed in June 2019 and the preliminary results are discussed in the next section of the report. The sulfate special study began in November 2019 and will continue through October 2020. The results of both of these studies will be discussed in detail in a future basin highlights report.

In addition to the monthly special study sampling, quarterly monitoring for flow, bacteria, and for field and conventional parameters continue at station 10261 (FM 3417) in 2020.

SEGMENT 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 two small tributaries to the east of Mount Pleasant, Hayes Creek and Evans Creek. The City of Mount Pleasant WWTP outfall is located on Hart Creek approximately 2 kilometers upstream of station 10266, located on County Road 4550.

The *2020 Integrated Report* included an impairment in Hart Creek for bacteria. The geometric mean was 399 MPN/100 mL, more than three times the criterion of 126 MPN/100 mL. Hart Creek was first identified as not meeting the water quality standard for bacteria in 2006. Data collected since the last assessment indicated that bacteria concentrations on Hart Creek continued to exceed the criterion. Due to the listing, Hart Creek was included in the contact recreation study and RUAA funded by the Texas State Soil and Water Conservation Board. The TCEQ will use information obtained from a bacteria study, completed in 2011, to determine the best management strategy to address this impairment.

The *2020 Integrated Report* also showed a concern for nitrate. Routine conventionals sampling began at Station 10266 at CR 4550 in FY 2013 to obtain recent data for the stream. Prior to FY 2013, no samples had been reported after 2003. The mean nitrate concentration for samples collected since 2013 was 7.37 mg/L with the highest result of 15.4 mg/L collected in July 2013. Over half of the results assessed exceeded the 1.95 mg/L screening level.

Due to the high nitrate levels, Hart Creek was included as part of the nitrate special study. Monthly samples for ammonia, nitrite, nitrates, TKN, and total phosphorus were collected at two stations in Hart Creek in order to identify potential sources. Monitoring was conducted at station 10272 (SH 49) and at station 10266 (CR 4550). The special study monitoring was completed in June 2019, and the preliminary results are discussed below.

Unlike Tankersley Creek and Big Cypress Creek, phosphorus and sulfate were below the screening levels. No samples exceeded the screening level for either parameter.

NETMWD/WMS is scheduled to collect samples for flow, bacteria, field, and conventional parameters quarterly at station 10266 (CR 4550) in 2020.

NITRATE SPECIAL STUDY RESULTS

Stations in both Tankersley and Hart Creeks were sampled on a monthly basis for a period of one year at sites located both upstream and downstream of the wastewater treatment plants. Based upon samples from the upstream stations, the preliminary results of the special study indicated that the primary source of excessive nutrients, including ammonia, nitrate, and total phosphorus, in both Tankersley and Hart Creeks were a result of waste water treatment plant discharge. In Tankersley Creek, the results from the station located below the outfall had lower total phosphorus results than in previous years suggesting that the recent upgrades to the Pilgrim's Pride wastewater treatment plant have significantly reduced the amount of total phosphorus entering the stream. However, the results of the study suggested that the plant upgrades have not addressed the input of nitrate and other forms of nitrogen. Nitrate, nitrite, ammonia, and total Kjeldahl nitrogen were much higher at the station located below the outfall than at the most upstream station. These constituents appeared to have been diluted during periods of high flow at the most downstream station.

Non-point sources may be contributing less nitrate in the watershed than previously thought. The sample results indicated that the concentration of nitrate decreased as the water moved downstream. However, non-point sources may be significant contributors of total phosphorus to Tankersley Creek.

Similar to Tankersley Creek, the results for Hart Creek indicated that the City of Mount Pleasant wastewater treatment plant was likely the main contributor of nitrate into the watershed. Sample results suggested that the plant was not contributing excessive amounts of other

nutrients such as ammonia, nitrite, or total phosphorus into Hart Creek. However, the reduction of nutrients discharged in this stream should not be discounted. Excess nutrient contributions from both point and non-point sources have resulted in elevated algal productivity in Lake O' the Pines which has affected the water quality of the entire reservoir. This study will be discussed in more detail in a future basin highlights report.

SEGMENT 0404E – DRY CREEK

The headwaters of Dry Creek are located south of Pittsburg, Texas. The stream serves as a receiving water for the City of Pittsburg wastewater treatment plant. Dry Creek flows toward the east to its confluence with Big Cypress Creek in northeast Camp County. Sampling in Dry Creek was conducted at station 10274 at McMinn Road. The riparian zone of the property immediately upstream and downstream of the bridge crossing is improved pasture and is used for grazing cattle. Cattle were noted to be in the stream during several monitoring events and likely affect the water quality at the station.

The stream was shown as impaired for *E. coli* in the *2020 Integrated Report* and identified nitrate as a concern. Recent sampling began in the summer of 2015 at station 10274 at McMinn Road. The *E. coli* results had a geometric mean of 544 MPN/100 mL while nitrate exceeded the 1.95 mg/L screening level with a mean of 6.86 mg/L.

TCEQ is scheduled to monitor this stream for bacteria and flow nine times in 2020.

SEGMENT 0404F – SPARKS BRANCH

Sparks Branch is a tributary of Dry Creek and is a receiving water for the City of Pittsburg wastewater treatment plant. There is little riparian vegetation along the stream as land in the Sparks Branch watershed is intensively used for improved pastures and grazing.

Sparks Branch had not been assessed previously due to the lack of recent data. Monitoring at station 10276 at CR 4220 began in April 2016 and continued through FY 2018. The station was temporarily discontinued in FY 2019 since enough data had been collected for an assessment. The *2020 Integrated Report* was the first complete assessment of the water body and showed concerns for *E. coli* and nitrate. The bacteria results were very high with a geometric mean of 695 MPN/100 mL while over half of the nitrate samples were above the screening level with a mean of 10.39 mg/L.

TCEQ is scheduled to monitor this stream for bacteria and flow nine times in 2020.

SEGMENT 0404J – PRAIRIE CREEK

Prairie Creek flows on the southern border of Camp County before its confluence with Big Cypress Creek near US 259. The Lake O' the Pines I-Plan workgroup identified 24-Hour dissolved oxygen monitoring as a priority for this watershed in order to evaluate potential impacts on loadings into the reservoir.

The stream was shown as impaired in the *2020 Texas §303(d) List* for non-attainment of the 24-Hour dissolved oxygen average and minimum criteria. The impairment was based upon limited data as there were only eight diel events assessed. Due to a concern for dissolved oxygen shown in previous assessments, diel sampling began in FY 2017 at station 15386 at FM 557. Three of the eight diels conducted during the assessment period were below the criterion for 24-Hour dissolved oxygen average and 24-Hour dissolved oxygen minimum. The stream was not flowing during all three of these studies.

Four diel events are scheduled to be conducted by NETMWD/WMS at station 15386 in 2020. Conventionals and bacteria sampling may be added to the schedule in the future.

SEGMENT 0404K – WALKERS CREEK

Walkers Creek arises in Camp County northwest of Pittsburg. The stream flows generally to the north east to its confluence with Big Cypress Creek. Walkers Creek was included in the contact recreation study in 2009 to 2011. The bacteria study results were below the criterion indicating that the stream supported its contact recreation designation. However, a concern for *E. coli* was shown for this stream as a carry-over from previous assessments since no data were evaluated during the assessment period. Due to meeting its stream standards, stakeholders agreed to discontinue monitoring at this water body in FY 2013 in order to address impairments and concerns elsewhere within the basin.

Segment 0404O – Dragoo Creek

Segment 0404S – Unnamed Tributary of Big Cypress Creek

Segment 0404T – Prairie Branch

Segment 0404U – Evans Creek

Segment 0404V – Hayes Creek

These stream segments are intermittent tributaries to Tankersley, Hart, and Big Cypress Creeks and were included as part of *The Assessment of Contact Recreation Use Impairments and Watershed Planning for Big Cypress Creek and Tributaries (Hart and Tankersley Creeks)*. No samples have been collected in these streams since the study was completed in 2011. The *2020 Integrated Report* showed concerns for *E. coli* and depressed dissolved oxygen as a carry-over from previous assessments since no data were collected during the current assessment period. No monitoring is scheduled in these water bodies in 2020.

Segment 0404A – Ellison Creek Reservoir

Ellison Creek Reservoir (sometimes called Lone Star) is located due west of Lone Star in southern Morris County. The drainage area of the Ellison Creek watershed is thirty-seven square miles and the reservoir has a surface area of approximately 1,516 acres. The reservoir provides process water and cooling water for U. S. Steel Company and the Southwest Gas and Electric Company Power Plant. Water discharged from Ellison Creek Reservoir flows into Big Cypress Creek immediately above US 259 near the headwaters of Lake O' the Pines.

Ellison Creek Reservoir was included on the *2020 Texas §303(d) List* for Polychlorinated biphenyls (PCBs) and dioxin in fish tissue, and for sediment toxicity. The *2020 Integrated Report* showed concerns for screening levels for cadmium, iron, lead, manganese, nickel, and zinc in sediment. Sediment samples were last collected in June 2005. All sediment samples were collected at station 14473 near the dam greatly exceeded the screening limits.

TCEQ Region 5 monitors Station 14473, located at the dam, quarterly, for metals in water and field parameter. Although sediment samples are needed to address the concerns, no sediment sampling is scheduled during 2020.

Figure 15: Sunset over Lake Lone Star Park

SEGMENT 0404N – LAKE DAINGERFIELD

Lake Daingerfield is an eighty-acre reservoir which was completed in 1935 as a Civilian Conservation Corps project. Water released from Lake Daingerfield flows into Brutons Creek and then into Ellison Creek Reservoir. This segment was included on the *2020 Texas §303(d) List* for non-support and concern for the screening level of mercury in fish tissue. A fish consumption advisory is in effect for the entire reservoir.

Region 5 monitors at station 17337 (Lake Daingerfield at Headwaters in Daingerfield State Park) quarterly for conventionals, bacteria, and field parameters.

SEGMENT 0403 – LAKE O' THE PINES

The Lake 'O the Pines watershed encompasses approximately 885 square miles. The lower portion of the watershed lies within the Pineywoods Ecoregion and is composed of hardwood and pine forests. The upper portion, near Lake Bob Sandlin is in the Post Oak Savanah Ecoregion which is comprised of patches of oak woodlands interspersed with grasslands. The watershed is rural. Land is predominantly used for agriculture, including silviculture, poultry, and cattle.

Lake O' the Pines, which is about 18,700 acres, was created for flood control after the historic flooding of the City of Jefferson in 1945. The reservoir was authorized by the U.S. Congress through the Flood Control Act of 1946. Construction of the Ferrell's Bridge Dam on Big Cypress Bayou was completed in 1959.

Figure 16: Photo of the 1945 flood in Jefferson

Despite historic rainfall in 2015 and in early 2016, Lake O' the Pines performed its primary function and prevented the City of Jefferson from flooding. Through controlled water releases,

over one million acre-feet of water was discharged from the reservoir between January and August 2016 which is enough water to fill Caddo Lake almost seven times.

Lake O' the Pines has a normal conservation pool of 228.5 feet. Discharges from the two gates in the control structure vary from a minimum of five cfs to a maximum of 3,000 cfs. The storage capacity of the reservoir is approximately 254,000 acre-feet. Lake O' the Pines provides water for eight cities and towns, numerous rural water districts, a steel manufacturer, and electricity generators. In addition to recreation and tourism, the reservoir is an important resource to the timber industry as well as to agricultural enterprises such as poultry, dairy, and cattle operations.

Figure 17: Photo of Lake O' the Pines from the dam

In the *2020 Integrated Report*, the TCEQ showed Lake O' the Pines as an eutrophic reservoir and ranked it in the top thirty percent for elevated chlorophyll compared with over 130 resevoirs state-wide. As discussed in the Lake Cypress Springs narrative, samples collected midday with a high pH and super-saturated dissolved oxygen was an indication of eutrophication.

In the *2020 Integrated Report*, all but the upper assessment unit (AU 0403_04) of the reservoir was impaired for high pH. AU 0403_04 was impaired for dissolved oxygen. Over 25 percent of the pH samples collected in the lower three assessment units exceeded the 8.5 s.u. pH criterion with a median of the exceedances of 8.82 s.u.

Unlike the rest of the reservoir, only one high pH value was recorded in AU 0403_04 during the assessment period. A value of 8.7 s.u. was observed in September 2012. Chlorophyll *a* was 62.1 µg/L, almost triple the screening level, while dissolved oxygen was observed at 118.4% saturation.

Another area of interest in Lake O' the Pines was nutrient input since they are necessary to support primary productivity. As discussed earlier in this section, the TMDL study found that a 56% reduction in phosphorus entering the reservoir was necessary to increase dissolved oxygen concentrations within Lake O' the Pines.

Nutrients and/or chlorophyll concentrations regularly exceeded their respective screening levels during the assessment period. Chlorophyll *a* exceeded the 26.7 µg/L screening level in about forty percent of the samples. While none of the total phosphorus or nitrate samples collected in the two lower assessment units exceeded screening levels, the excess nutrients entering Lake O' the Pines resulted in elevated chlorophyll *a* results throughout the entire reservoir. Although the mean chlorophyll concentration of samples collected throughout the reservoir was only slightly below the 26.7 µg/L screening level, the highest chlorophyll *a* concentration was measured in June 2018 at 97.3 µg/L. Similar to pH, most elevated chlorophyll values were obtained from samples starting in 2011.

In contrast to the lower assessment units, the mean of the nitrate samples collected in the headwaters assessment unit was nearly 4.5 times the screening level of 0.37 mg/L, while the mean total phosphorus concentration was 1.5 times the screening level. Although highly diminished by the time the water reached the next assessment unit, nitrate was still twice the screening level and phosphorus was still well above the method detection limit.

High pH, chlorophyll, and dissolved oxygen values suggest that Lake O' the Pines is becoming more eutrophic. Since all of the grab samples were primarily collected between 10 AM and 2 PM, the peak hours of primary productivity, the pH cycling phenomenon can be assumed. However, without diel data, pH cycling cannot be demonstrated nor the pH range measured.

The data further suggest that pH is generally increasing throughout the entire reservoir including the two middle assessment units where the the increasing trend was found to be statistically significant in the *2019 Cypress Creek Basin Summary Report*. All of the pH measurements reported above the 8.5 s.u. criterion in Lake O' the Pines were also reported with super-saturated dissolved oxygen values. Similar to Lake Cypress Springs, a correlation between pH and DO percent saturation was approximately 0.8. The combination of elevated chlorophyll and super-saturated dissolved oxygen supports the assumption that the higher pH readings were a direct result of primary productivity.

Unlike the other assessment units, low dissolved oxygen was more frequently observed in the headwaters of the reservoir. Nearly one-quarter of the 26 dissolved oxygen grab samples collected were below the criterion, with a mean of 3.67 mg/L. Due to these low DO grab samples, the headwaters assessment unit had a concern for low dissolved oxygen. Additionally, this AU was impaired for low 24-Hour dissolved oxygen minimum. There were no diel data collected during the assessment period and none are presently scheduled. Diel collections should be considered in the future to address this impairment.

As a result of the pH impairments, a special study was scheduled to be conducted in 2020 and 2021. Targeted diels will be performed in the lower assessment units in the months of May through October 2020 and in May through August 2021. These data will be compared with the results obtained from the continuous monitors located in the upper portion of the reservoir.

TCEQ Region 5 is scheduled to collect quarterly field parameters, bacteria, and conventionals samples at stations representing all four assessment units.

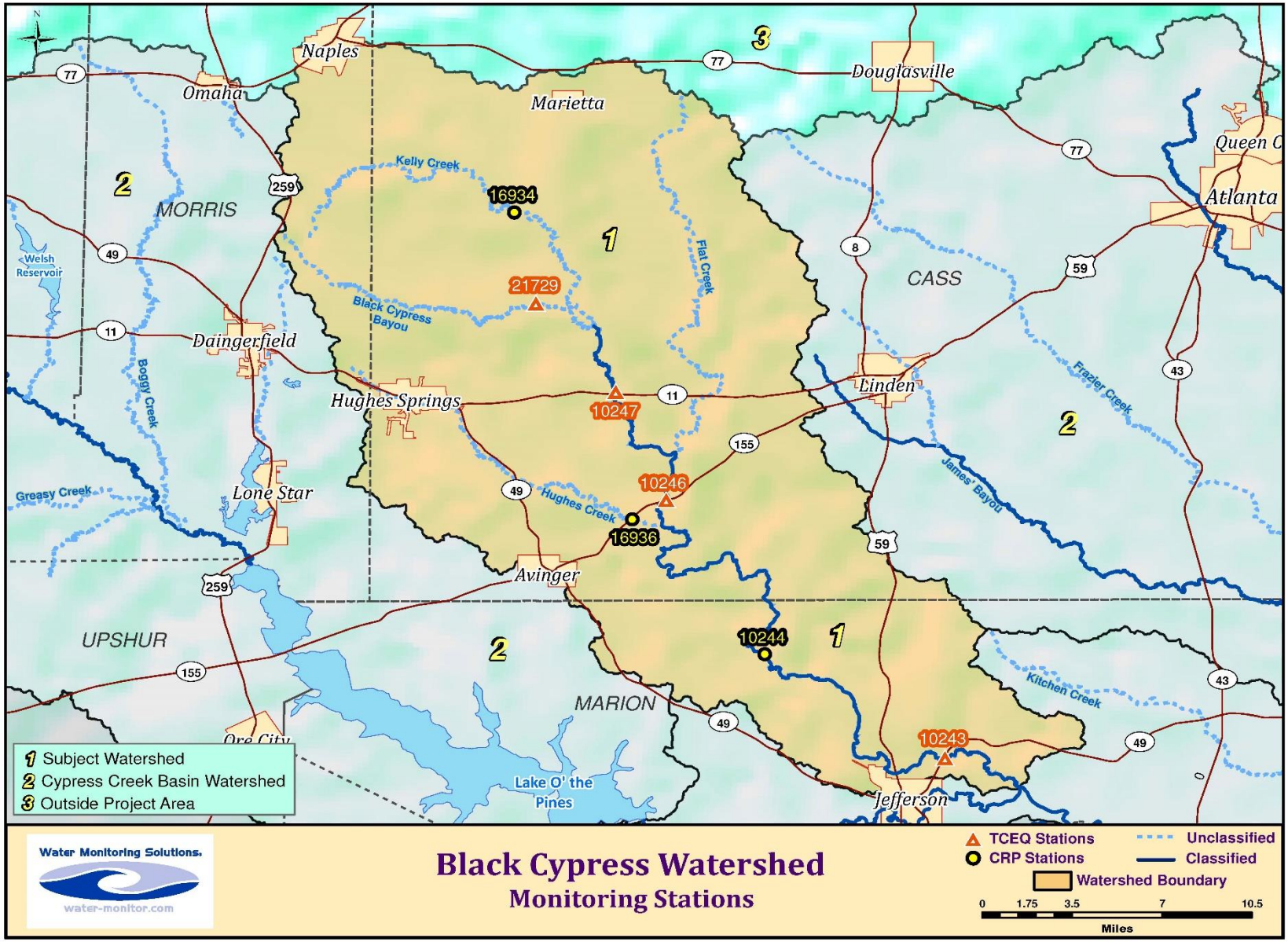

Figure 18: Map of Black Cypress Bayou watershed

SEGMENT 0410 – BLACK CYPRESS CREEK (BAYOU)

Black Cypress Bayou was formerly designated as Segment 0402A, an unclassified water body. Segment 0410 became a classified water body in the most recent Texas Surface Water Quality Standards revision and is shown as Segment 0410 in the *2020 Integrated Report*. The segment boundary begins at the confluence with Big Cypress Creek and upstream to FM 250. Segment 0410 is divided into four assessment units in addition to the unclassified water body 0410A which is intermittent with perennial pools.

Figure 19: Black Cypress Creek at US 59

Segment 0410 was included on the *2020 Texas §303(d) List* for copper and lead in water, dissolved oxygen, and mercury in fish tissue. The lowest assessment unit was impaired for copper, although this impairment was based upon limited data. Presently, the source of copper has not been identified.

Routine sampling at station 10244 near Berea resumed in 2015. The assessment unit had impairments for 24-Hour dissolved oxygen average based upon two out of eleven diel studies not meeting the 5 mg/L criterion. Both of these results occurred during low flow. Due to limited data, the assessment unit also showed a concern for non-attainment of the bacteria standard with a geometric mean of 194.38 MPN/100 mL.

Pruitt Lake, AU 0410_03, was shown as impaired for lead in water. Out of fourteen samples, a single result of 0.43 µg/L exceeded the 0.40 µg/L criterion. Pruitt Lake was also impaired for mercury in fish tissue. Sample results obtained during the current assessment period revealed that this reach met stream standards for dissolved oxygen and copper in water. As a result, these parameters were removed from the *§303(d) List.*

The uppermost reach of Black Cypress Creek, AU 0410_04, was removed from the *§303(d) List* for bacteria, but remained impaired for dissolved oxygen grab sample. It should be noted that none of the sixteen dissolved oxygen measurements made during the assessment period fell below the criterion.

0410A Black Cypress Creek

Segment 0410A is an intermittent reach of Black Cypress Creek. It extends from Kelly Creek upstream to FM 250. This reach had previously been impaired for dissolved oxygen, but sampling results met the criterion during the current assessment period. The *2020 Texas §303(d) List* showed an impairment for bacteria. The twenty-three *E. coli* samples analyzed during the assessment period had a geometric mean of 281.58 MPN/100 mL, well above the 126 MPN/100 mL criterion.

In 2020, the TCEQ Region 5 is scheduled to collect field, flow, conventionals and bacteria samples on a quarterly basis at stations 10243 (SH 49), 10247 (SH 11), and 21729 (SH 11 and FM 250). In addition, Region 5 will collect bacteria samples at station 10247 three additional times along with collecting a single metals in water sample at station 10243.

NETMWD/WMS is scheduled to collect field, conventionals, bacteria, and flow on a quarterly basis at station 10244 (near Berea).

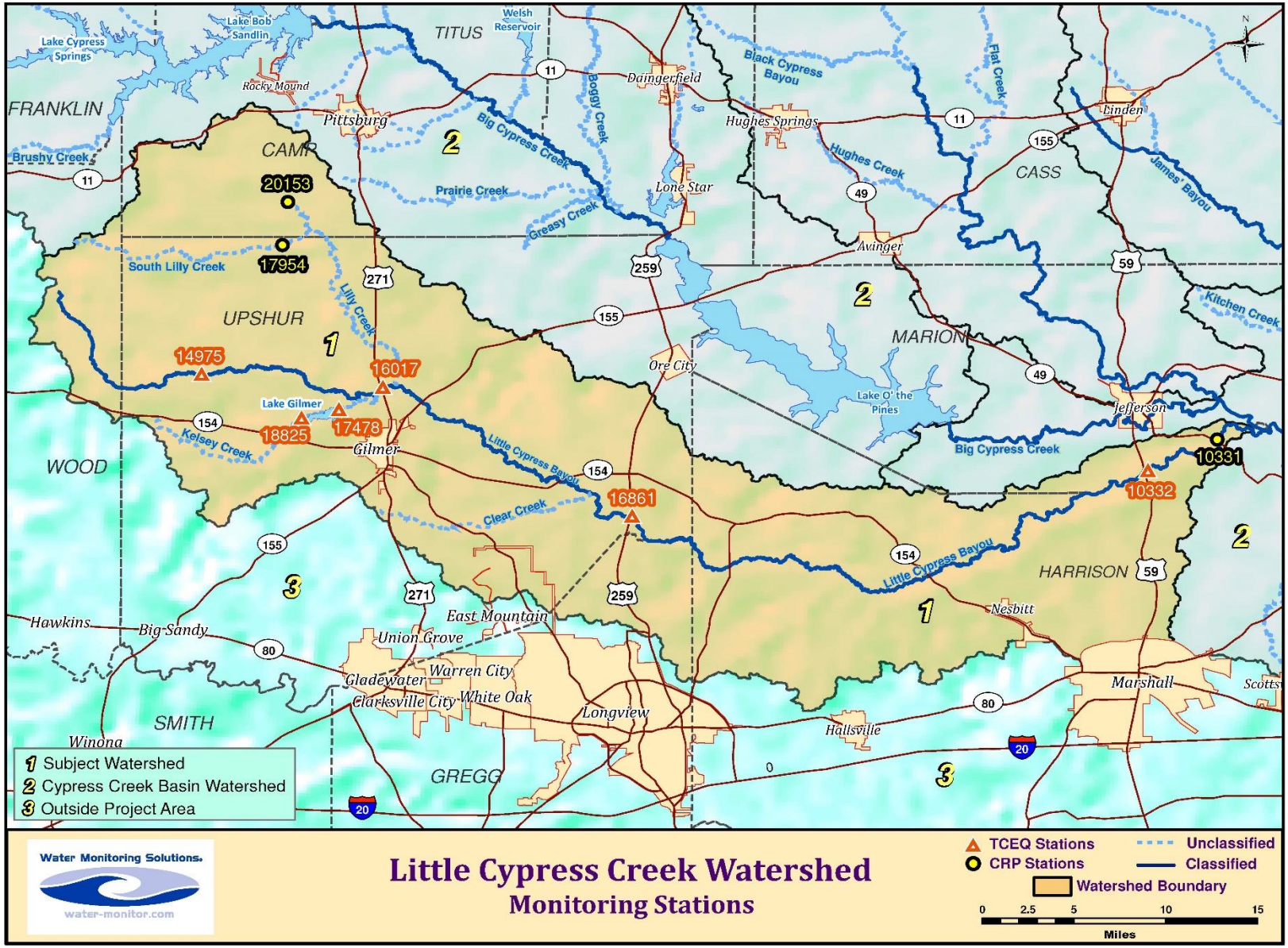

Figure 20: Map of Little Cypress Creek watershed

SEGMENT 0409 – LITTLE CYPRESS CREEK (BAYOU)

Little Cypress Bayou emerges in the Pineywoods near FM 2088 in Wood County. The approximately 163-kilometer (105 miles) bayou forms much of the southern boundary of the Cypress Creek Basin, and joins Big Cypress Creek east of Jefferson.
The Little Cypress Creek segment was identified as impaired for low levels of dissolved oxygen in 2000 and for elevated bacteria in 2006. These impairments were included in the *2020 Texas §303(d) List*.

Figure 21: Photo of Little Cypress Creek at station 10331

ASSESSMENT UNIT 0409_01

The lower 41 kilometers of Little Cypress Creek, from the confluence with Big Cypress Creek on the Harrison/Marion County line to Lawrence Creek, encompasses AU 0409_01. Sampling is conducted at station 10331 at FM 134 and at station 10332 at US 59.

The reach was listed for non-support of the 24-Hour dissolved oxygen criteria. The listing had been a carry-forward from previous assessments due to inadequate data. Due to the listing in

the 2016 assessment, diel studies resumed in this reach in October 2016. Five out of the eight diels completed during the assessment period had a 24-Hour dissolved oxygen average reported less than the 4.14 mg/L criterion while half had a 24-Hour dissolved oxygen minimum below the 3.14 mg/L criterion.

In 2020, NETMWD/WMS will monitor station 10331 quarterly for field, flow, bacteria, and conventional parameters and will conduct diel studies four times per year. TCEQ Region 5 is scheduled to collect field, flow, bacteria, and conventional parameters quarterly at station 10332.

ASSESSMENT UNIT 0409_02

The 29.2-kilometer reach extending upstream of Lawrence Creek, AU 0409_02, was on the *2020 Texas §303(d) List* for not supporting the 24-Hour dissolved oxygen average and *E. coli* criteria. There was also a concern for non-attainment of the 24-Hour dissolved oxygen minimum standard. These listings were a carry-forward from previous assessments and were based upon inadequate data.

All data for AU 0409_02 were collected at station 15773, located at FM 450. Sampling at this station was discontinued in 2012. TCEQ staff determined that the location was not representative of the hydraulic conditions of the AU and another station has yet to be identified. The *E. coli* results for the two samples collected from 2011 to 2012 had a geometric mean of 97.57 MPN/100 mL, below the 126 MPN/100 mL criterion. However, until sampling is resumed within this assessment unit, theseimpairments will likely remain.

ASSESSMENT UNIT 0409_03

The upper-middle reach of Little Cypress Creek extends 52.2 kilometers upstream to the confluence with Kelsey Creek. The AU was removed from the *Texas §303(d) List* for *E. coli* as it met the criterion during the current assessment period. There were no impairments or concerns shown for this assessement unit in the *2020 Integrated Report*.

Region 5 is scheduled to collect field, flow, bacteria, and conventional parameters quarterly at station 16861, located at US 259, in 2020.

ASSESSMENT UNIT 0409_04

The uppermost reach of the segment extends from the headwaters near FM 2088 in Wood County downstream 41.1 kilometers. The AU is monitored by TCEQ at station 16017 (US 271) and at station 14975 (FM 852).

The assessment unit was included on the *2020 Texas §303(d) List* for not supporting the *E. coli* criterion. The geometric mean of the 37 samples collected during the assessment period was 351.5 MPN/100 mL.

TCEQ Region 5 is scheduled to collect quarterly samples for field, flow, conventional, and bacteria samples at station 16017 in 2020 and is sampling nine times for bacteria and flow at station 14975.

SEGMENT 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. Lilly Creek is sampled at station 20153, located on FM 556 south of Pittsburg. The stream is routinely reported as low or no flow.

Lilly Creek was impaired for bacteria in the *2020 Texas §303(d) List*. The geometric mean of the *E. coli* samples was 283.64 MPN/100 mL. A Recreational Use Attainability Analysis should be considered in Lilly Creek to determine whether primary contact recreation is the appropriate use designation.

Concerns for dissolved oxygen grab and chlorophyll screening levels were included in the *2020 Integrated Report*. Four samples fell below the 3.0 mg/L screening level with a mean of 1.95 mg/L. The low dissolved oxygen readings were observed in July of those years. No values less than 3.0 mg/L were reported in Lilly Creek after October 2014, suggesting that the low dissolved oxygen readings were due to low stream flow. About forty percent of the sample results exceeded the screening criterion of 14.1 µg/L with a mean of the exceedances of 31.91 µg/L.

In 2020, quarterly sampling is scheduled to be conducted at station 20153 for bacteria, flow, conventional, and field parameters by WMS.

Figure 22: Photo of Lilly Creek at station 20153

SEGMENT 0409B – SOUTH LILLY CREEK

South Lilly Creek is an unclassified water body that extends from its confluence with Lilly Creek to FM 1647 in Upshur County. The stream is intermittent, the watershed has no population centers, and is comprised of improved pastures and forested land. Much of riparian vegetation along the stream has been removed and cattle commonly have direct access to the stream. South Lilly Creek is sampled at station 17954, located at FM 2454 south of Pittsburg.
South Lilly Creek was first identified as impaired for bacteria in 2006. The impairment continued into the *2020 Texas §303(d) List*. Data collected during the assessment period had a geometric mean of 398.11 MPN/100 mL, well above the 126 MPN/100 mL criterion.

A Recreational Use Attainability Analysis was conducted in South Lilly Creek by the Texas Institute for Applied Environmental Research in 2016 (*Texas Institute for Applied Environmental Research, 2017*). No recreational use of the stream was observed during the study period, and landowner interviews indicated that the stream was not used for contact recreation. Barriers to recreational use included access to the stream limited to road crossings, barbed wire fencing, logjams, thick vegetation, and venomous snakes. As a result of the study, TCEQ may choose to apply a secondary contact recreation standard.

NETMWD/WMS is scheduled to conduct quarterly monitoring for field parameters, flow, conventional parameters, and *E. coli* at station 17954 in 2020.

SEGMENT 0409D – LAKE GILMER

Lake Gilmer is located in central Upshur County. The reservoir was constructed in 2001 and covers approximately 1,010 surface acres. There were no concerns or impairments shown in the *2020 Integrated Report* for this water body. Quarterly monitoring is conducted by TCEQ Region 5 at stations 17478 (dam) and 18825 (FM 852) for conventional, bacteria, and field parameters.

SEGMENT 0409E – CLEAR CREEK

Clear Creek, located in Upshur County, is a small tributary to Little Cypress Creek. The *2020 Integrated Report* shows a concern for non-attainment for impaired benthic community along with a concern for screening level for habitat. Biological monitoring was conducted in Clear Creek at station 18590 (Bobwhite Road) in June and August 2006. The mean rapid bio-assessment score (benthic macroinvertebrates) was 19, well below the criterion of 29. The habitat quality index was 15.

No monitoring is scheduled in Clear Creek in 2020, but may be considered for future biological studies.

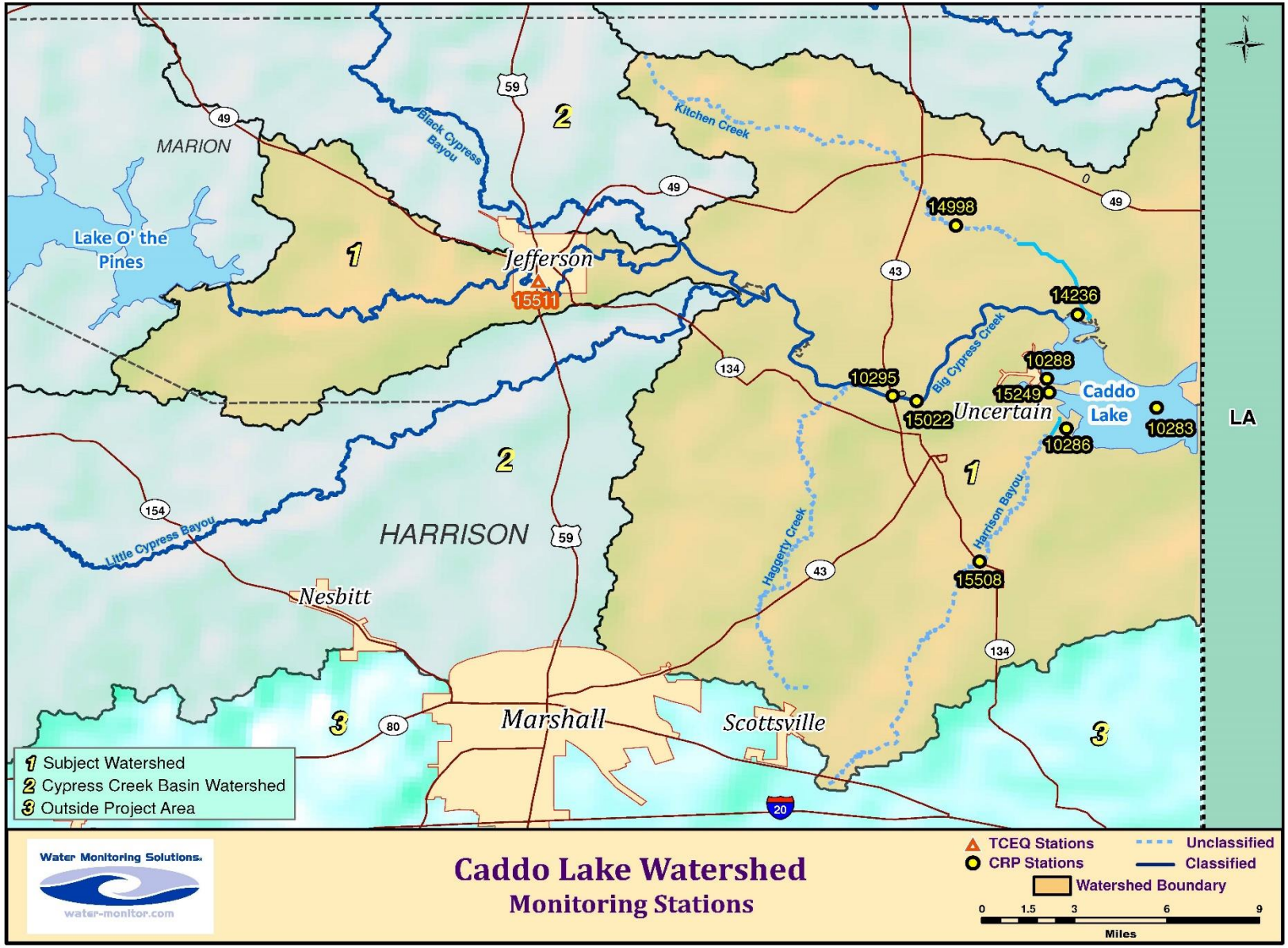

Figure 23: Map of Caddo Lake watershed

CADDO LAKE WATERSHED

The Caddo Lake and its watershed straddles the Texas and Louisiana border. It is in the rolling terrain of the Pineywoods Ecoregion. The landscape is a mix of rich bottomlands and pine and oak forests with scattered areas of cropland, planted pastures and native pastures. Caddo Lake has a surface area of approximately 26,800 acres with approximately half of the water body located within each state. Texas encompasses approximately 358 square miles of the 2,700 square-mile drainage basin. Caddo Lake and much of the surrounding watershed are swampland with shallow waters and towering bald cypress trees.

Urban development is sparse. The largest city is Jefferson, with a population of about 2,400. The land is predominantly used for agriculture, including forestry, poultry, and cattle production. Major tributaries include Black Cypress Bayou (0410), Little Cypress Bayou (0409), Kitchen Creek (0401B), Haggerty Creek (0401C), and Big Cypress Creek below Lake O' the Pines (0402). Black Cypress and Little Cypress Bayous are discussed in their respective sections.

Figure 24: Photo of Dr. Roy Darville monitoring Caddo Lake

SEGMENT 0402 – BIG CYPRESS CREEK (BAYOU) BELOW LAKE O' THE PINES

Segment 0402 is the portion of Big Cypress Creek that flows between Ferrell's Bridge Dam forming Lake O' the Pines and Caddo Lake. This segment is generally deep, wide, and supports heavy recreational use including boating and camping activities. The Big Cypress Creek watershed contains over five thousand acres of bottomland hardwood forest dominated by cypress swamps. Because of the uniqueness of the habitat, the TPWD has designated it an important recovery area for the state-threatened paddlefish. A discussion about the efforts to reintroduce paddlefish follows the water quality section of this chapter.

Segment 0402 was identified in the *2020 Texas §303(d) List* as having elevated mercury in fish tissue, and the DSHS fish consumption advisory extends across the entire segment.

ASSESSMENT UNIT 0402_01

The 15 km reach of Big Cypress Creek between Caddo Lake and Haggerty Creek had a concern for chlorophyll. Half of the eight results assessed exceeded the 14.1 µg/L screening level with a mean of 19 µg/L. Quarterly monitoring is conducted at station 10295 at SH 43 by NETMWD/WMS and monthly field parameters are collected by Caddo Lake Institute (CLI) at station 15022 at the Caddo Lake State Park boat ramp.

ASSESSMENT UNIT 0402_02

Big Cypress Creek between Haggerty Creek and the confluence with Black Cypress Bayou (AU 0402_02) was first listed for depressed dissolved oxygen in 2010. The impairment was based upon one of the four monitoring events failing to meet the 5.0 mg/L 24-Hour DO Average criterion. The result of the low measurement was 4.9 mg/L, collected in July 2010. At present, no sampling is being conducted in this reach. All sampling was discontinued after FY 2012 due to a change in property ownership preventing access to the stream. Other potential monitoring locations within the reach either posed safety concerns or were not representative of the AU. Note that monitoring at station 16254, the City of Marshall water intake, was discontinued after FY 2009 due to the determination that the site was not representative of the assessment unit.

Figure 25: Photo of Big Cypress Creek at station 10295 (AU 0402_01)

ASSESSMENT UNIT 0402_03

The portion of Big Cypress Creek between the confluences with Black Cypress Bayou and upstream to French Creek comprises AU 0402_03. With the exception of mercury in fish tissue, there were no impairments in this reach. The *2020 Integrated Report* showed a concern for impaired macroinvertebrate community. Biological sampling was last conducted outside of the current assessment period in May 2007. The benthic organisms had an RBA score of 24, falling below the 29 criterion. Critical period monitoring was not performed that year due to high water levels in the stream. Benthic monitoring, in coordination with the TPWD and USF&W paddlefish reintroduction project, is being considered by the coordinated monitoring committee. For 2020, quarterly monitoring for conventionals and field parameters is being conducted by TCEQ at station 15511 at US 59.

ASSESSMENT UNIT 0402_04

With the exception of mercury in fish tissue, there were no concerns or impairments in AU 0402_04, the 13 km reach between French Creek and Lake O' the Pines. There is no sampling scheduled within this reach in 2020.

SEGMENT 0402B HUGHES CREEK

Hughes Creek is a tributary of Black Cypress Bayou. Hughes Creek was included on *2020 Texas §303(d) List* for not meeting the dissolved oxygen grab minimum criterion of 3 mg/L. Three of the fifteen samples collected during the assessment period fell below the grab criterion with a mean of 2.5 mg/L. There is a large pool at the station 16936 (SH 155) crossing, and the stream often has very low flow resulting in low dissolved oxygen values. Access to a more representative location further away from the road crossing is restricted due to fencing on private property. In 2020, NETMWD/WMS is scheduled to collect field parameters at station 16936 on a quarterly basis.

0402E KELLEY CREEK

Like Hughes Creek, Kelley Creek is also a tributary to Black Cypress Bayou. The *2020 Integrated Report* included a concern for dissolved oxygen screening level. Four of the thirteen samples assessed fell below the 5 mg/L grab screening level with a mean of 3.45 mg/L. NETMWD/WMS is scheduled to measure field parameters at station 16934 at FM 250 on a quarterly basis in 2020.

Figure 26: Tishomingo National Fish Hatchery stocks paddlefish at the Jefferson Boat Ramp

BIG CYPRESS BAYOU PADDLEFISH REINTRODUCTION PROJECT

By Mike Montagne, U.S. Fish and Wildlife Service

The paddlefish (*Polyodon spathula*) is native to the Big Cypress Bayou and Caddo Lake, as part of the Red River drainage. In 1959, Ferrell's Bridge Dam was completed creating Lake O' the Pines, the paddlefish fishery began to decline, and since the 1980's no occurrences of paddlefish have been reported. It is well documented that certain life history patterns required by paddlefish have been disturbed by the addition of dams, which hinder migration and alter historical flows and pulses that the paddlefish need to reproduce and recruit into their populations.

In 2011, the U.S. Army Corps of Engineers and Northeast Texas Municipal Water District agreed to implement the key recommendations of the stakeholders for the environmental flow regime in Big Cypress Bayou. Over the next five years, releases from Lake O' the Pines provided prescribed base flows and time specific pulses while stakeholders monitored the ecological responses. The pulses include flows necessary for paddlefish spawning. In 2016, the stakeholders agreed to extend the environmental flow recommendations another five years.

In 2014, the U.S. Fish and Wildlife Service (USFWS) initiated the Paddlefish Reintroduction Project as a tool to help evaluate the effectiveness of the newly implemented environmental flow regime. The paddlefish is an ideal species to evaluate the new flow regime as it is believed the dam, and altered flows, were directly responsible for its decline in the Big Cypress Bayou. If the paddlefish can successfully be reintroduced under the new environmental flow regime, then other native species are likely to benefit from it as well.

In February of 2014, biologists from USFWS and Tishomingo National Fish Hatchery (TNFH) implanted 47 hatchery-reared paddlefish with radio tags for phase one of the project. In March of 2014, 36 of the paddlefish were released into the Big Cypress Bayou at Caddo Lake State Park, and eleven were released 18 miles upstream at the boat ramp in Jefferson Texas. In the fall of 2014, an additional 2,000 young of the year paddlefish from TNFH were stocked into the Big Cypress Bayou. In April 2016, 621 paddlefish, 21 of which were implanted with one-year radio tags, were released into the Big Cypress Bayou at the Starr Ranch on the Caddo Lake National Wildlife Refuge.

The initial results from the introduction were encouraging. Radio tagged paddlefish have shown a fidelity to the Big Cypress Bayou and Caddo Lake. None of the 68-tagged fish were documented to have gone over the spillway at the Caddo Lake Dam.

In 2018, the next phase of the reintroduction began. In this phase, paddlefish that were previously released (3-5 years old) were recaptured and implanted with long lasting (7-10 years) acoustic telemetry tags so the fish can be tracked into adulthood. Paddlefish do not reach sexual maturity until they are six to eight years old, so we do not have any data as to how sexually mature paddlefish will react to the environmental flows. If the paddlefish that survive to sexual maturity are unable to spawn and recruit into their population, it must be determined which part of their lifecycle is being interrupted, why, and what to do about it.

Acoustic telemetry receivers are being deployed at known gravels shoals, to detect paddlefish use in these areas during the presumed spawning season in the spring. The receivers will also be place strategically throughout the Big Cypress Bayou and at Caddo Lake Dam spillway to track movement throughout the system.

Due to the encouraging initial results, the USFWS, TPWD, and the Louisiana Department of Wildlife and Fish developed a ten-year stocking plan for the Big Cypress Bayou and Caddo Lake and began implementation in 2018. In 2018, TNFH stocked 12,076 paddlefish into the Big Cypress Bayou and 12,276 paddlefish were stocked in 2019. Monitoring of the stocked fish is ongoing and will continue through the ten-year stocking plan to evaluate the environmental flows.

Figure 27: Mike Montagne implants radio tags in juvenile paddlefish.

SEGMENT 0401 – CADDO LAKE

Caddo Lake is impounded by Caddo Dam in Caddo Parish, Louisiana. The uppermost portion of the lake extends into Harrison and Marion Counties in East Texas. Believed to have been formed by 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 the lake is shallow and swamp-like creating an unique and diverse ecosystem that is one of the best examples in the southern United States of a mature Bald Cypress forest. In recent years, it has been invaded by nonnative plants such as Hydrilla, water hyacinth (*Eichhoria crassipes*), and giant salvinia (*Salvinia molesta*). Invasive plant species in the Cypress Creek Basin were discussed in detail in the 2016, 2017, and 2018 Cypress Creek Basin Highlights Reports. Efforts to control giant salvinia using weevils is discussed later in this chapter.

In 1998, the Texas Department of State Health Services issued a fish consumption advisory for Caddo Lake due to mercury in fish tissue. As a result, all assessment units of Caddo Lake were listed for mercury in fish tissue in the *2020 Texas §303(d) List*.

Due to its shallow, swamp-like conditions, the most common water quality impairment in Caddo Lake was for low dissolved oxygen. Invasive aquatic plants often cover the entire surface of the arms of the lake, especially in the summer months, preventing sunlight from entering the water column and exacerbating the low dissolved oxygen problems.

Low dissolved oxygen values were commonly reported in the Harrison Bayou arm (AU 0401_02), Goose Prairie arm (AU 0401_03), Clinton Lake (AU 0401_05), and mid-lake near Uncertain (AU 0401_07), especially during the warm months. Between one-quarter and one-third of the surface dissolved oxygen grab samples collected in these AUs were reported below the screening level or criterion. Despite low dissolved oxygen in these areas, none of the samples collected at the mid-lake station fell below the dissolved oxygen criterion of 3 mg/L.

The Harrison Bayou arm, Clinton Lake, and the mid-lake near Uncertain assessment units were impaired for not meeting the 24-Hour DO Average and 24-Hour DO Minimum criteria of 5 mg/L and 3 mg/L, respectively. It should be noted that these listings were carried forward from previous assessments into the *2020 Texas §303(d) List*. Diel studies in Caddo Lake were discontinued in 2009. Although numerous diel events had been conducted during the previous decade, all of these studies yielded similar low dissolved oxygen results and were possibly

reflective of the natural oxygen cycles in the arms of Caddo Lake. As a result, stakeholders recommended that the limited CRP resources be directed elsewhere within the basin.

Figure 28: Photo of Caddo Lake near Goose Island

Similar to the other shallow assessment units of Caddo Lake, the Goose Prairie Arm was shown as impaired for not meeting the DO Grab Minimum criterion of 3 mg/L. Over twenty percent of the 74 dissolved oxygen readings reported during the assessment period were below the criterion, with an average of the low DO concentrations of 1.46 mg/L.

The *2020 Integrated Report* included a concern for screening level for iron in sediment in AU 0401_01, lower 5,000 acres. This concern was a carry-forward from previous assessments as no sediment data were collected during the assessment period and no sediment sampling is currently scheduled.

Caddo Lake is monitored quarterly by NETMWD/WMS at stations 10283 (mid-lake), 10288 (Goose Prairie), 14236 (Clinton Lake), and 15249 (Uncertain) for field parameters, bacteria, and conventionals. The Caddo Lake Institute monitors for field parameters on a monthly basis at stations 10283, 10288, 14236, 15249, and 10286 (Harrison Bayou arm).

SEGMENT 0401A – HARRISON BAYOU

Harrison Bayou (0401A) is a tributary of Caddo Lake. The stream is approximately 14 miles long and extends from its confluence with Caddo Lake toward the southwest to a point just upstream of FM 1998, east of Marshall, Texas.

Harrison Bayou was shown as impaired for low dissolved oxygen in 2000 and was included in the *2020 Texas §303(d) List* for not meeting the 24-Hour DO Average and 24-Hour DO Minimum criteria. These impairments were based upon inadequate data as only three diels were conducted during the assessment period. None of the results fell below the 24-Hour DO Average criterion while one event was reported below the 24-Hour DO Minimum criterion. Similar to many areas of Caddo Lake, these impairments were possibly due to natural conditions.

Quarterly monitoring is conducted at station 15508 for flow, bacteria, and for field and conventional parameters by NETMWD/WMS.

SEGMENT 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. Kitchen Creek is monitored quarterly by NETMWD/WMS for field parameters at station 14998. There were no impairments or concerns for this tributary.

THE BATTLE TO SAVE CADDO LAKE

By Laura Speight, Project Manager, Caddo Biocontrol Alliance

Giant Salvina (GS) was first discovered on Caddo Lake in early 2006. Early efforts of containment included organized volunteer clean ups, herbicide applications and physical barriers. In 2008 TPWD and TAMU teamed up to experiment with a biological control agent it hoped would stop the spread of Giant Salvinia (GS), however, Caddo seemed to provide a near perfect environment for it to flourish. Some years were worse than others. Weevils were showing some signs of success but the temperate climate in our region was sometimes a hindrance to their over winter survival.

Figure 29: CBA staff releasing salvinia weevils in the "Do Not Spray" area

During the summer of 2013 it was virtually impossible to navigate the Texas side of Caddo in anything other than a mud boat and there was fear the lake would be "lost". The community around the lake held a series of meetings and determined that the biocontrol agent known as the *Salvinia Weevil (Cyrtobagous salviniae)* held promise as an important tool in an integrated approach to be able to control the plant. The grassroots efforts to locate land and raise funds to

build a greenhouse in which to raise weevils was initiated by the Greater Caddo Lake Association of Texas. A standalone entity was later formed to continue this effort. That organization called the Caddo Biocontrol Alliance (CBA) is a 501 c3 nonprofit organization with mass producing weevils for release on Caddo Lake as its sole mission. GCLAT continues to support these efforts with fundraising activities throughout the years.

Since 2013 CBA has released close to 500,000 weevils and has developed a great partnership with Texas Parks and Wildlife as we strive to combat what is known as the "World's Worst Weed". Over winter samples have shown that weevils can survive warmer winters at Caddo so a second greenhouse was recently completed next to the original one in Uncertain Texas. The idea is to "super stock" as many weevils as possible on Caddo. These will be put in the backwater areas that are inaccessible by spray boats. These backwater areas serve as nurseries for GS and the hope is that by introducing weevils into these areas it will minimize how much GS is reintroduced into other parts of the lake.

Biological Control is a slow process and it takes a while to see results. As one of our board members famously said "It is a Marathon, not a Sprint." Sometimes it feels more like a Triathlon but the good folks at Caddo and their partners are in it for the long haul.

CADDO LAKE NUTRIENTS AND CYANOTOXINS STUDY

By Chris Churchill, PhD. U.S. Geological Survey

Overview

In 2018, the U.S. Geological Survey, in cooperation with the Caddo Lake Institute, conducted a study assessing cyanobacterial and nutrient occurrence and concentrations in Caddo Lake, Texas and Louisiana. The study was designed to determine concentrations of phytoplankton (including cyanobacteria), cyanotoxins, taste-and-odor compounds, nutrients, and other water-quality compounds associated with cyanobacterial and harmful algal blooms. All data, including phytoplankton taxonomy, collected during the study will be available to the public through the USGS ScienceBase data repository website after they have passed internal quality assurance checks.

Background

The objectives of this study were to detect and quantify phytoplankton (notably cyanobacteria), cyanotoxins, taste-and-odor compounds, nutrients, and other compounds that are associated with the formation of harmful algal blooms in Caddo Lake. Samples were collected during two surveys in 2018. Samples were collected during August and early October because formation of cyanobacterial blooms and harmful algal blooms is more likely during dry, low-flow periods. During each survey, at least 20 sites on the lake were screened for chlorophyll and phycocyanin concentrations to determine the optimal site to collect samples. Water samples were collected and processed by USGS personnel following methods described in the USGS National Field Manual (U.S. Geological Survey, variously dated) and in sampling-method procedures provided by labs that analyzed samples.

Quality Assurance

The Caddo Lake study overlapped with a long-term, statewide cyanobacteria and cyanotoxin study conducted by the USGS and funded by the TCEQ. Because both the Caddo Lake and the long-term, statewide studies use identical field and lab methods to quantify cyanobacteria, cyanotoxins, taste-and-odor compounds, and other associated water-quality compounds, the results, including those from quality control samples, can be considered to be in the same inference space. Therefore quality assurance results from the long-term study can be used to evaluate results from the Caddo Lake study. Quality control samples from the long-term study include replicate water samples and equipment blank samples. Data from the quality assurance samples were used to quantify bias and precision of analytical methods and to detect contamination. Quality assurance measures were followed to ensure quality, precision,

accuracy, and completeness of data generated during the study. Quality assurance objectives for the measurement and collection of data are to provide data that will:

- withstand scientific scrutiny,
- be obtained by methods appropriate for its intended use, and
- be of known precision, accuracy, completeness, representative, and comparability.

Caddo Lake Water-Quality and Cyanotoxin Results

Most water quality parameters did not significantly change from August to October. Most nitrogen was in organic forms and between 37 and 42% was in the dissolved organic phase. Total phosphorus concentrations were < 1.0 mg/L during both surveys. Generally, nutrient (nitrogen and phosphorus) concentrations did not significantly change from August to October. Chlorophyll and phycocyanin concentrations increased between the two surveys based on sonde measurements and lab analyses. The parameters with the most significant changes were manganese and geosmin. Manganese increased from 0.90 µg/L to 26.2 µg/L and Geosmin increased from 8.0 ng/L to 18.1 ng/L.

Cyanotoxin results for anatoxin-*a* (neurotoxin, known as very fast death factor), cylindrospermopsin (hepatotoxin), and microcystin (hepatotoxin) via rapid-assessment dipstick kits were negative. Cyanotoxin result for microcystin via ELISA was 0.15 µg/L for the sample collected on August 23, 2018. This value is less than the U.S. EPA 10-day health advisory level for human consumption of finished drinking water for children less than six years old (0.3 µg/L) and less than the Unregulated Contaminant Monitoring Rule 4 for public water systems (0.3 µg/L). Microcystin results were less than the laboratory reporting level (LRL) for the sample collected on October 4, 2018. Cyanotoxin results for anatoxin-*a*, cylindrospermopsin, and saxitoxin (neurotoxin, best-known paralytic shellfish toxin) via ELISA were less than the LRLs.

Caddo Lake Phytoplankton Results

Total number of species increased from 54 to 64 phytoplankton species from August to October. For both samples, the phytoplankton community was dominated by Cyanophyta followed by Chlorophyta, in terms of biovolume and number of species. Haptophyta, specifically *Chrysochromulina parva*, was the only phytoplankton division present in August but not in October. In August, the most common species by a large margin were *Pseudanabaena limnetica* and *Cylindrospermopsis raciborskii* (22.4% and 19.6% of total biovolume, respectively). *Cylindrospermopsis raciborskii* is a known bloomer and can produce cylindrospermopsin, anatoxin-*a*, and saxitoxin. In October, *Cylindrospermopsis raciborskii*

biovolume dropped to 2.1% and was replaced by *Cryptomonas erosa* (17.8% of total biovolume) as the second most dominant species. *Pseudanabaena limnetica* remained the most abundant species with 24.7% of total biovolume in October.

Caddo Lake Harmful Algal Blooms and Cyano-Harmful Algal Blooms Results

Although a bloom was not detected during the surveys, several genera and species (most notably *Cylindrospermopsis raciborskii*) were present that can bloom if conditions are favorable for proliferation of cyanobacteria. These conditions are most commonly stagnation, high temperatures, and excessive nutrient loadings.

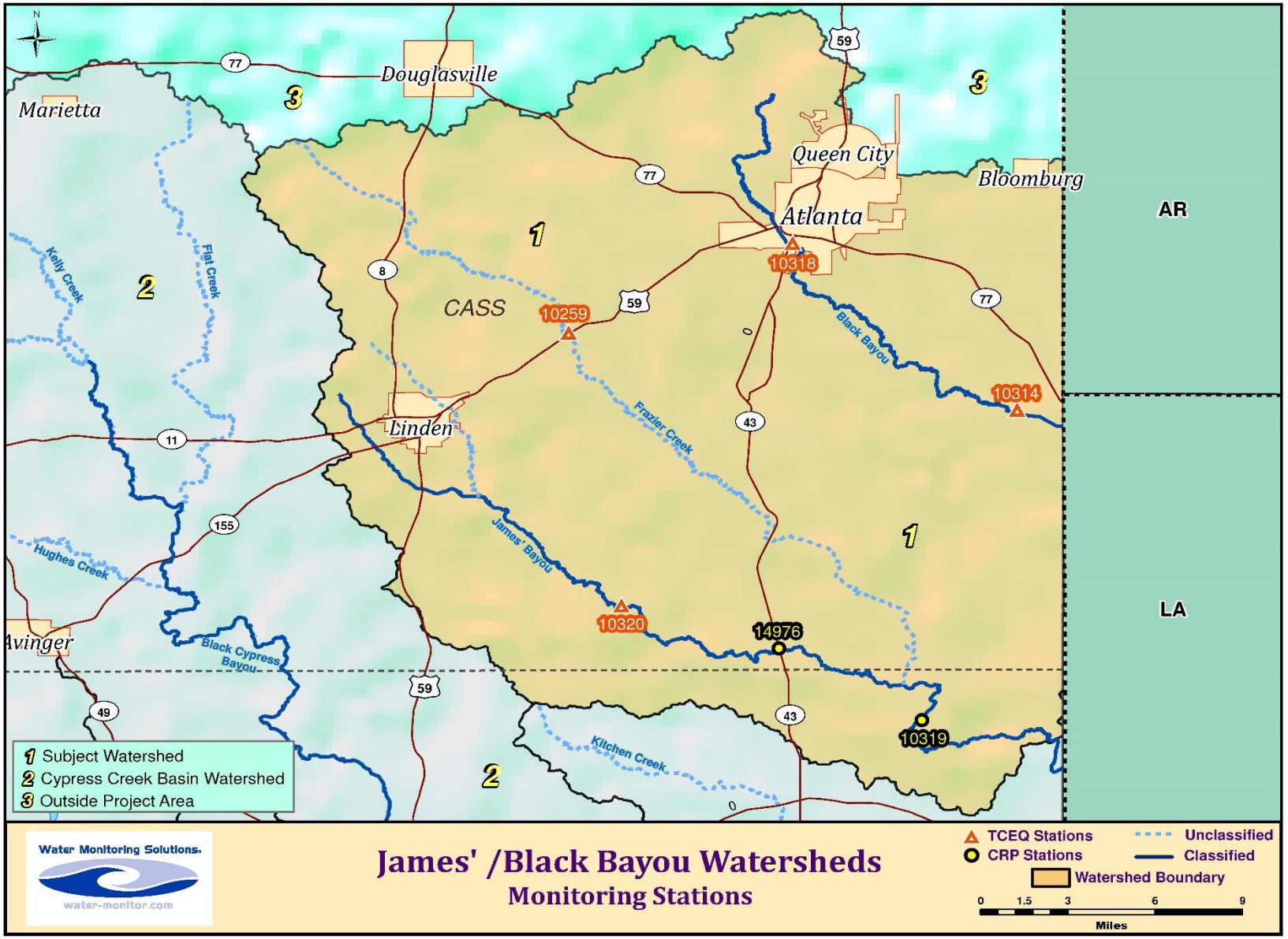

Figure 30: Map of James' Bayou and Black Bayou watersheds

SEGMENT 0406 – BLACK BAYOU

Black Bayou, a relatively small watershed, emerges near Wright Patman Reservoir in northeastern Cass County, flows through Atlanta, Texas and on to the Louisiana border. The stream is intermittent in its upper reaches and traverses flat to gently rolling terrain that supports grasses, mixed hardwoods, and pines. Black Bayou is generally a slow, meandering water body with sand and clay loam bottom. During periods of low flow, the stream has a tendency to become stagnant and dissolved oxygen levels decrease under these conditions. As a result, both assessment units of Black Bayou were impaired for depressed dissolved oxygen in the *2020 Texas §303(d) List*.

Beginning in 2006, the upper assessment unit was shown as impaired for *E. coli* and has continued into the current assessment with a geometric mean of 157.52 MPN/100 mL. There are no permitted dischargers and very limited development within this reach of the stream suggesting that bacteria are probably due to non-point sources such as livestock and wildlife. A Recreation Use Attainability Analysis may be considered to address this impairment.

Concerns for impaired benthic macroinvertebrate community are shown in both assessment units while concerns for fish and habitat are shown for AU 0406_01 in the *2020 Integrated Report*. Biological monitoring was conducted in both assessment units in 2012 and in 2014. Unfortunately, the stream was pooled at the downstream station during three of the site visits so only one of the four monitoring events was completed in this reach. Refer to the *2019 Cypress Creek Basin Summary Report* for a complete discussion of biological monitoring conducted in Black Bayou.

For 2020, quarterly sampling for flow, bacteria, conventional, and field are scheduled to be collected by TCEQ at stations 10314 (CR 4659) and 10318 (SH 43).

SEGMENT 0407 – JAMES' BAYOU

Figure 31: Photo of seining in Jims Bayou at station 14976

The headwaters for James' Bayou are located west of Linden. The stream flows toward the southeast through pine and hardwood forests before crossing the Louisiana border to ultimately flow into Caddo Lake.

Since 2000, the upper assessment unit of James' Bayou has been impaired for not meeting the 24-Hour Dissolved Oxygen Average and Minimum criteria. From 2015 through 2018, WMS conducted 24-Hour dissolved oxygen monitoring four times per year to address the low dissolved oxygen impairments. Out of eleven studies, two of the results fell below the 24-Hour Dissolved Oxygen Average criterion while four were reported below the 24-Hour Dissolved Oxygen Miniumum criterion. The impairments continued into the *2020 Texas §303(d) List*.
The upper AU of James' Bayou became impaired for elevated *E. coli* bacteria in 2006, but was removed from the *2020 Texas §303(d) List* as result of meeting its contact recreational use standard. The lower reach, however, remained impaired for bacteria with a geometric mean of 185.85 MPN/100 mL.

The *2020 Integrated Report* showed a concern for habitat in both reaches along with a concern for the benthic macroinvertebrate community in the lower reach. Refer to the *2019 Cypress Creek Basin Summary Report* for a complete discussion of biological monitoring conducted in James' Bayou in 2016 and 2017.

TCEQ Region 5 is scheduled to collect bacteria and flow data nine times in the upper assessment unit while NETMWD/WMS will sample for conventionals, bacteria, field parameters, and flow on a quarterly basis in the lower AU.

SEGMENT 0407B –FRAZIER CREEK

Frazier Creek is an unclassified water body that originates near US 59 in Cass County and flows southeast for 38.6 kilometers to its confluence with James' Bayou in Marion County.

Previous assessments showed concerns for dissolved oxygen. All samples collected during the current assessment period met the criteria. There were no concerns or impairments shown for this stream in the *2020 Integrated Report*. There is no sampling scheduled in 2020.

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