2021 CYPRESS CREEK BASIN HIGHLIGHTS REPORT

SPECIAL CONTRIBUTIONS:

Cypress Creek Basin Mussel Surveys

Clinton Robertson, Texas Parks and Wildlife Department

Northeast Texas Aquatic Turtle Surveys

Mandi Gordon, Environmental Institute Houston

University of Houston – Clear Lake

Invasive Aquatic Vegetation Update

Tim Bister, Texas Parks and Wildlife Department

Cover photo: Station 10244: Black Cypress Creek at CC Bridge Road near Berea

GET INVOLVED!

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

Under the CRP, biologists and field staff collect water and biological samples, field parameters, and measure flow at sites throughout the Cypress Creek Basin. Monitoring and analysis are the basis for protecting and improving water quality in the Cypress Creek Basin. Within the cooperative program, directed by the NETMWD, these activities are an integral part of the CRP. The NETMWD plans and coordinates monitoring efforts with other basin entities, the TCEQ monitoring staff, Caddo Lake Institute, 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 Quality Assurance Project Plan. The data collected are analyzed and used to produce an annual report. These reports are then used to develop and prioritize programs that will protect the quality of healthy waterbodies and improve the quality of impaired waterbodies.

Each spring, the 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 Basin 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 CRP 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. This meeting is typically held in March or April at the NETMWD executive office in Hughes Springs. Due to COVID-19 precautions, the CRP Steering Committee meeting was held virtually in July 2020. The topics included a compliance report with the Total Phosphorus Load Agreement, and a discussion of the 2020 Cypress Creek Basin Highlights Report.

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

The 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

The TCEQ CRP provides funding to and contracts with NETMWD to fulfill the responibilities of the Cypress Creek Basin Clean Rivers Program. The NETMWD contracts with Water Monitoring Solutions, Inc. (WMS) to perform the quality assurance, sampling, data analysis, and reporting tasks of the CRP.

Figure 1: Clean Rivers Program Steering Committee Meeting

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LIST OF ACRONYMS AND ABBREVIATIONS

AU	Assessment Unit
cfs	cubic feet per second (measurement of stream flow)
CMS	Coordinated Monitoring Schedule
CR	County Road
CRP	Clean Rivers Program
DO	Dissolved Oxygen
eDNA	Environmental DNA
EIH-UHCL	Environmental Institute Houston – University of Houston - Clear Lake
FM	Farm-to-Market Road
FY	Fiscal Year
LOQ	Limit of Quantitation
MGD	Million Gallons per Day
mg/L	milligrams per liter
NETMWD	Northeast Texas Municipal Water District
PCB	Polychlorinated biphenyls
QAPP	Quality Assurance Project Plan
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
TPDES	Texas Pollutant Discharge Elimination System
TPLA	Total Phosphorus Load Agreement
TPWD	Texas Parks and Wildlife Department
UAV	Unmanned Aerial Vehicle
USACE	United States Army Corps of Engineers
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

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.

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. Water quality sampling regimens are established though an annual Coordinated Monitoring Meeting with the objective of ensuring that resources and efforts are not duplicated or overlapped. 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.

Most years, a Basin Highlights Report is authored, presented at stakeholder meetings, and posted to the NETWMD website. While the basin highlights report is typically non-technical and intended to provide a high-level overview of issues that may affect water quality in the basin, the results of two special studies and the preliminary findings from the Lake O' the Pines special studies are presented in this report. These sections are often technical due to discussions of the physicochemical interactions between parameters along with the statistical analysis performed on the collected data. If you have questions, please contact the NETMWD for further clarification.

OVERVIEW OF 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 drought was followed by near-historic flooding in 2015 and 2016 which ended the drought.

Rainfall records at the Fort Sherman Dam (Lake Bob Sandlin), located in the upper portion of the basin, have been maintained since its completion in 1978. Over the past forty-two years, annual precipitation has averaged around 52 inches. However, from 1979 to 1998, the average was 54 inches per year, as compared to 50 inches from 1999 through 2020. During the 1999 - 2014 drought, an annual average of 48 inches of rain was recorded. 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 since its completion.

The 2020 rainfall at Fort Sherman Dam was above average at 56.26 inches. In past years, the rain gauge located near the U. S. Army Corps of Engineers (USACE) offices by the Lake O' the Pines dam had shown a general agreement with the Fort Sherman Dam gauge. However, over the past three years, the USACE gauge has measured substantially more rainfall, including almost 20 inches more rain in 2020 than at the Fort Sherman Dam gauge, with a total of 75.93 inches. A comparison between the rainfall amounts at each reservoir is shown in Figure 2.

Year	Lake Bob Sandlin	Lake O' the Pines	Delta
2015	74.90	72.82	(2.08)
2016	52.37	52.22	(0.15)
2017	48.45	43.57	(4.88)
2018	54.58	67.39	12.81
2019	48.69	62.94	14.25
2020	56.26	75.93	19.67

Figure 2: Rainfall Records for Lake Bob Sandlin and Lake O' the Pines

Releases from Lake Bob Sandlin play an important role in the water quality of Big Cypress Creek and Lake O’ the Pines. In addition to providing stream flow in Big Cypress Creek, the high-quality water from Lake Bob Sandlin helps to offset the nutrient-laden discharges from wastewater treatments plants in the Lake O’ the Pines watershed. Since there are no instream flow requirements in Big Cypress Creek, water is only released by the Titus County Freshwater Supply District #1 to maintain freeboard of the Fort Sherman Dam.

In 2020, over 197,000 acre-feet was released from Lake Bob Sandlin with most of that water released in the first few months of the year. No water was released after June 16, 2020. Similarly, no water was released after July 22, 2019. Over the past five years, that has been the common release pattern with the exception of 2018, which had releases in both the first and fourth quarters of the year.

Releases (acre-feet)	**2020**	**2019**	**2018**	**2017**	**2016**	**Average**
January	12,305	43,068		1,397	18,737	15,101
February	57,839	22,953	30,096	9,980	20,108	28,195
March	47,550	23,866	37,890	8,253	60,767	35,665
April	35,700	34,494	15,404	38,452	50,707	34,951
May	36,493	96,159	4,540	2,452	14,765	30,882
June	7,636	42,377		2,907	8,072	12,198
July		5,991			496	1,297
August				4,438		888
September				1,227		245
October			1,359			272
November			27,806			5,561
December			37,832			7,566
Total	**197,524**	**268,908**	**154,927**	**69,106**	**173,652**	**172,823**

Figure 3: 2016 – 2020 Monthly Releases from Lake Bob Sandlin

From 2000 through 2014, a combined total of 939,956 acre-feet of water was released from the reservoir. Due to the pervasive drought, there were zero releases in seven out of those fifteen years which included the years 2005 through 2007 and 2011 through 2014.

As a result of the large amount of rainfall, a record amount of water was released from the Fort Sherman Dam in 2015, at over 280,000 acre-feet, followed by nearly 269,000 acre-feet in 2019. Over 1.1 million acre-feet of water was released in the six-year period of 2015 through 2020. This amount of water represents over half of the releases since 1999 and over one-quarter of all releases from Lake Bob Sandlin since its impoundment.

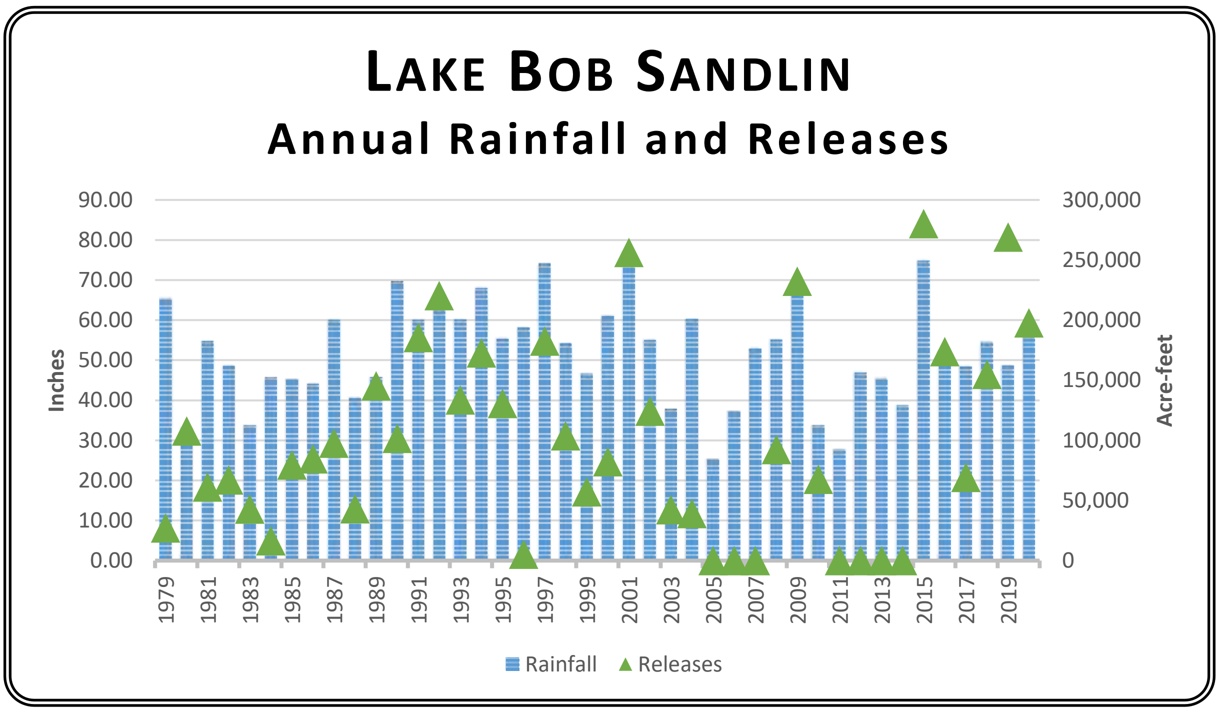

Figure 4: Graph of annual rainfall and releases from Lake Bob Sandlin

The remainder of the 2021 Cypress Creek Basin Highlights Report discusses the following topics:

- 2021 Cypress Creek Basin Monitoring Program
- Special Studies Reports
- Species of Concern
- Invasive Aquatic Vegetation

The Special Studies Report section features reports on the Nitrate Special Study, the Sulfate Special Study, and the preliminary findings on the Lake O' the Pines pH Special Studies. The Species of Concern section discusses potentially threatened or endangered species in the basin while the Invasive Aquatic Vegetation section reports on the results of the 2020 vegetation survey performed by the TPWD along with their activities to treat and control these non-native species.

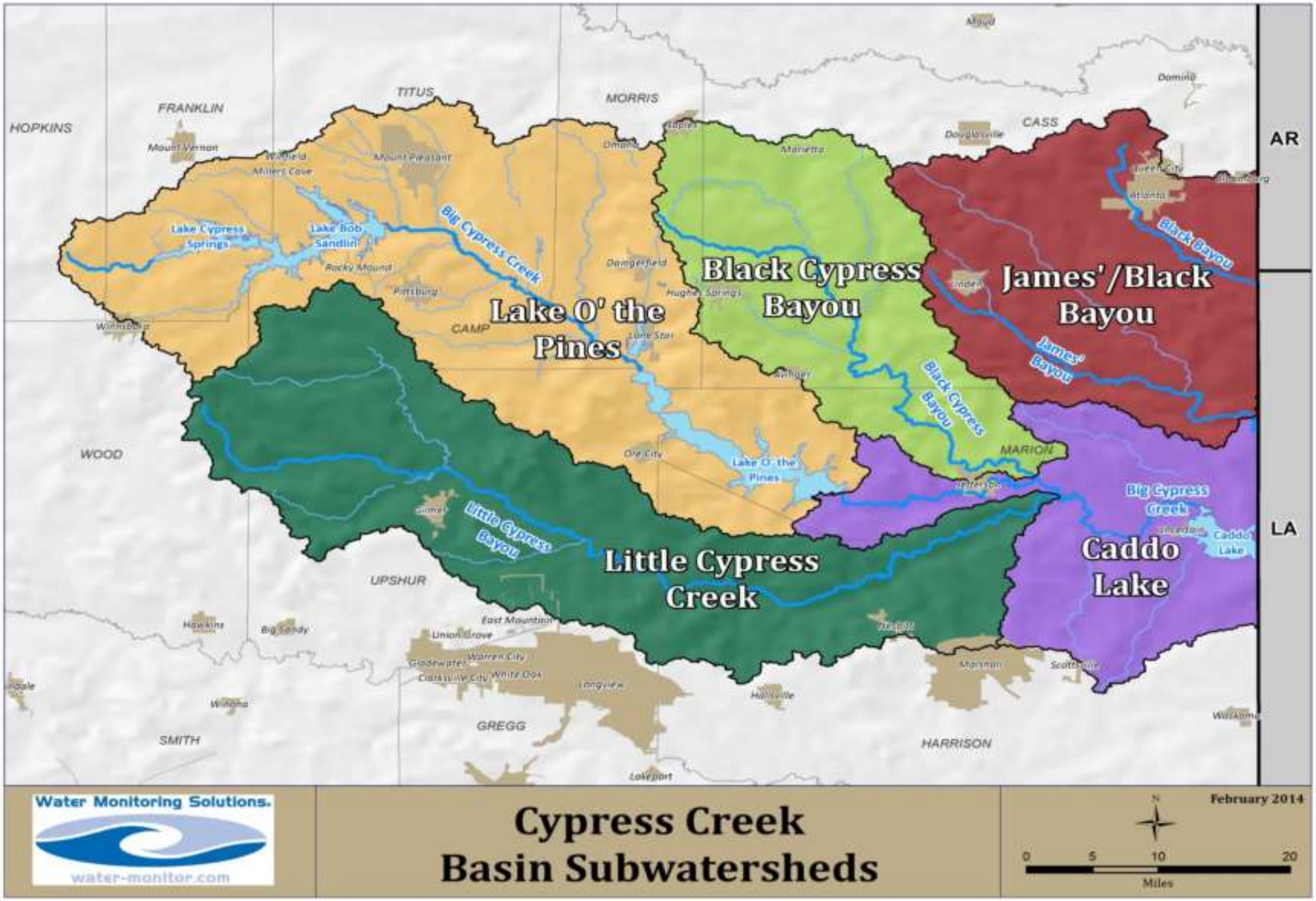

Figure 5: Map of the Cypress Creek Basin watersheds

THE 2021 CYPRESS CREEK BASIN MONITORING PROGRAM

WATER QUALITY MONITORING AND ASSESSMENT

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 FY 2021 Coordinated Monitoring Schedule is presented at the end of this section.

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 water quality of the basin.

Physical and chemical measurements of water quality are typically made at each station. Common parameters include dissolved oxygen (DO), pH, suspended sediments, nutrients, bacteria, and stream flow or lake level. Biological assessments include the collection of fish, aquatic invertebrates, and habitat assessments to quantify 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 monitoring.

The most recent water quality assessment, the *2020 Texas Integrated Report* was approved by the TCEQ on March 25, 2020 and by the U.S. Environmental Protection Agency on May 12, 2020. In the 2020 Integrated Report, the TCEQ evaluated 36 classified and unclassified water bodies in the Cypress Creek Basin. The results indicated that over half of the water bodies evaluated did not meet surface water quality standards for one or more parameters. The *2020 Texas §303(d) List* identified nine classified and twelve unclassified water bodies that did not meet the water quality criteria. Low concentrations of dissolved oxygen, high levels of bacteria, and mercury in fish tissue were the most common impairments. A table of the segments and parameters included on the *2020 Texas §303(d) List* is shown in Figure 6. Information about the water quality impairments and concerns shown in the *2020 Texas Integrated Report* were discussed in detail in the 2020 Cypress Creek Basin Highlights 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 6: Table of Impairments

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.

Figure 7: Sample bottles and instruments used to measure field parameters and stream flow

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 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 runoff. 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 nitrite can produce nitrite toxicity, or “brown blood disease.” Excess nitrate 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.

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. Despite being banned in the United States in 1977, PCBs remain in the environment, and they accumulate in fish and human tissues when consumed.

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 and organs, posing a long-term significant health threat. Bioaccumulation of mercury in the edible tissue of many fish species to the point of becoming a human health concern has prompted the Texas Department of State Health Services to issue fish consumption advisories around the Basin. Mercury in edible tissue has been identified in fish tissue in water bodies throughout East Texas.

Fiscal Year 2021

Fourteen stations will be sampled quarterly for field and conventional laboratory parameters. In addition, three stations are monitored for field parameters and stream flow, and diel sampling will be conducted at three stations each quarter. In FY 2021, Aquatic Life Use monitoring is scheduled to be performed in Tankersley Creek. Aquatic Life Use is comprised of biological, physical habitat, stream flow, and diel sampling methods to assess the overall health of the stream. Monitoring activities will be conducted twice during the warm weather months of 2021.

The following pages include a map of the FY 2021 Cypress Creek CRP monitoring stations and the 2021 CRP monitoring schedule. For a full list of stations monitored by both TCEQ Region 5 and the NETMWD (WMS), visit the Coordinated Monitoring Schedule.

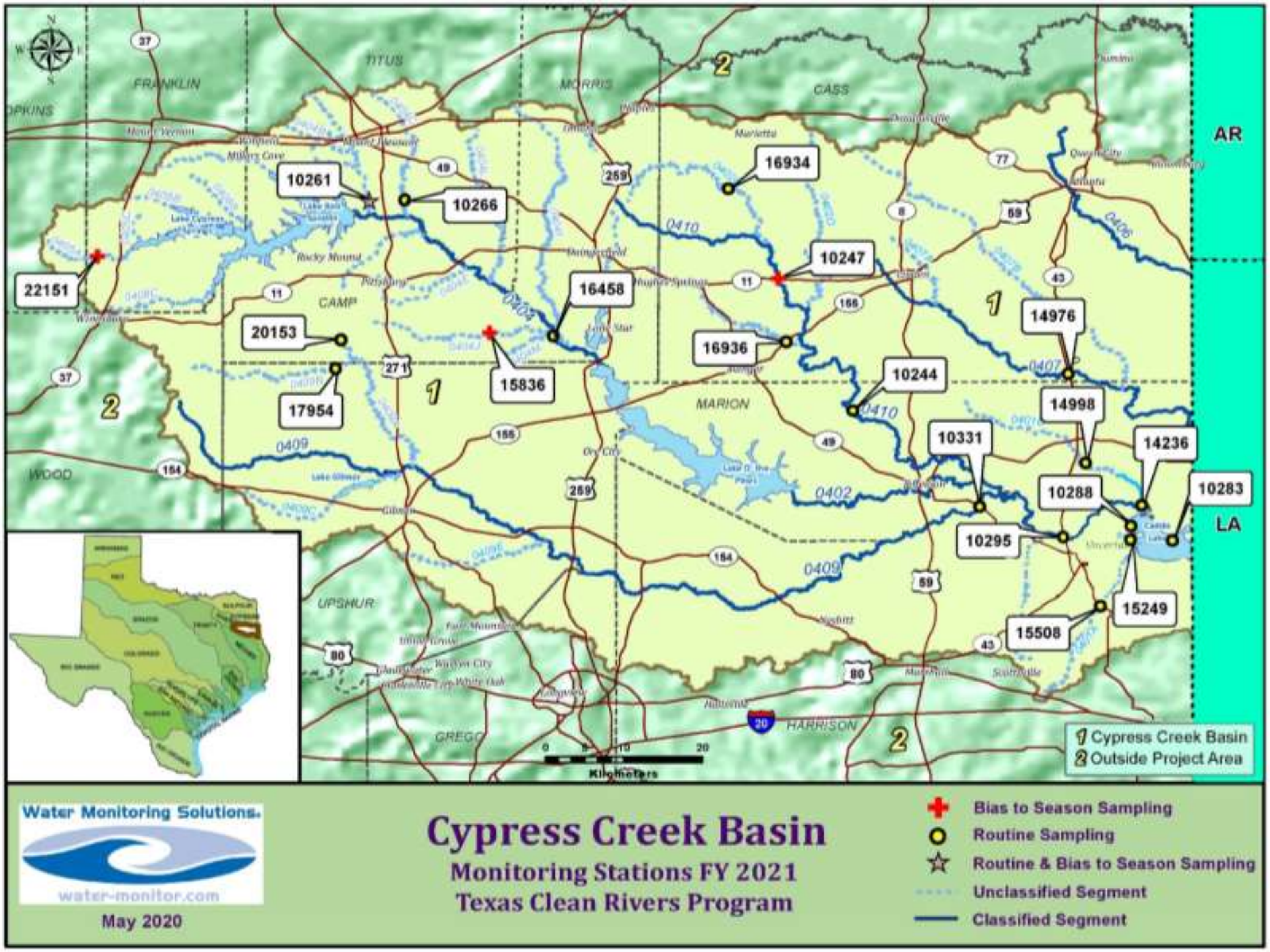

Figure 8: Map of 2021 CRP Monitoring Stations

Station Description	Station	Segment	Field	Conv	Bacteria	Flow	24 HR DO	ALU
Segment 0401 Caddo Lake								
CADDO LAKE IN GOOSE PRAIRIE	10288	0401	4	4	4			
CADDO LAKE MID LAKE	10283	0401	4	4	4			
CADDO LAKE TURTLE SHELL	15249	0401	4	4	4			
CLINTON LAKE	14236	0401	4	4	4			
HARRISON BAYOU AT FM 134	15508	0401A	4	4	4	4		
KITCHEN CREEK AT MARION CR3416	14998	0401B	4					
Segment 0402 Big Cypress below Lake O' the Pines								
BIG CYPRESS CREEK AT SH 43	10295	0402	4	4	4	4		
HUGHES CREEK AT SH155	16936	0402B	4					
KELLEY CREEK AT FM250	16934	0402E	4			4		
Segment 0404 Big Cypress below Lake Bob Sandlin								
BIG CYPRESS CREEK NEAR GREASY CK	16458	0404	4	4	4			
TANKERSLEY CREEK AT FM3417	10261	0404B	4	4	4	4		
TANKERSLEY CREEK AT FM3417	10261	0404B	2			2		2
HART CREEK AT COUNTY ROAD 4550	10266	0404C	4	4	4	4		
PRAIRIE CREEK AT FM 557	15836	0404J	4			4	4	
Segment 0405 Lake Cypress Springs								
BIG CYPRESS CREEK AT CR SW 3170	22151	0405A	4			4	4	
Segment 0407 James Bayou								
JIMS BAYOU AT SH43	14976	0407	4	4	4	4		
Segment 0409 Little Cypress Creek								
LITTLE CYPRESS CREEK AT FM 134	10331	0409	4	4	4	4		
LILLY CREEK AT FM 556	20153	0409A	4	4	4			
SOUTH LILLY CREEK AT FM 2454	17954	0409B	4	4	4	4		
Segment 0410 Black Cypress Bayou								
BLACK CYPRESS BAYOU AT CCBR	10244	0410	4	4	4	4		
BLACK CYPRESS BAYOU AT SH 11	10247	0410	4			4	4	

Figure 9: FY 2021 CRP Monitoring Schedule

Lake O' the Pines TMDL Implementation

Monitoring data indicated that 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 Total Maximum Daily Load (TMDL) Implementation Plan was developed to reduce phosphorus loading into Lake O' the Pines and 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 Implementation 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 Implementation 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, such as stormwater runoff. Technical and financial programs were created for agricultural producers; and local/county programs were created to address on-site sewage facilities, marine sanitation, and education. Loading from point sources were addressed through the limitation of phosphorus in discharges from wastewater treatment plants (WWTP).

Figure 10: Lake O' the Pines near the NETMWD intake

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. That year, Pilgrim's Pride WWTP discharged over 101,000 pounds of phosphorus. From 2015 through 2019, the WWTP has released a combined total of 66,000 pounds of phosphorus which was nearly 200,000 pounds below its permitted allocation.

Ore City and both Pittsburg WWTPs have successfully met the permitted phosphorus allocations every year since the permit was implemented. The Cities of Lone Star and Omaha have never met their phosphorus allocation limit. The City of Omaha was almost seventy percent over its five-year allotment; the City of Lone Star exceeded its permit by 336 percent at over 7,500 pounds. Despite the City of Mt. Pleasant meeting its permitted allocation in three out of six years, it exceeded its five-year combined phosphorus apportionment by 33 percent.

Despite some cities failing to meet their permitted phosphorus load allocation, the members of the combined permit have reduced the phosphorus loading into Lake O' the Pines by almost 100 tons over the past five years. This reduction was due, in a large part, to the plant upgrades at the Pilgrim's Pride WWTP.

Permitted Discharger	2015 – 2019 Allocation	2015 – 2019 Actual Discharge	Delta
Daingerfield	2,550	2,684	134
Lone Star	2,250	9,802	7,552
Mt. Pleasant	10,900	14,463	3,563
Omaha	1,300	2,201	901
Ore City	5,000	3,030	(1,970)
Pilgrim's Pride	266,000	66,078	(199,922)
Pittsburg/Dry Creek	2,850	714	(2,136)
Pittsburg/Sparks Branch	8,900	5,384	(3,516)
Total	**299,750**	**104,356**	**(195,394)**

Figure 11: Five-Year TPLA Discharge Totals of phosphorus in pounds.
Delta numbers in green are the amount of phosphorus (in pounds) discharged less than the five-year allocation

SPECIAL STUDIES REPORTS

- **NITRATE SPECIAL STUDY OF TANKERSLEY CREEK AND HART CREEK**
- **SULFATE SPECIAL STUDY OF TANKERSLEY CREEK AND BIG CYPRESS CREEK**
- **LAKE O' THE PINES pH SPECIAL STUDY**

NITRATE SPECIAL STUDY OF TANKERSLEY CREEK AND HART CREEK

INTRODUCTION

The result of the Lake O' the Pines TMDL Implementation Plan, approved in 2008, was to significantly reduce phosphorus entering the reservoir from tributary streams. Water quality improvements were primarily focused on its main tributary, Segment 0404 - Big Cypress Creek. Two significant contributors to this reach of Big Cypress Creek are Segment 0404B - Tankersley Creek and Segment 0404C - Hart Creek. Both streams run along the boundaries of the City of Mount Pleasant with Hart Creek located on the eastern side of the city while Tankersley Creek is to the west. Both streams are receiving waters from wastewater treatment plants with permitted discharges of approximately 3 million gallons per day. Both streams have a similar drainage area (approximately 23,000 acres in Hart; 31,000 acres in Tankersley), stream orders, and land uses.

The *2016 Texas Integrated Report* included concerns for ammonia, nitrate, and total phosphorus in Tankersley Creek while Hart Creek showed a concern for nitrate. These concerns were identified from samples collected at stations located downstream of the City of Mount Pleasant (Hart Creek) and the Pilgrim's Pride (Tankersley Creek) wastewater treatment plant outfalls. Routine sampling had been conducted at station 10266 on Hart Creek and at station 10261 on Tankersley Creek from the late 1990's through 2001, but monitoring was discontinued in 2002. Routine quarterly sampling was resumed at these stations in October 2012.

Recent results have shown exceptionally high nitrate concentrations in Tankersley Creek, with a maximum result of 110 mg/L. Out of eighteen samples collected between October 2012 and June 2017, all results exceeded the 1.95 mg/L screening level, with a mean of all samples of 33.6 mg/L. During this same period of time, fourteen out of twenty-two samples collected in Hart Creek exceeded the screening level, with a mean of all samples of 4.99 mg/L. In both streams, these high concentrations were distributed across all seasons, but were most often obtained during lower flows of less than 10 cfs, indicating that the source of the high concentrations were possibly from these point-sources.

For samples collected between January 2013 and April 2015, total phosphorus results regularly exceeded the 0.69 mg/L screening level in Tankersley Creek with an average concentration of 3.37 mg/L. It should be noted that after the multi-million-dollar Pilgrim's Pride wastewater plant upgrades were completed in the spring of 2015, the mean total phosphorus result from July 2015 to April 2018 was 0.31 mg/L with no samples reported above the screening level.

None of the total phosphorus samples collected in Hart Creek exceeded the screening level which had a mean of 0.18 mg/L. None of the ammonia samples collected at either station exceeded the screening level, and over half of the values were reported below the Limit of Quantitation (LOQ) of 0.1 mg/L.

Due to these high nitrate results and concerns for nutrient parameters in the *2016 Texas Integrated Report*, a special study was designed and implemented to identify the source(s) of nutrients in the Tankersley Creek and Hart Creek watersheds and to determine whether the contribution was primarily from point or non-point sources. Potential non-point sources included the field application of wastewater sludge, failing septic systems, livestock, wildlife, and the over-application of commercial fertilizers. Another objective of this study was to compare the water quality of both streams since they are similar in population density, land use, and watershed size. The final objective was to attempt to develop a relationship between nutrient concentrations and stream flow in each watershed.

It should be noted that the Pilgrim's Pride wastewater outfall is located on Tankersley Creek about 150 meters upstream of the FM 127 crossing (station 10263). In 2018, the Pilgrim's Pride Texas Pollutant Discharge Elimination System (TPDES) permit was renewed which allowed the plant to discharge a daily average of 3.5 million gallons per day (MGD) with a daily maximum release of up to 5 MGD. The permit included discharge limits for Total Nitrogen. Total Nitrogen is comprised of both organic and inorganic forms of nitrogen. Organic nitrogen is measured using the Total Kjeldahl Nitrogen method which includes ammonia, while inorganic nitrogen consists of nitrite and nitrate-nitrogen. The Pilgrim's Pride TPDES permit allows for a daily average of 103 mg/L and daily maximum of 147 mg/L of Total Nitrogen.

Figure 12: Station 10263: Tankersley Creek at FM 127, below the Pilgrim's Pride outfall

Study Design

Sites were chosen in each stream that were accessible from public roads and located similar distances apart. The total reach length of Hart Creek is about five kilometers while the reach length for Tankersley is approximately 6.5 kilometers. Sites were selected both above and below the wastewater plant outfalls. For Tankersley Creek, station 10264, located at FM 899, was the most upstream site of the study. Station 10263, located approximately 150 meters downstream of the Pilgrim's Pride outfall, was monitored along with the most downstream site (station 10261) which is approximately five kilometers downstream of 10263. Station 10272 at SH 49 was the upstream station in Hart Creek, while station 10266, located about 1.6 kilometers downstream of the City of Mount Pleasant outfall, was the downstream station. Both downstream stations 10261 (Tankersley) and station 10266 (Hart) are located approximately two kilometers above their confluences with Big Cypress Creek (*Figure 14*).

Sampling was conducted at all stations on a monthly basis for twelve months, from July 2018 through June 2019. Samples were collected without the intentional examination of any particular targeted environmental or stream flow conditions. Field parameters, including dissolved oxygen, pH, temperature, and transparency were measured during sample collection. A flow measurement was made when the station was wadable. When the stream was too deep or unsafe to make a flow measurement, a flow estimate was recorded. Laboratory samples were analyzed for nitrate, nitrite, ammonia, total Kjeldahl nitrogen, and total phosphorus. All monitoring data were submitted to TCEQ for inclusion in the SWQMIS database. All laboratory results are provided in the appendix.

Station Description	Station #	Segment	MT	Field	Conv	Flow
TANKERSLEY CREEK AT FM 899	10264	0404B	RTSI	12	12	12
TANKERSLEY CREEK AT FM127	10263	0404B	RTSI	12	12	12
TANKERSLEY CREEK AT FM3417	**10261**	0404B	RTSI	8	8	8
TANKERSLEY CREEK AT FM3417	**10261**	0404B	RT	4	4	4
HART CREEK AT SH 49	10272	0404C	RTSI	12	12	12
HART CREEK AT COUNTY ROAD 4550	**10266**	0404C	RTSI	8	8	8
HART CREEK AT COUNTY ROAD 4550	**10266**	0404C	RT	4	4	4

Figure 13: Nitrate Special Study Monitoring Schedule

Figure 14: Tankersley Creek and Hart Creek Monitoring Stations results

TANKERSLEY CREEK

For station 10264, the most upstream site in Tankersley Creek, all nitrate results were reported below the 1.95 mg/L screening level regardless of stream flow. The mean result was 0.19 mg/L with a maximum value of 0.44 mg/L (*Figure 15*).

The highest nitrate results were obtained at station 10263, located below the Pilgrim's Pride outfall at FM 127. Nine of the twelve samples exceeded the nitrate screening level of 1.95 mg/L. The highest result was 121.0 mg/L, and nitrate averaged 25.4 mg/L, or over thirteen times the screening level. At the most downstream station 10261, the nitrate concentration was consistently lower than at station 10263; however, ten samples exceeded the screening level. The highest sample was 74.6 mg/L with a mean of 16.6 mg/L, or 8.5 times over the screening level.

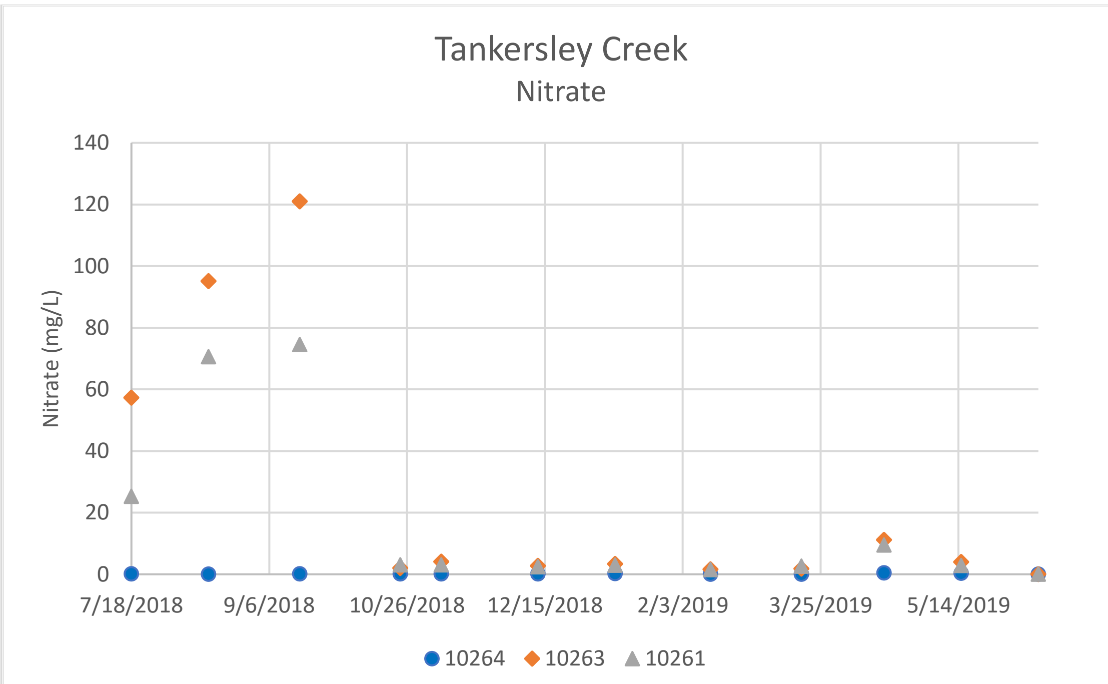

Figure 15: Tankersley Creek Nitrate Results

Nitrate results had an inverse relationship with stream flow at stations 10263 and 10261. The highest nitrate results were obtained during lower flow conditions at these stations (*Figure 16*). The highest nitrate concentrations were collected when stream flow was below 10 cubic feet per second (cfs) indicating that effluent was the primary source of nitrate in the stream. Nitrate had a negative relationship with stream flow with correlation coefficients of -0.67 at station 10263 and -0.60 at station 10261. The negative correlation confirms that nitrate concentrations were highest at the lowest stream flows. Nitrate and stream flow were not correlated at station 10264.

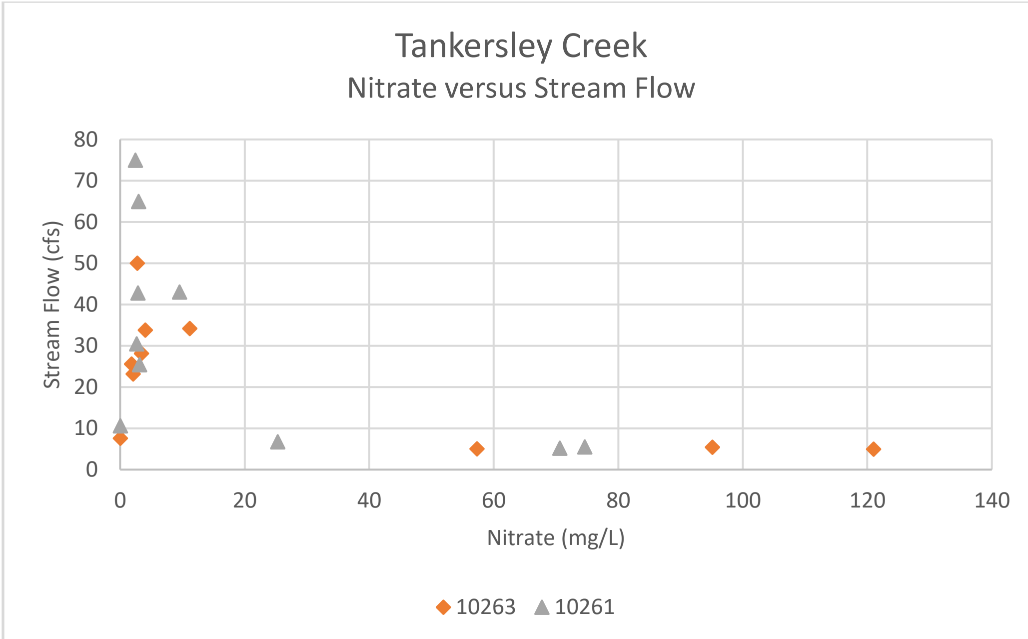

Figure 16: Tankersley Creek: Nitrate versus Stream Flow

In general, nitrite concentrations were low in Tankersley Creek. Over a third of all nitrite samples were reported below the LOQ of 0.01 mg/L while the mean ranged from 0.04 mg/L at station 10264 to 0.35 mg/L at station 10263. Similar to nitrate, the highest values were found in samples collected at lower stream flows. The highest result of 0.75 mg/L was collected at station 10261 in September 2018. The stream flow was measured at 5.53 cfs at the time of sample collection.

Ammonia also tended to be very low for most samples. None of the results at the most upstream station exceeded the 0.33 mg/L screening level with a mean of 0.08 mg/L.

Two samples at station 10263 were above the ammonia screening level. An extremely high concentration of 8.75 mg/L was reported in June 2019. The laboratory was consulted and verified this result, but no cause for the anomalous value was identified. Despite the highly toxic concentration of ammonia, fish were observed swimming and did not appear to be in distress at the time of sampling. At the most downstream station 10261, ammonia on this date was still elevated at 0.986 mg/L or about three times the screening level. No other results at station 10261 were reported above the screening level.

Even though, on average, Total Kjeldahl Nitrogen concentrations were highest at station 10263, the overall concentrations tended to be relatively low with a mean of 1.46 mg/L and 1.03 mg/L for station 10261. At the upstream station 10264, Total Kjeldahl Nitrogen averaged 0.81 mg/L. The highest Total Kjeldahl Nitrogen sample was collected at station 10263 in June 2019 with a value of 12.0 mg/L. This result is likely due to the high ammonia concentration since ammonia is a portion of the Total Kjeldahl Nitrogen calculation. All other Total Kjeldahl Nitrogen results at this station ranged from 0.81 to 3.26 mg/L. Total Kjeldahl Nitrogen was consistently lower at the downstream station 10261. The anomalous ammonia and Total Kjeldahl Nitrogen values may be the result of an upset at the treatment plant, a potentially contaminated sample, or a possibly mistake made during the laboratory analysis. There was no correlation between Total Kjeldahl Nitrogen and stream flow at any of the Tankersley Creek stations.

Despite some results being well over the screening level at station 10263, none of the Total Nitrogen concentrations exceeded the Pilgrim's Pride TPDES permit limits. The highest result, collected in September 2018, was 124.33 mg/L, comprised of 121 mg/L of nitrate. While the Total Nitrogen concentration was above the daily average limit of 103 mg/L, it did not exceed the maximum grab sample limit of 147 mg/L. All other results fell below these limits with a mean of 27.8 mg/L.

Total phosphorus concentrations exceeded the 0.69 mg/L screening level at least once at each of the Tankersley Creek stations (*Figure 17*). The highest result for all stations, 3.09 mg/L, was collected at the most upstream station, 10264 in May 2019. Since the sample was collected during a period of higher flows and frequent runoff events, the elevated concentration was likely a result of non-point sources such as the over-application of commercial fertilizer on the improved pastures upstream of the station. Another source of phosphorus may have been from exposed soils due to on-going power line construction in the riparian area upstream of the site. Since the area had experienced heavy rainfall events prior to sampling, excess nutrients from the exposed soils may have been washed into the stream. Of note is that total phosphorus was reported at 0.32 mg/L and 0.38 mg/L at the stations downstream on that date. With the exception of this single event, all samples were within the screening level and averaged 0.12 mg/L at this station.

Despite the Pilgrim's Pride WWTP extensive upgrades in 2015 which substantially reduced the amount of total phosphorus entering Tankersley Creek, five of the twelve sampling events at station 10263 exceeded the screening level of 0.69 mg/L. The highest value was 2.49 mg/L. The mean of all phosphorus samples for this station was 0.88 mg/L. On average, total phosphorus was about 0.76 mg/L higher at station 10263 than at station 10264.

With the exception of one result, all phosphorus samples collected at the most downstream station, 10261, were reported below the screening level, indicating that the excess phosphorus was being sequestered between the stations. The mean result for all samples collected at station 10261 was approximately half of the phosphorus concentration measured at station 10263. The exception was in July 2018 at 1.92 mg/L, about three times higher than reported upstream. This high value was likely the result of non-point sources such as the over-application of commercial fertilizer on the improved pastures between the two stations. All other samples at station 10261 were reported below the screening level and averaged 0.43 mg/L for the study period.

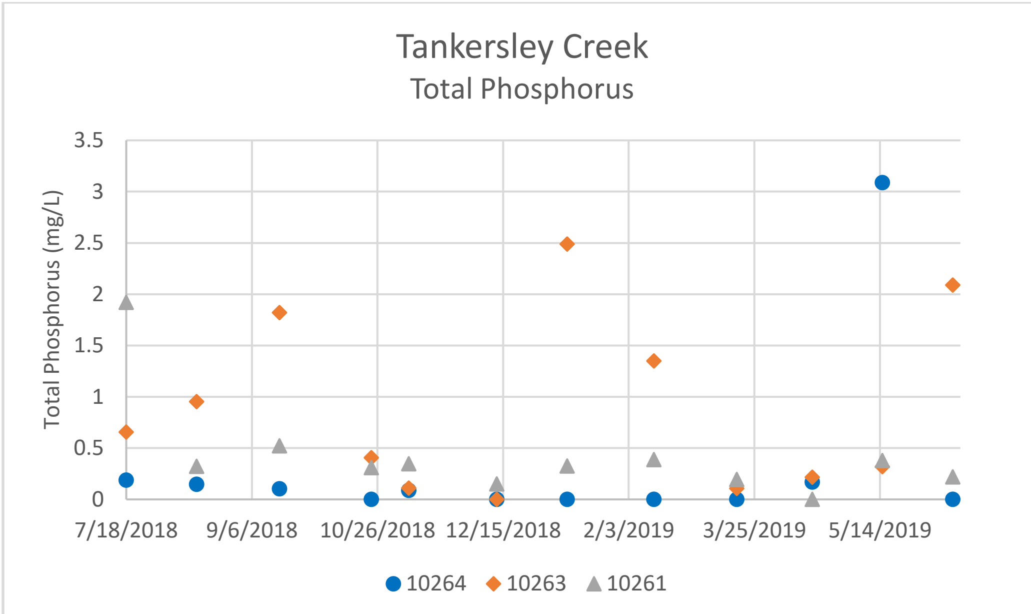

Figure 17: Total Phosphorus Results in Tankersley Creek

Although most elevated phosphorus results were obtained at flows measured below 10 cfs, there was not a significant correlation between total phosphorus and stream flow at any of the Tankersley Creek stations (*Figure 18*).

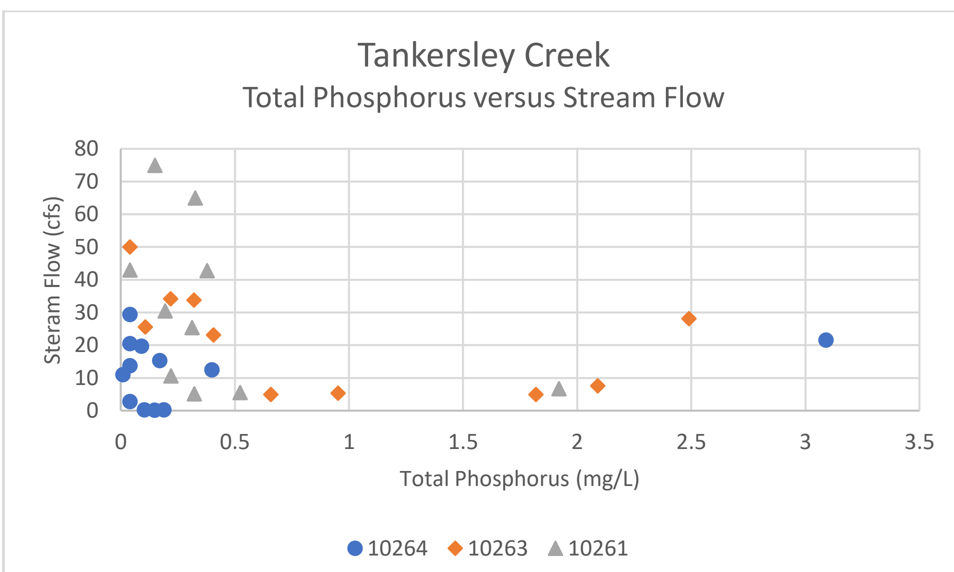

Figure 18: Tankersley Creek: Total Phosphorus versus Stream Flow

Hart Creek

Similar to the most upstream station in Tankersley Creek, none of the nitrate samples exceeded the 1.95 mg/L screening level at the upstream Hart Creek station, 10272 (*Figure 19*). These results also showed no correlation with stream flow. The maximum value obtained at this station was 0.27 mg/L and had a mean 0.14 mg/L.

Five of the nitrate samples collected at the downstream station, 10266, were reported above the screening level. The maximum result was 10.9 mg/L, while the mean was almost twice the screening level at 3.51 mg/L. On average, the nitrate concentration at station 10266 was over 25 times higher than at station 10272.

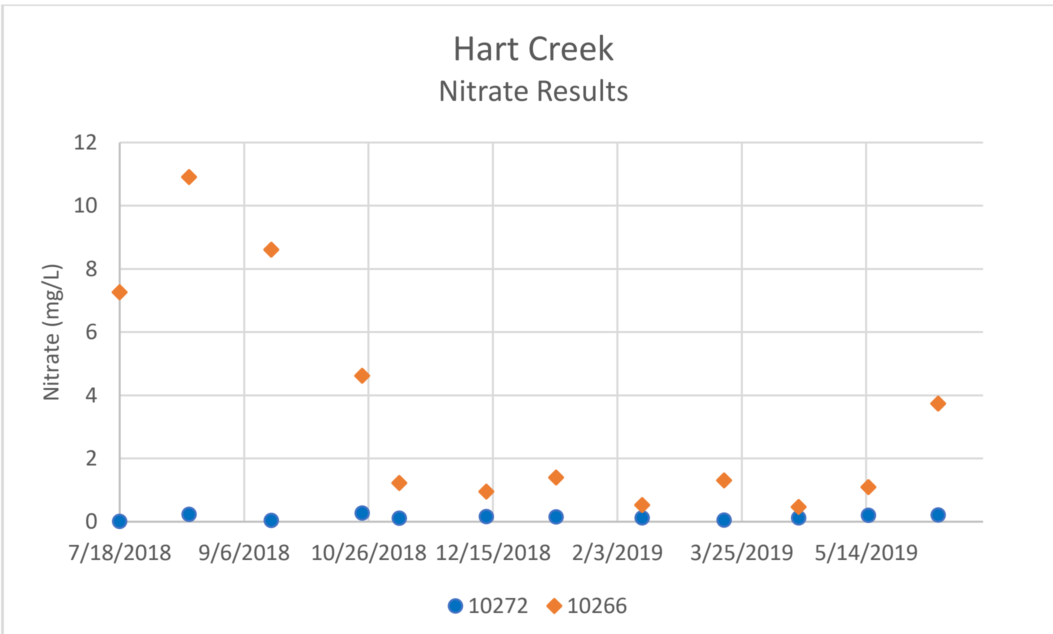

Figure 19: Hart Creek Nitrate Results

All five nitrate results that exceeded the 1.95 mg/L screening level at station 10266 were collected during the low flow period of July through October 2018 and in June 2019 (*Figure 20*). Nitrate had a strong inverse correlation with stream flow with a correlation coefficient of -0.82. These results suggest that primary source of excess nitrate was from the City of Mount Pleasant WWTP located about 1.6 kilometers upstream.

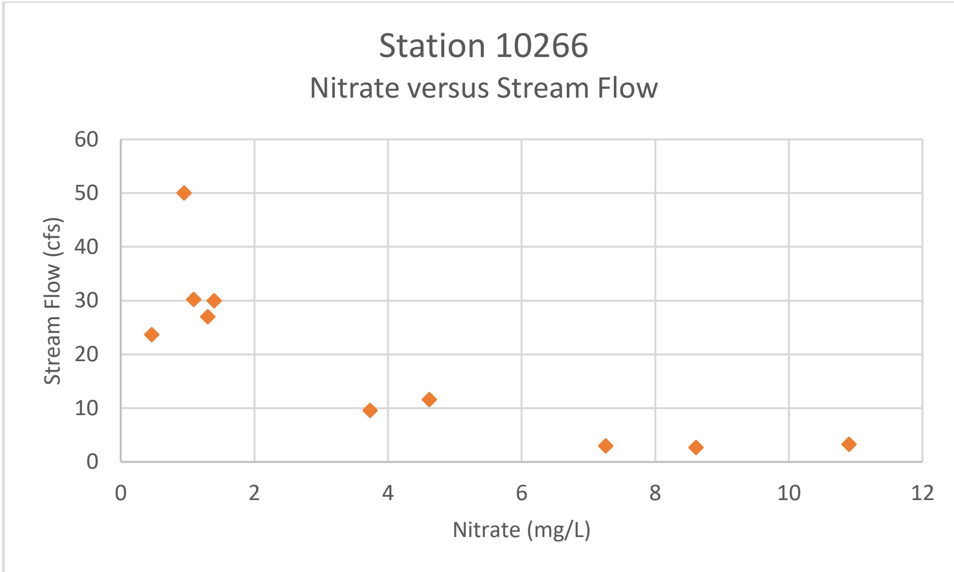

Figure 20: Station 10266: Nitrate versus Stream Flow

None of the ammonia samples exceeded the 0.33 mg/L screening level at either Hart Creek station. Approximately one quarter of all ammonia samples collected were reported below the LOQ of 0.02 mg/L. Both stations had a mean ammonia result of 0.06 mg/L with a maximum concentration of 0.15 mg/L at station 10272 and 0.13 mg/L at station 10266.

The Total Kjeldahl Nitrogen results were similar between the two stations. A mean of 0.79 mg/L was calculated for station 10272 and 0.77 mg/L for station 10266. The maximum concentration was 1.54 mg/L at station 10272, while the highest result at station 10266 was 1.10 mg/L. These results indicate the City of Mt. Pleasant WWTP had little to no effect on the concentrations of ammonia or Total Kjeldahl Nitrogen in the stream.

None of the total phosphorus samples collected in Hart Creek exceeded the 0.69 mg/L screening level (*Figure 21*). One-third of the results from station 10272 were reported below the LOQ of 0.08 mg/L. The highest concentration was 0.27 mg/L with an average of 0.16 mg/L. The results for station 10266 tended to have higher concentrations of phosphorus than at station 10272; however, the maximum result at 10266 was 0.52 mg/L with a mean phosphorus concentration of 0.24 mg/L. The difference in phosphorus concentrations between these stations was most pronounced during low flows indicating that the City of Mt. Pleasant effluent was a contributing source of phosphorus. However, since there was no significant correlation between phosphorus and stream flow, this suggests that the higher results could also be due to contributions from non-point sources.

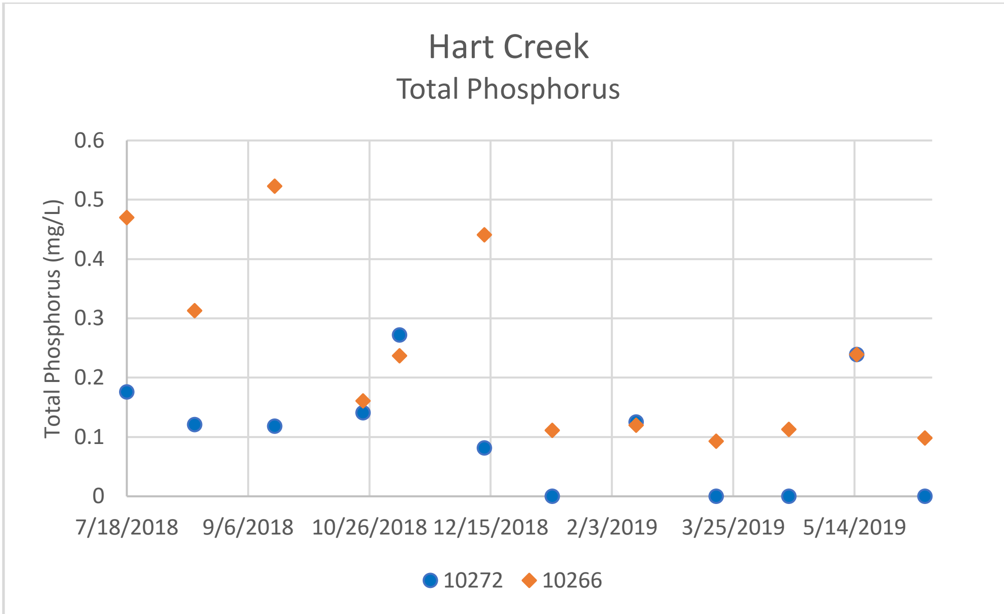

Figure 21: Total Phosphorus Results in Hart Creek

The TCEQ Region 5 office collected samples in Big Cypress Creek at SH 11 (station 10308) and US 259 (station 13631) monthly during this study period. Station 10308 is located below both the Tankersley Creek and Hart Creek confluences. Station 13631 is located at the headwaters of Lake O' the Pines at US 259.

A review of these results revealed that the nitrate concentrations were well-above the screening level in the months of July through September 2018. For station 10308, nitrate ranged from 4.33 mg/L to 51 mg/L during this three-month period, and from 3.4 mg/L to 19.4 mg/L at station 13631. The mean nitrate concentration for all samples collected during this period at 10308 was 7.06 mg/L and 3.64 mg/L at 13631. These averages were heavily skewed by the July through September 2018 results. The mean nitrate concentration for October 2018 through June 2019 was 0.62 mg/L and 0.28 mg/L at stations 10308 and 13631, respectively. The high nitrate concentrations were collected during periods of lower stream flow. The average flow at 10308 for the July, August, and September samples was 8.1 cfs, while the mean discharge during the other months was 592 cfs.

All but three ammonia results were reported below the LOQ, while the mean Total Kjeldahl Nitrogen was approximately 0.7 mg/L at both stations. None of the total phosphorus samples exceeded the 0.69 mg/L screening level. Similar to the nitrate results, the highest total phosphorus concentrations were collected at lower flows. The maximum result of 0.49 mg/L was collected at station 10308 in July 2018. The maximum concentration at station 13631 of 0.29 mg/L was collected in July 2018. The average of the total phosphorus samples at stations 10308 and 13631 was 0.17 mg/L and 0.13 mg/L, respectively.

Even though station 13631 is considered a stream station, it is located at the headwaters of Lake O' the Pines. With the exception of periods of very low flow, the station functions more like a reservoir, rather than a stream. As a result, stream flow was not measured at this location. Correlation analysis was performed for nitrate and total phosphorus versus flow at station 10308 on samples collected during the study period. Although the nitrate results were much higher during periods of low flow, there was no significant correlation identified between nitrate and stream flow. However, an inverse correlation between total phosphorus and stream flow was discovered with a correlation coefficient of -0.69. This correlation supports the assumption that higher phosphorus concentrations were likely obtained during periods of lower flows.

Figure 22: Station 10266: Hart Creek at CR 4550

CONCLUSIONS

The study results indicate that the primary source of excess nutrients in Tankersley Creek was treated effluent discharged from the Pilgrim's Pride wastewater treatment plant. Although the upgrades to the facility have significantly reduced the amount of total phosphorus entering the stream, the results of the study suggest that the plant upgrade did not address the input of nitrate into the watershed. Further, other forms of nitrogen are also entering the stream from this outfall including ammonia, nitrite, and Total Kjeldahl Nitrogen. It should be noted that none of the sample results from station 10263, located below the Pilgrim's Pride WWTP outfall, exceeded its TPDES Total Nitrogen permit limit.

These constituents were diluted during periods of higher flows. The sample results indicated that the concentration of nitrate decreased as the water moved downstream of the outfall in Tankersley Creek especially when stream flows were less than 10 cfs. When flows were greater than 10 cfs, little variation in nitrate concentrations were noted between stations 10263 and 10261. This observation is supported by the inverse correlation of nitrate to stream flow identified at both stations.

The contribution of nutrients from non-point sources should not be discounted even though they could not be quantified through this study. A single elevated total phosphorus results was obtained at the most downstream station in Tankersley Creek even though total phosphorus was below the screening level at station 10263, suggesting that the high concentration was the due to non-point sources. On one occasion, total phosphorus was elevated at station 10264. This sample was collected following a large runoff event and was possibly due to power line construction in the riparian zone upstream.

The results for the Hart Creek study indicated that the City of Mount Pleasant wastewater treatment plant was the main contributor of nitrate into the watershed. Sample results suggested that the plant was not contributing excessive amounts of other nutrients into Hart Creek including ammonia, nitrite, or total phosphorus.

Based upon the results of TCEQ samples collected in Big Cypress Creek during periods of low flow, nitrate and phosphorus remained elevated as they entered Lake O' the Pines, located almost sixty kilometers downstream of the confluence with Tankersley Creek. Practices to reduce the amount of these nutrients entering Lake O' the Pines should be implemented. Nutrient contributions from both point and non-point sources have increased the algal productivity in Lake O' the Pines which has resulted in concerns for chlorophyll in the lower assessment units of the reservoir.

SULFATE SPECIAL STUDY OF TANKERSLEY CREEK AND BIG CYPRESS CREEK

INTRODUCTION

Both assessment units of Segment 0404 – Big Cypress Creek below Lake Bob Sandlin were first shown as impaired for sulfate in the *2014 Texas §303(d) List*. A review of the historical data discussed in the *2019 Cypress Creek Basin Summary Report* indicated that Segment 0404B - Tankersley Creek was possibly a significant contributor of sulfate in the watershed.

It should be noted that the Pilgrim's Pride WWTP outfall is located on Tankersley Creek about 150 meters upstream of the FM 127 crossing. In 2018, the TPDES permit was renewed which allowed the plant to discharge a daily average of 3.5 MGD with a daily maximum release of up to five MGD. The permit included sulfate limitations of 661 mg/L for a single grab sample and a maximum daily average sulfate release of 312 mg/L.

The sulfate criterion for Segment 0404 is 100 mg/L. Sulfate concentrations in the lower assessment unit (0404_01) had an historical average of 43.1 mg/L based upon 185 samples collected from 1979 through 2018. The highest sulfate concentration in this assessment unit, 171 mg/L, was collected at station 13631, located at the headwaters of Lake O' the Pines on US 259, in September 2011. Other high sulfate samples were collected in the period of near-record drought between October 2010 and September 2012. The lowest values were reported for this date range were collected during the flooding and high release periods of 2015 and 2016.

Monitoring in the upper assessment unit of Big Cypress Creek (0404_02) has been conducted at station 10310, located at US 271, and at station 10308 on SH 11. Station 10310 is downstream of the confluence with Tankersley Creek while Station 10308 is below the confluence with Hart Creek and Walkers Creek. The highest sulfate result of 490 mg/L at station 10310 was collected in June 2014, while the maximum for station 10308 was 293 mg/L, collected in July 2012. Of note is that the average of all sulfate samples was more than double at station 10310 as compared to station 10308. Since 2014, the average sulfate concentration has declined at both stations. This reduction was possibly due to higher flows and releases from Lake Bob Sandlin than had been experienced during the pervasive drought. High sulfate concentrations at both stations clustered at lower flows indicated that point sources were responsible for the elevated sulfate concentration in the watershed.

No routine monitoring had been conducted in Segment 0404B – Tankersley Creek from FY 2003 until quarterly sampling resumed in FY 2013 at station 10261, located at the FM 3417 crossing. Similar to Segment 0404, sulfate concentrations were often reported above the criterion, with a maximum result of 508 mg/L, collected in July 2013. The mean of all samples collected between 2013 and 2018 exceeded the 100 mg/L criterion at 138 mg/L.

Due to the sulfate impairment, the CRP funded a special study to meet the following objectives:

- measure the background sulfate concentration in the stream,
- identify potential sources of sulfate in the watershed,
- determine whether sulfate concentrations are reduced as they enter Segment 0404 of Big Cypress Creek below Lake Bob Sandlin.

It should be noted that the sulfate impairment was removed in the *2020 Texas §303(d) List*. Data collected during the assessment period of December 2011 to November 2018 were below the 100 mg/L criterion, and as a result, the segment met its General Use designation.

Figure 23: Station 10264: Tankersley Creek at FM 899

Study Design

Three sites were selected in Tankersley Creek that were accessible from public roads and had been used in previous studies including the Recreation Use Attainability Analysis in 2009 – 2011 and in the FY 2018 Nitrate Special Study (*Figure 25*). Sites were chosen above and below the Pilgrim's Pride WWTP outfall and on Big Cypress Creek at the US 271 crossing (station 10310). Station 10264 on Tankersley Creek is located on FM 899 above the Pilgrim's Pride WWTP. Station 10263, at FM 127, is situated approximately 150 meters downstream of the Pilgrim's Pride outfall. The most downstream site on Tankersley Creek (station 10261) is approximately five kilometers downstream of the outfall. The Tankersley Creek confluence with Big Cypress Creek is about two kilometers downstream of station 10261 and approximately two kilometers upstream of US 271 (station 10310).

Samples were collected on a monthly basis over thirteen months, from October 2019 through November 2020. Sampling was conducted without the intentional examination of any particular targeted environmental or stream flow conditions. Field parameters, including dissolved oxygen, pH, temperature, and transparency, were recorded during sample collection. A flow measurement was made at all of the Tankersley Creek stations except on two occasions at station 10264 when the water was too shallow to measure. On those two occasions, flow estimates of <0.5 cfs were reported. For station 10310, flow was recorded from the USGS gage located on the bridge. Laboratory samples were analyzed using EPA Method 300.0 (rev. 2.1) which, in addition to sulfate, produces results for nitrate, nitrite, and chloride. All monitoring data were submitted to TCEQ for inclusion in the SWQMIS database. All laboratory results are available in the appendix.

Station Description	**Station #**	**Segment**	**MT**	**Field**	**Conv**	**Flow**
TANKERSLEY CREEK AT FM 899	10264	0404B	RTSI	12	12	12
TANKERSLEY CREEK AT FM 127	10263	0404B	RTSI	12	12	12
TANKERSLEY CREEK AT FM3417	**10261**	0404B	RTSI	8	8	8
TANKERSLEY CREEK AT FM3417	**10261**	0404B	RT	4	4	4
BIG CYPRESS CREEK AT US 271	10310	0404	RTSI	12	12	12

Figure 24: Sulfate Special Study Monitoring Schedule

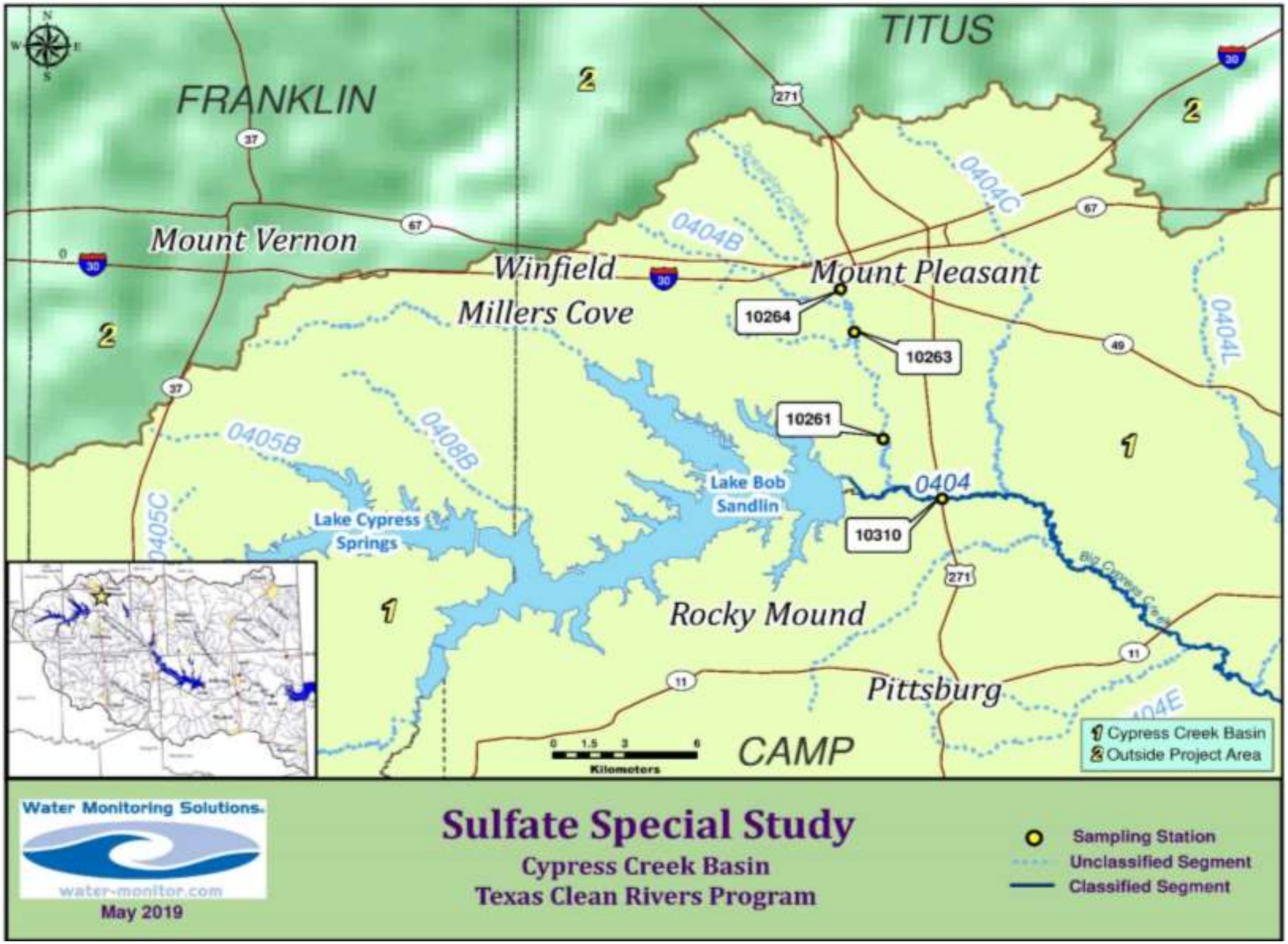

Figure 25: Sulfate Study Monitoring Stations

RESULTS

At station 10264, the most upstream site in Tankersley Creek, all sulfate results were well below the 100 mg/L criterion regardless of stream flow. The mean result was 47.6 mg/L, with a maximum value of 72.1 mg/L. The highest sulfate concentrations were obtained at station 10263 which is located below the Pilgrim's Pride outfall. Two of the twelve samples exceeded the criterion at 111 mg/L and 102 mg/L, while the mean concentration for all samples was 83.4 mg/L. None of the samples from station 10261 exceeded the criterion. The maximum concentration was 92.2 mg/L and the mean was 71.4 mg/L. For station 10310 in Big Cypress Creek, the mean of all samples was 50.0 mg/L with a maximum result of 86.3 mg/L (*Figure 26*).

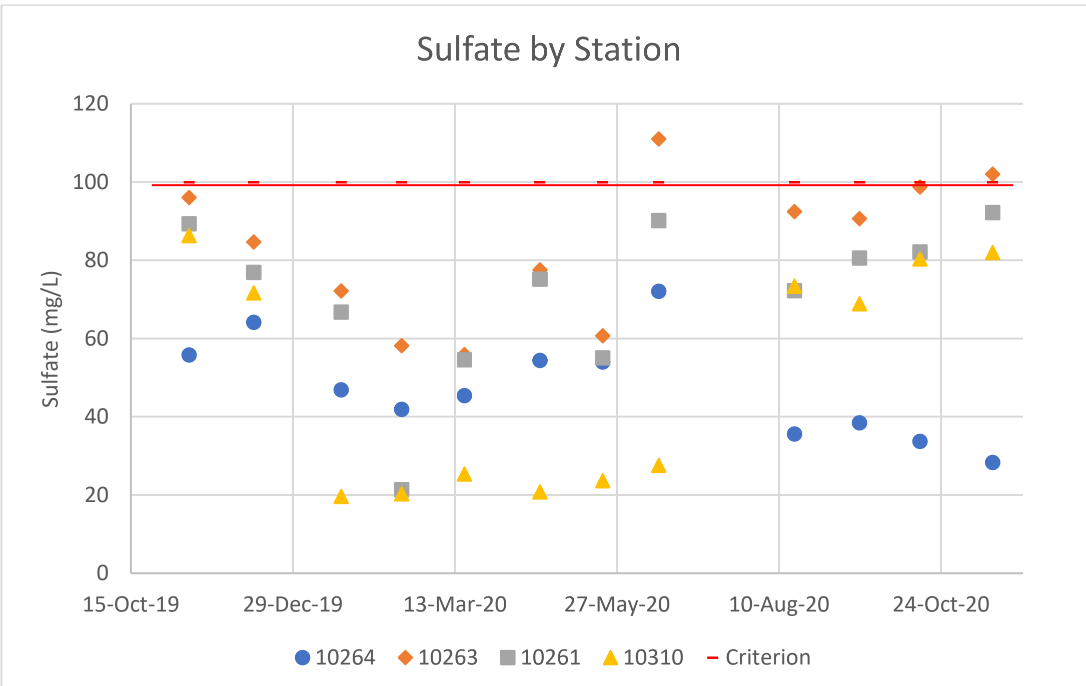

Figure 26: Sulfate Results by Station

The highest sulfate results were obtained at station 10263 for each of the monthly samples. Station 10263 averaged approximately 36 mg/L or 175 percent higher than at the most upstream station, 10264, indicating that the Pilgrim's Pride outfall was a significant source of sulfate in the watershed. With the exception of the February 2020 samples, all results collected at station 10261 were higher than at station 10264. Station 10261 averaged 23.8 mg/L, or approximately 150 percent higher than at the most upstream station.

Unlike the other sites in the study, the sulfate results at station 10264 were unrelated to stream flow. In fact, the maximum (72.1 mg/L) and minimum (28.3 mg/L) concentrations were collected at low flows of less than 0.6 cfs. Sulfate values for station 10263 were strongly inversely related to flow with a correlation coefficient of -0.89. The high negative correlation coefficient indicated that sulfate concentrations were highest during low flows. Station 10261, the most downstream station in Tankersley Creek, also had a strong inverse correlation of -0.74 (*Figure 27*).

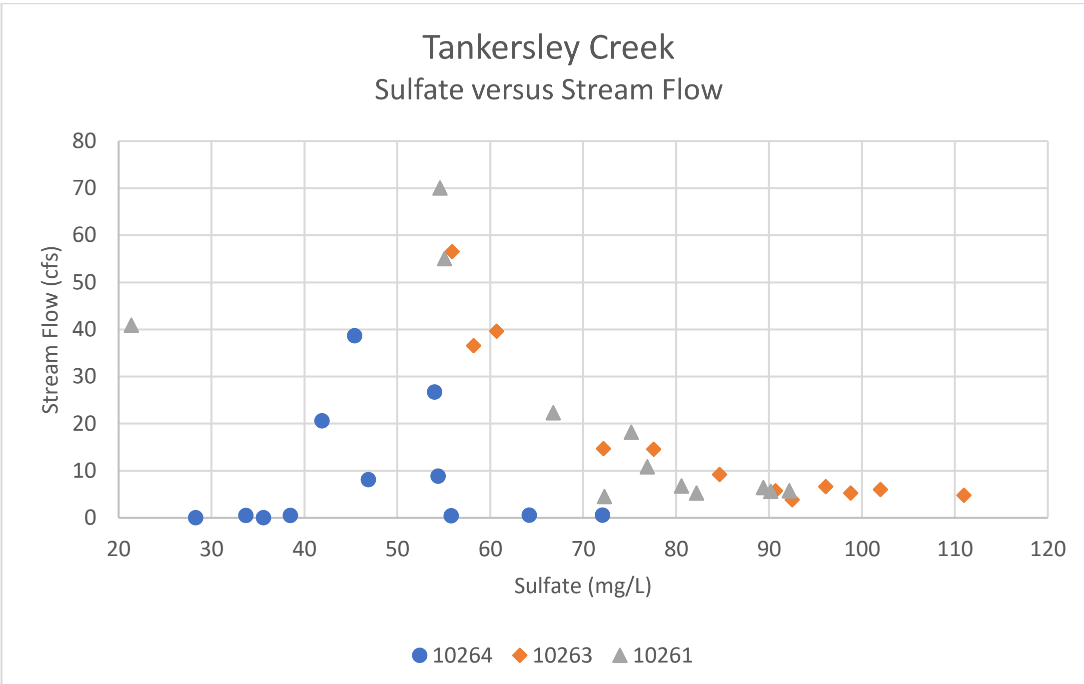

Figure 27: Tankersley Creek: Sulfate versus Stream Flow

The results for the station 10310 Big Cypress Creek samples were highly influenced by stream flow with a correlation coefficient of -0.8. For the six samples collected with flow rates above 16 cfs, sulfate concentrations were lower than at the most upstream Tankersley Creek station, 10264. However, there was little difference in the sulfate results at station 10310 than at station 10261 for samples collected at low flows.

Nitrate samples yielded similar to results to those obtained in the FY 2018 Nitrate Special Study. For station 10264 in Tankersley Creek, all nitrate values were well below the 1.95 mg/L screening level regardless of stream flow. The mean value was 0.2 mg/L, with a maximum of 0.8 mg/L. The highest nitrate concentrations were obtained at station 10263 below the Pilgrim's Pride outfall. All samples exceeded the screening level with a mean of 45.2 mg/L and maximum concentration of 97.3 mg/L. All but one of the samples at station 10261 exceeded the screening level. The highest concentration was 68.0 mg/L while the average was 34.9 mg/L. For station 10310 in Big Cypress Creek, the mean of all samples was 24.3 mg/L with a maximum result of 56.5 mg/L (*Figure 28*).

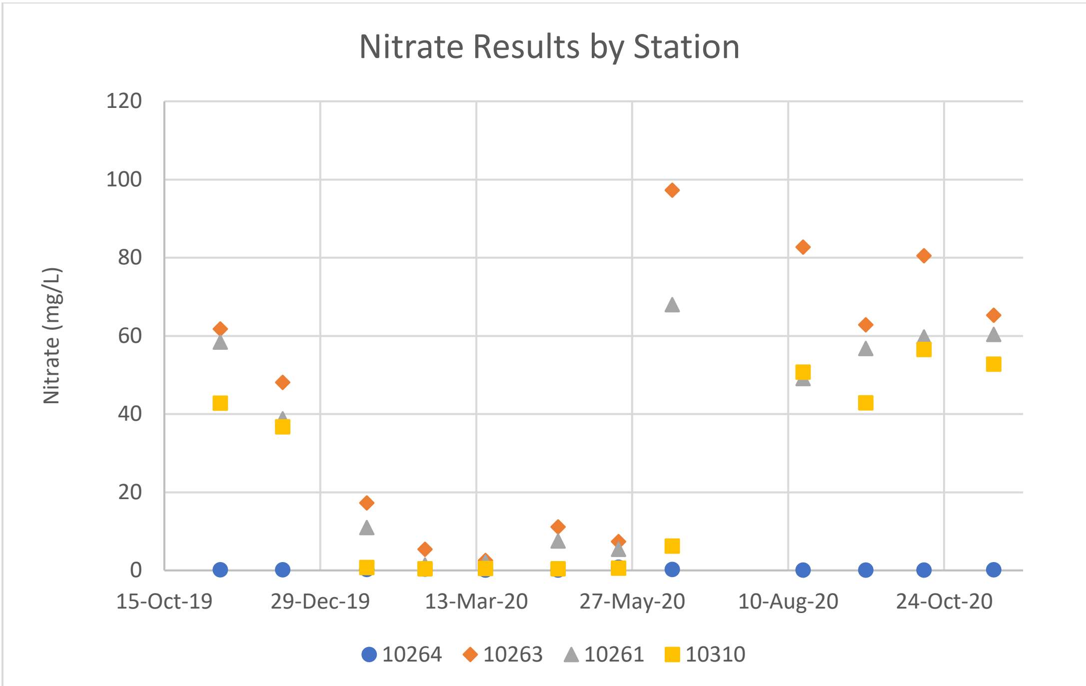

Figure 28: Nitrate Results by Station

Recall the TPDES permit discussion from the FY 2018 Nitrate Special Study. The Pilgrim's Pride WWTP does not have a permit limit for nitrate; however, it has a Total Nitrogen limit. Total Nitrogen is comprised of both organic and inorganic forms of nitrogen. Organic nitrogen is measured using the Total Kjeldahl Nitrogen method which includes ammonia while inorganic nitrogen consists of nitrite and nitrate-nitrogen. The Pilgrim's Pride TPDES permit has a daily average limit of 103 mg/L and daily maximum of 147 mg/L. As found in the FY 2018 Nitrate Special Study, most of the nitrogen being discharged from the plant was in the form of nitrate-nitrogen. In most cases, very few samples of ammonia and nitrite-nitrogen were high enough to be measured by the laboratory and every Total Kjeldahl Nitrogen sample was low. All Total Nitrogen results from the CRP quarterly samples collected at station 10261 during this special study period were well within the permit limits. The highest Total Nitrogen result of 59.8 mg/L was obtained in October 2020.

Unlike the other sites in the study, the nitrate results at station 10264 were unrelated to stream flow. However, it should be noted that the highest concentrations were collected at higher flows suggesting that the nitrate concentrations were possibly due to non-point sources. Nitrate values for station 10263 were strongly inversely correlated to flow with a correlation coefficient of -0.8. As with the sulfate results, the high negative correlation coefficient indicated that nitrate values were most concentrated during low flows. The most downstream station in Tankersley Creek (10261) also had a strong inverse correlation of -0.82 (*Figure 29*).

The results for the station 10310 Big Cypress Creek samples were also highly influenced by stream flow with a correlation coefficient of -0.79. For the five samples collected at flow rates over 60 cfs, nitrate concentrations were well-below the 1.95 mg/L screening level and yielded similar results as the most upstream Tankersley Creek station, 10264. However, when stream flow was less than 60 cfs, all nitrate samples exceeded the screening level with a mean of 41.2 mg/L. For the six samples collected when flow was below 16 cfs, there was little difference in the nitrate results between station 10310 and station 10261.

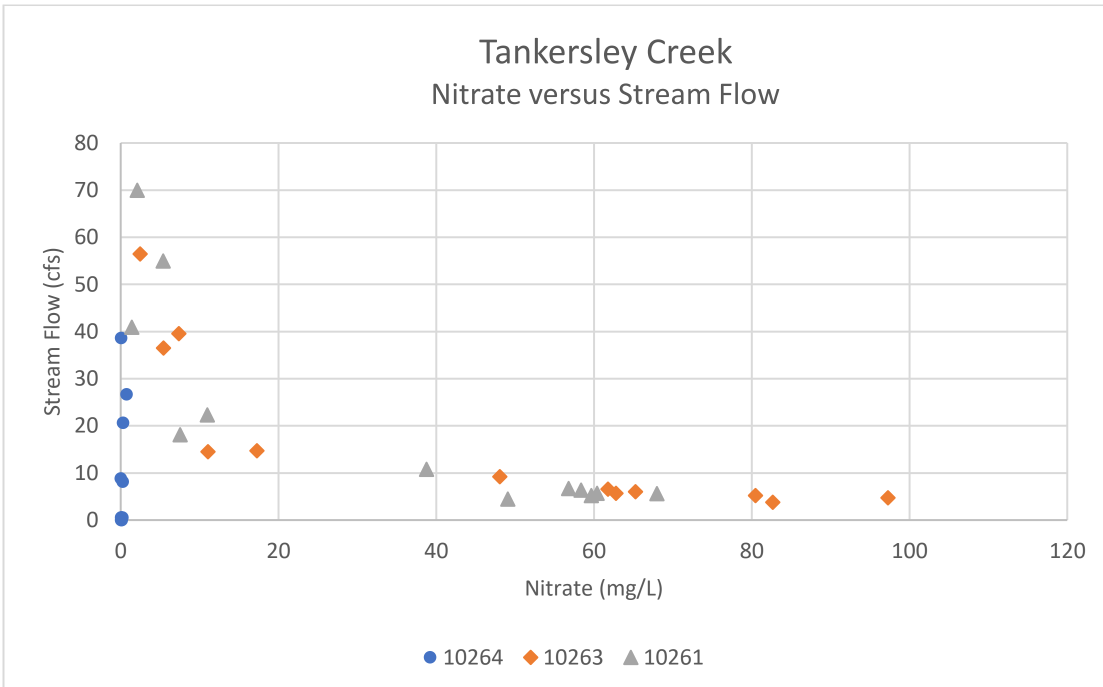

Figure 29: Tankersley Creek: Nitrate versus Stream Flow

As discovered in the FY 2018 Nitrate Special Study, most nitrite samples were reported below the LOQ of 0.01 mg/L. Only five of the forty-eight samples were reported above the LOQ, and each station had at least one measurable sample. Two of these samples were collected at station 10261 which also included the highest result of 0.193 mg/L, collected in November 2020. The other measurable nitrite samples ranged from 0.02 to 0.1 mg/L.

All chloride samples collected at station 10264 in Tankersley Creek were reported below the 100 mg/L criterion with a mean of 23.7 mg/L and maximum of 38.9 mg/L. The highest chloride values were obtained at station 10263 for each of the monthly samples. Half of the samples collected at station 10263 exceeded the criterion. The maximum result was 171 mg/L and had a mean chloride concentration of 92.4 mg/L. These results indicate that the Pilgrim's Pride outfall was a significant source of chloride in the watershed. Five of the samples at station 10261 exceeded the criterion while three results were reported above 100 mg/L at station 10310 in Big Cypress Creek. The mean results at stations 10261 and 10310 were 76.8 mg/L and 54.9 mg/L, respectively (*Figure 30*). As with sulfate results, all samples collected at station 10261 were higher than at station 10264 except in February 2020.

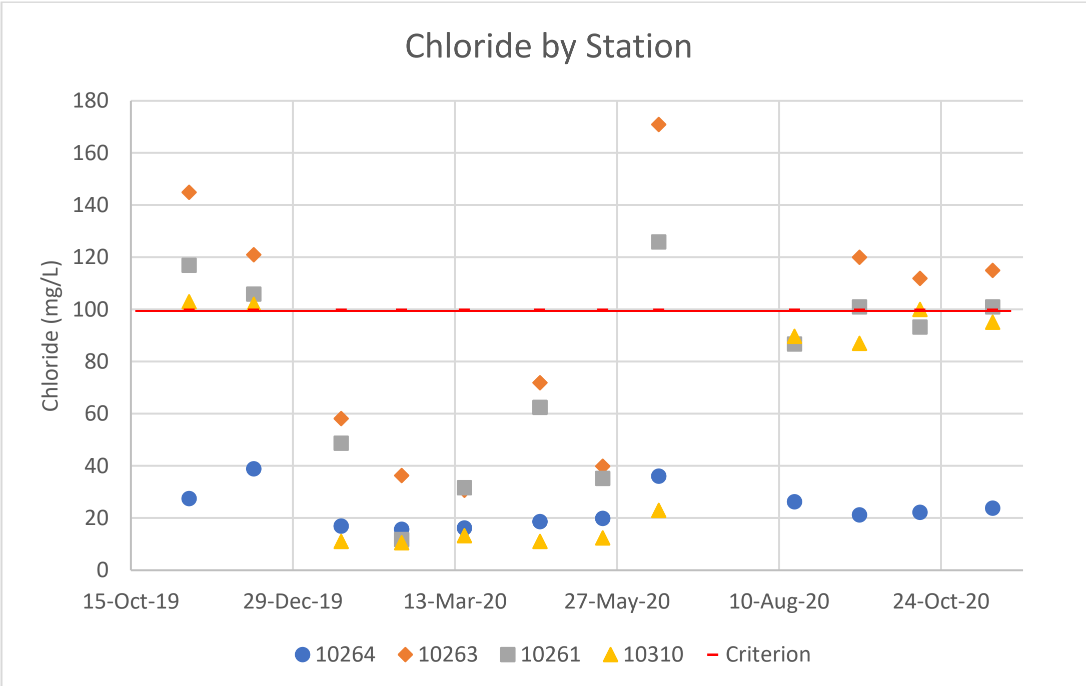

Figure 30: Chloride Results by Station

Unlike the other parameters, chloride results for station 10264 had an inverse relationship with stream flow with a correlation coefficient of -0.6. The negative correlation coefficient indicated that chloride concentrations were highest during low flows. As with the other parameters, chloride values for stations 10263 and 10261 were strongly inversely related to stream flow with correlation coefficients of -0.81 and -0.84 (*Figure 31*).

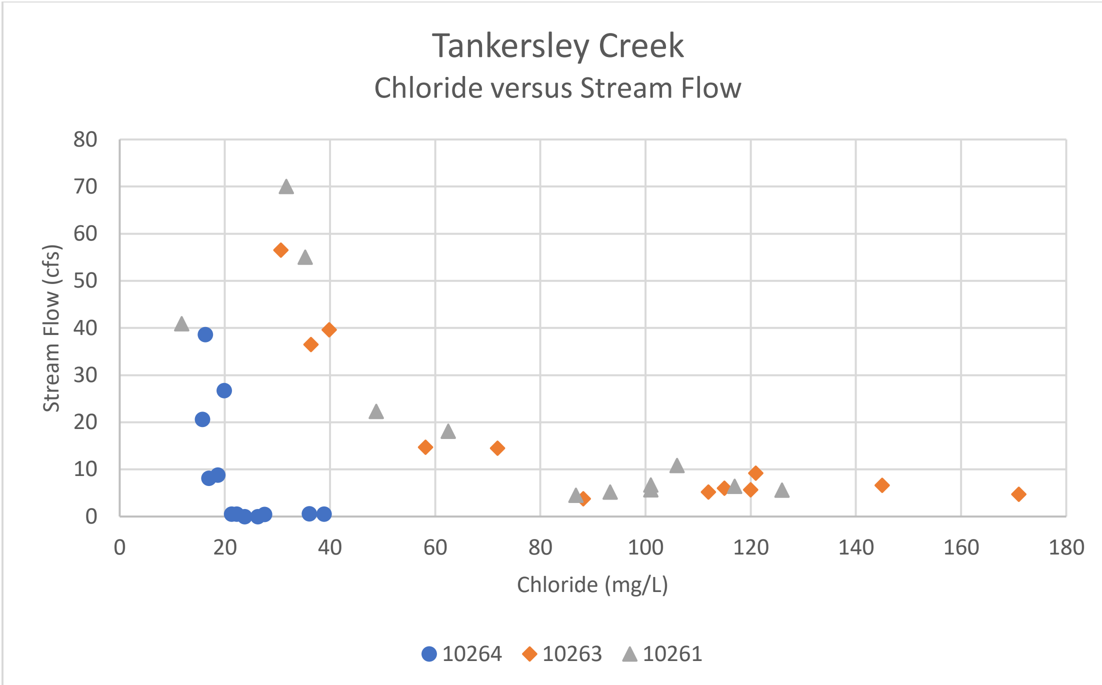

Figure 31: Tankersley Creek: Chloride versus Stream Flow

Figure 32: Station 10261: Tankersley Creek at FM 3417

As with sulfate and nitrate, the chloride results for the Big Cypress Creek station 10310 were highly influenced by stream flow (*Figure 33*). Chloride concentrations were also inversely related to stream flow with a correlation coefficient of -0.81. As found for sulfate, for the six samples collected at flow rates above 60 cfs, chloride concentrations were lower than at the most upstream Tankersley Creek station, 10264. Similar to the other parameters, there was little difference in the chloride results at station 10310 than at station 10261 for samples collected at low flows.

These results suggest that the releases from Lake Bob Sandlin directly affect the concentration of these parameters in Big Cypress Creek. In 2019, there were no releases from the reservoir after July 22, 2019. Releases resumed on January 15, 2020 and continued through June 16, 2020. As demonstrated in Figure 33, all parameters had dramatically lower concentrations during the release period as compared with the results without releases.

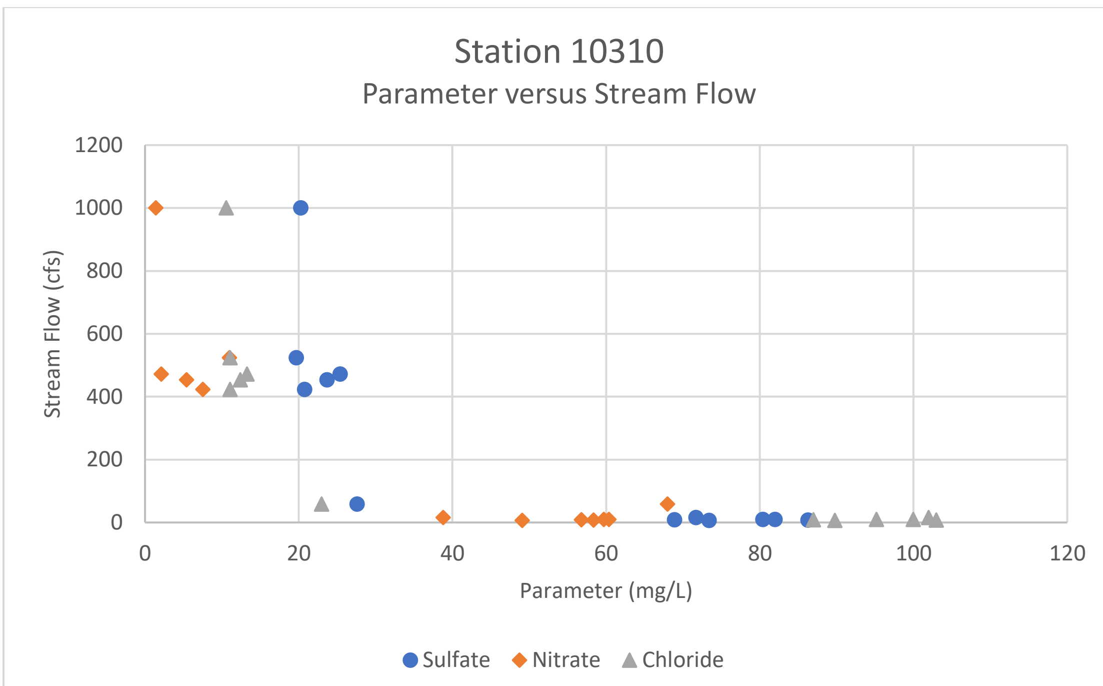

Figure 33: Station 10310: Parameter versus Stream Flow

A review of the five quarterly CRP samples collected at station 16458, Big Cypress Creek near the confluence with Greasy Creek, revealed similar findings to those at station 10310. Nitrate values at station 16458, located approximately 25 kilometers downstream of station 10310, remained over seven times the screening level for the three samples collected at flows below 60 cfs. The two samples collected at higher flows were reported below the 1.95 mg/L screening level. Similar to station 10310, releases from Lake Bob Sandlin impacted the concentration of these parameters.

Conclusions

The results of the Sulfate Special Study indicated that the primary source of sulfate, nitrate, and chloride in Tankersley Creek and the upper portion of Segment 0404 – Big Cypress Creek was the discharge from the Pilgrim's Pride wastewater treatment plant. Despite the upgrades to the facility in 2015 that have significantly reduced the amount of total phosphorus entering the stream, the results of this study suggest that the strategies to reduce the amount of sulfate, nitrate, and chloride being discharged would be beneficial to the water quality of Tankersley Creek and Big Cypress Creek. It should be noted that all parameters measured during this study were within the discharge limits set forth in the TPDES permit.

Station 10264, located upstream of the outfall had significantly lower concentrations of these parameters than at Tankersley Creek stations 10263 and 10261, located downstream of the outfall. On average, sulfate was 175 percent greater at station 10263 than at station 10264. For nitrate, the result was over 21,000 percent higher while chloride was almost 390 percent greater than at the most upstream station.

As found in the FY 2018 Nitrate Special Study, the high levels of nitrate in the discharge are of great concern. The TCEQ screening level for nitrate is 1.95 mg/L, and the mean nitrate result for the upstream station 10264 was 0.2 mg/L. The average nitrate concentration for station 10263, located below the outfall, was over twenty times the TCEQ screening level at 45.2 mg/L. Nitrate concentrations remained elevated with a mean of 34.9 mg/L at station 10261, located approximately 5 kilometers downstream and tended to remain high at the Big Cypress Creek station 10310 with a mean of 24.3 mg/L. These findings were corroborated with the results for samples collected at station 16458, located on Big Cypress Creek approximately 25 kilometers downstream. Despite these elevated nitrate results, the Pilgrim's Pride WWTP discharge appeared to be in compliance with its Total Nitrogen permit limits.

Stream flow played a significant role in the concentration of these constituents. For data collected during this study, a strong inverse correlation to stream flow was identified at all sites except station 10264. The inverse correlation indicated that sulfate, nitrate, and chloride concentrations were highest during periods of low flow, and that these constituents became diluted during periods of higher flow. These correlations further suggest that the primary source of these parameters was effluent discharged from the Pilgrim's Pride WWTP. Releases from Lake Bob Sandlin significantly reduced the concentrations of these parameters at both Big Cypress Creek stations 10310 and 16458.

For this study, non-point sources did not appear to be a significant contributor of sulfate, nitrate, or chloride in the watershed. These sample results also suggested that the concentration of the parameters decreased downstream during periods of higher flow, but remained relatively unchanged in Big Cypress Creek when stream flow was low. When stream flow was above 60 cfs at station 10310 in Big Cypress Creek, sulfate, nitrate, and chloride results were similar or lower than at the most upstream station in Tankersley Creek.

Figure 34: Station 10310: Big Cypress Creek at US 271

LAKE O' THE PINES PH SPECIAL STUDY

INTRODUCTION

Segment 0403 - Lake O' the Pines is divided into four assessment units (AU):

- AU_01 Lower 5,000 acres near the dam
- AU_02 Middle 5,000 acres
- AU_03 Middle 5,000 acres below SH 155
- AU_04 Upper 3,700 acres above SH 155

AU_02 was the first identified as impaired for high pH in the *2016 Texas §303(d) List*. The *2016 Texas Integrated Report* also included a concern for high pH in AU_01. In the *2020 Texas §303(d) List*, the three lower assessment units were impaired for high pH. Further, the *2020 Texas Integrated Report* defined Lake O' the Pines as an eutrophic reservoir and ranked it in the top thirty percent out of 130 Texas resevoirs for elevated chlorophyll. The high pH impairment was due to more than one-quarter of the pH samples exceeding the 8.5 s.u. pH criterion. Data collected during the assessment period also revealed high chlorophyll and dissolved oxygen values.

In eutrophic reservoirs, algae/phytoplankton consume the available carbon dioxide during the process of photosynthesis. Once the available carbon dioxide is exhausted, carbon dioxide will be broken away from the weak bond of carbonic acid, thereby increasing the pH in the water column. After sunlight is no longer available for photosynthesis, carbon dioxide, released through respiration, will bond with available hydrogen ions to reform carbonic acid, thereby lowering the pH.

The *2019 Cypress Creek Basin Summary Report* concluded that pH was generally increasing throughout the entire reservoir and identified statistically significant increasing pH trends in the middle two assessment units. All of the pH measurements reported above the 8.5 s.u. criterion corresponded with super-saturated dissolved oxygen values. A strong correlation between pH and dissolved oxygen percent saturation was also discussed in the report. The combination of elevated chlorophyll and super-saturated dissolved oxygen supported the assumption that the higher pH readings were a direct result of phytoplankton productivity since all of the data used in the assessment came from grab samples collected between 10 AM and 2 PM, the peak hours of primary production. The report suggested that diel pH cycling was likely to be occurring; however, no recent diel data were available for review to support the hypothesis.

Due to the pH impairments and data needs in order to validate these assumptions, two special studies were funded by the CRP. One study incorporated the use of two continuous water quality monitoring stations located in the upper portion of the reservoir. The second study incorporated targeted diel monitoring in the lower assessement units.

Study Design

The objective of the special studies was to test the relationships between pH, DO, and chlorophyll in order to better understand the daily range of pH throughout the reservoir. To this end, sites were chosen that were readily accessible and did not require permission from the USACE to install buoys or alter boat markers in the reservoir. As a result, the stations selected were not necessarily representative of each assessment unit. Most stations are located near the shore, rather than in the central portion of the reservoir where routine monitoring is conducted. For the upper portion of Lake O' the Pines, the two NETMWD continuous water quality monitoring stations were selected. In the lower assessment units, diel monitoring was performed at the City of Longview intake and at a swimming area near the dam (*Figure 36*).

The continuous monitor at US 259 is located in Segment 0404_01 of Big Cypress Creek, rather than in Segment 0403_04 of Lake O' the Pines. With the exception of extended drought periods, this station functions more lacustrine than riverine so it was chosen to represent the upper assessment unit of the reservoir. The NETWMD intake is located in AU_03, and the continuous monitor installed at the intake represented that assessment unit. Station 22172, located at the City of Longview intake, represented AU_02 while station 22173, located by a public swimming area near the dam, represented AU_01.

Both continuous water quality instruments measure DO, pH, chlorophyll, and other parameters at 15-minute intervals. Data generated by these continuous monitors are used by NETMWD for internal purposes and are not submitted to TCEQ for inclusion in SWQMIS. Since chlorophyll is also measured, data obtained from the monitors were used to make general assertions about primary productivity in addition to providing diel DO and pH ranges.

Since data were also needed to characterize water quality in the lower portion of the reservoir, a targeted diel study was designed to measure daily DO and pH ranges. The study was targeted to the summer months since almost all high pH values in Lake O' the Pines were obtained during these months. For this study, an instrument was deployed at each station and programmed to record DO and pH at 15-minute storage intervals for a minimum of 24 hours. The diel studies were scheduled to be performed in the months of May through August 2020 and 2021. The diel results will be compared with the continuous water quality monitoring data and with the quarterly grab sampling results collected by the TCEQ Region 5. The diel data will be submitted to TCEQ for inclusion in the SWQMIS database, but were not intended for assessment purposes since the stations are not representative of their associated assessment units. Regardless of being representative of the associated assessment unit, these results will be instrumental in determining if future study is warranted.

Figure 35: US 259 (left) and NETMWD Intake (right) Continuous Water Quality Monitoring Stations

Figure 36: Lake O' the Pines Special Study Site Map

Results

Please note that the following discussion is a review of the **preliminary results** of the study. Data are scheduled to be collected through August 2021, and the final results of these studies will be discussed in a future basin highlights report.

Both continuous water quality sondes were installed on November 20, 2019. Both sondes measured specific conductance, temperature, dissolved oxygen, pH, turbidity, chlorophyll, and blue-green algae and were programmed to internally record these parameters every fifteen minutes. Between November 20, 2019 and December 9, 2020, over 385,000 measurements were made at the US 259 station while over 352,000 readings were recorded at the NETMWD intake. Power failure and routine maintenance accounted for data loss.

The instruments were serviced and calibrated approximately every six to eight weeks during the study period. Site visits were more frequent in the warmer/biologically productive months and less frequent in the cooler months. The central wiping mechanism on the instruments proved to be effective at keeping the sensors free from biological fouling. Fouling did not appear to significantly impact the readings. Both instruments passed post-deployment calibration tests during each service visit.

Figure 37: Water Quality Sonde After Eight-Week Deployment at NETMWD Intake

One of the challenges for analyzing and comparing the results from the continuous monitors was the inability to maintain the instrument at a fixed depth below the surface. Ideally, the measurements should be made between 0.3 and 0.5 meters below the surface. At the beginning of the study and throughout most months of 2020, Lake O' the Pines was well above its conservation pool. Since the instruments were mounted in a fixed position inside the deployment apparatus, the instrument depth ranged from around 0.5 to 2.7 meters with an overall average depth of over 1.1 meters at both stations. Moreover, the reservoir level increased dramatically in January 2020 due to heavy rainfall and releases from Lake Bob Sandlin. The reservoir elevation remained well-above the conservation pool through April before dropping throughout the summer (*Figure 38*).

Due to heavy rainfall in May 2020, the diel studies in the lower portion of Lake O' the Pines were postponed until June. The sondes were deployed in June, July, and in early and late August. Fifteen-minute data were collected for 24 to 48 hours at both stations. There were no results reported for the dam station (22173) in July due to the deployment apparatus becoming dislodged from its mooring. Divers were able to find and recover the instrument in August. Since the instrument sensors failed the calibration check, the data were not valid for analysis or reporting.

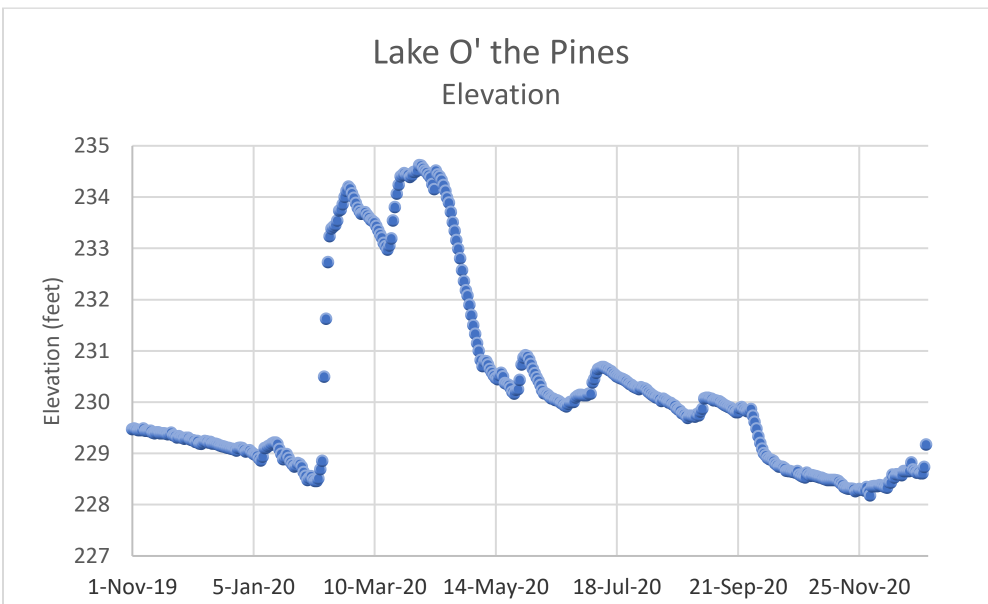

Figure 38: Lake O' the Pines Elevation

A USGS weather station, located near the dam, recorded precipitation, wind speed, and wind direction at fifteen-minute intervals. Approximately 13 inches of rain was measured at the station between June 1 and August 26, 2020. Wind was generally calm throughout the study period with an average speed of 4.1 miles per hour in a southeasterly direction. A wind speed of 10 miles per hour or higher was recorded in fewer than 3.5 percent of the measurements made at the weather station.

The US 259 continuous water quality monitor recorded 35,167 pH readings between November 20, 2019 and December 9, 2020. The median pH during this time period was neutral at 6.9 s.u. The minimum pH was 6.0 s.u. and maximum was 8.9 s.u. Only 68 (0.2 percent) of the pH readings were reported above the 8.5 s.u. criterion. All high pH values all were measured between June 15 and October 10, 2020. Sixty-five of those high pH values were recorded during three time periods: June 18 – 21, July 27 - 30, and October 8 – 10 (*Figure 39*).

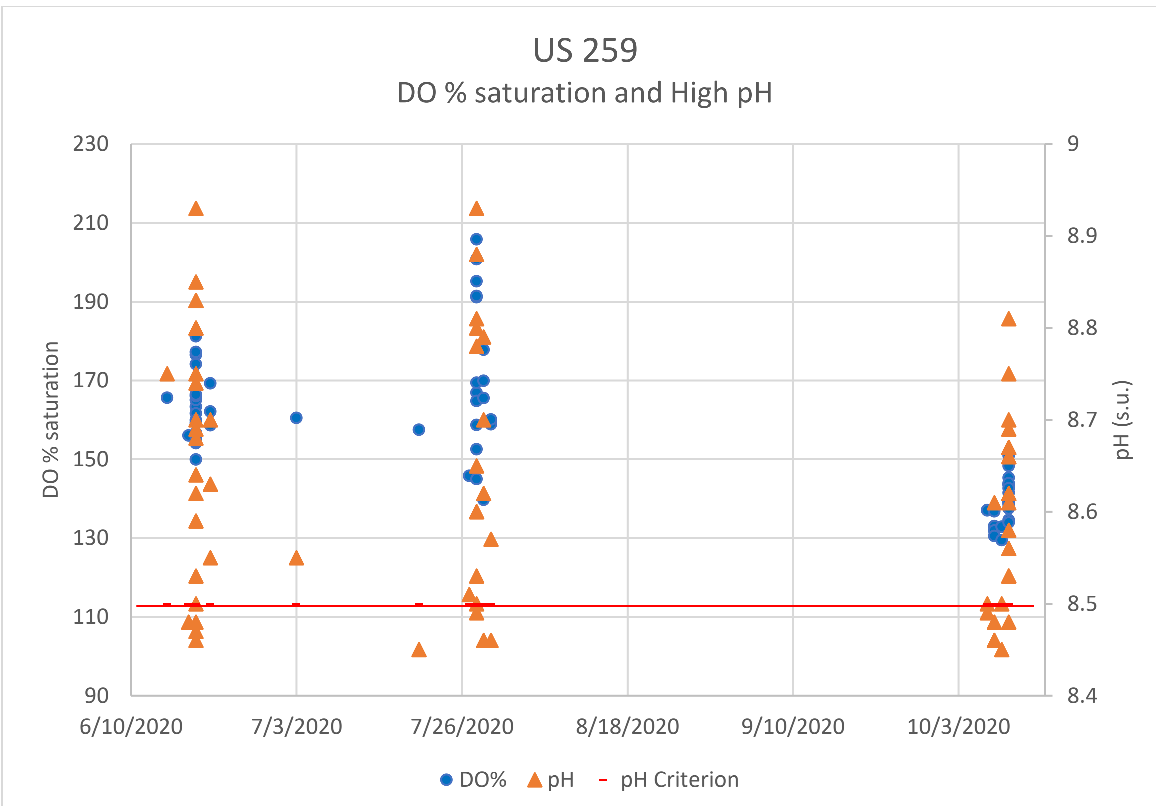

Figure 39: US 259: DO percent saturation and High pH

The highest pH values were obtained in the summer months with a peak of 8.9 s.u., collected in both June and July. The pH range, or the difference between the maximum and minimum pH (6.5 s.u.), was also largest during these months at 2.4 s.u. Recall that the pH scale is a logarithmic, base-ten scale meaning that each unit is ten times greater than the one below it. Considering the range of 2.4 s.u., the maximum value of 8.9 s.u. was 400 times higher than the minimum pH of 6.5 s.u.

The mean chlorophyll concentration for the study period at the US 259 station was 8.4 µg/L, and the median was 6.4 µg/L. Less than five percent of all chlorophyll readings exceeded the

26.7 µg/L screening level. The maximum result of 79.6 µg/L was recorded on July 29, 2020. Chlorophyll values exceeding the screening level were primarily observed during the warm months with eighty percent of the high values collected in June through August 2020.

The highest dissolved oxygen percent saturation and chlorophyll values were also obtained during these months. A statistically significant relationship between pH and DO percent saturation was identified with a correlation coefficient of 0.67. However, only weak and non-statistically significant relationships between DO percent saturation and chlorophyll, and pH and chlorophyll, were calculated. Both comparisons had a correlation coefficient of 0.4. A possible reason for the weak relationships is due to the station being located in a transition zone between riverine and lacustrine and confounded by the measurement depth ranging from 0.5 to 2.7 meters.

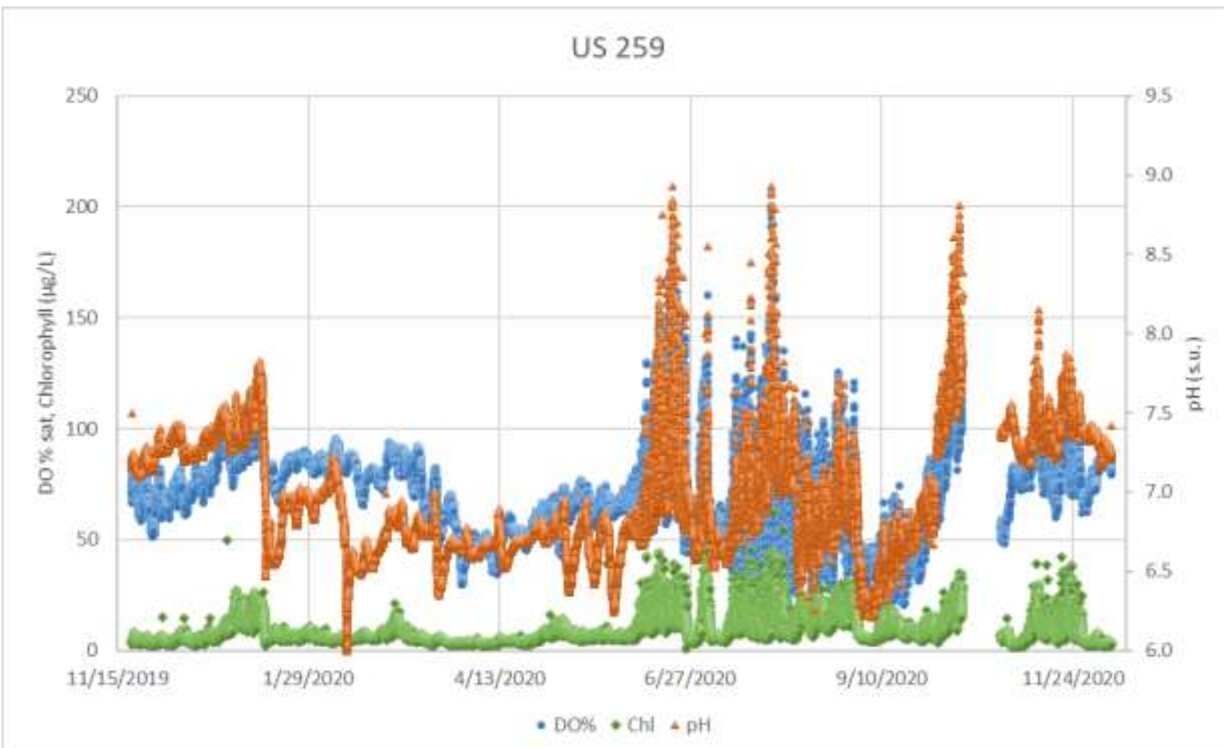

Figure 40: US 259: DO percent saturation, chlorophyll, and pH

The NETMWD intake continuous water quality monitor recorded 32,599 pH readings between November 20, 2019 and December 9, 2020. The median pH of all readings during this time period was neutral at 7.2 s.u. Similar to the US 259 site, the minimum pH was 5.9 s.u. and maximum of 9.3 s.u. Over 1.5 percent of the readings were reported above the 8.5 s.u. criterion during this period.

While all high pH values at US 259 were obtained in the months of June through October, about 14 percent of the high pH results for the NETMWD intake were collected in November, December, and January. Similar to US 259, many of the high pH readings were clustered in groups of a few days (*Figure 41*).

The summer months had the highest pH values and the greatest range between minimum and maximum pH. The highest pH value obtained during the study period, 9.3 s.u., was collected in June. The minimum pH that month was 6.3 s.u. for a range of 3.0 s.u. Although the maximum pH in July was 8.9 s.u., this month had the highest monthly range at 3.1 s.u., meaning that the peak pH was 1,100 times higher than the minimum.

For all pH readings above the criterion, a corresponding super-saturated dissolved oxygen value was reported. About 12.5 percent of all DO values recorded in the study period were at or above 100 percent saturation. Super-saturated DO occurred throughout the year, but the highest DO percent saturation values reported at the NETMWD intake were obtained during the summer months. All readings at or above 125 percent saturation were obtained between May and August with a peak value of 166.4 DO percent saturation in June.

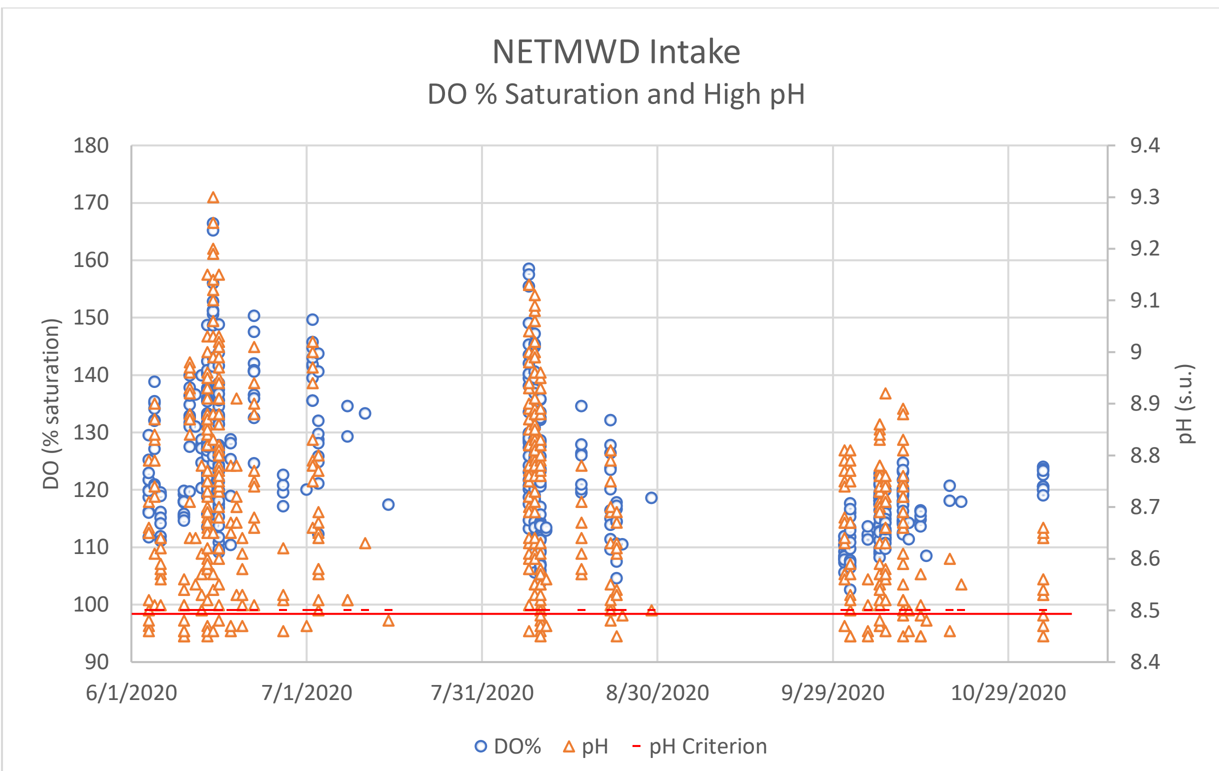

Figure 41: NETMWD Intake: DO percent saturation and High pH

The average chlorophyll concentration at the NETMWD intake was just slightly below the 26.7 µg/L screening level with a mean of 19.5 µg/L. Over 35 percent of the readings were at or above this screening level. Unlike the US 259 site, the winter months had the highest chlorophyll concentrations. With the exception of February, from December 2019 through March 2020, the monthly average for chlorophyll was at or above the screening level. Out of the 3,521 readings that were at or above 30 µg/L, 88 percent were collected between November 2019 and January 2020 while 99 percent of the measurements above 40 µg/L were recorded during this time period. The highest reading of 80 µg/L was obtained in December 2019, followed by several values reported above 60 µg/L in January 2020.

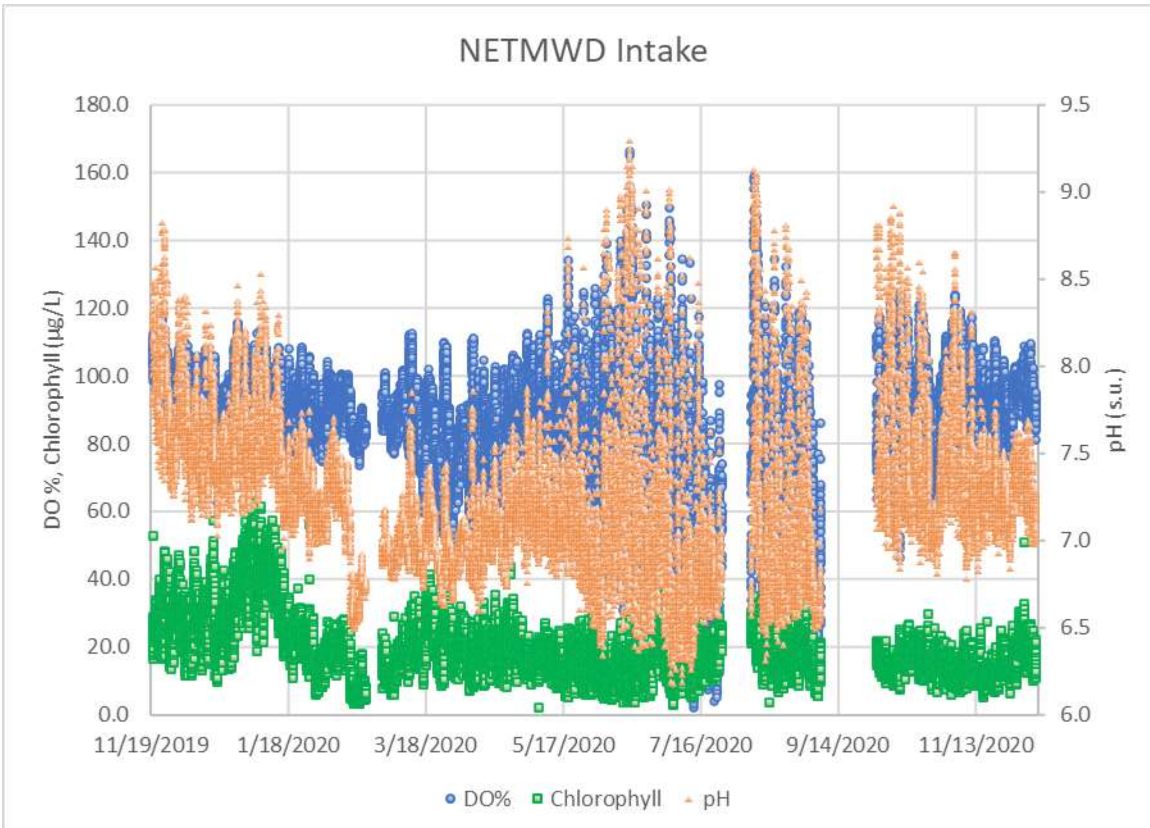

Figure 42: NETMWD Intake: DO percent saturation, pH, and Chlorophyll

While reviewing all data obtained in the study period, a statistically significant relationship between DO percent saturation and pH was discovered. DO percent saturation and pH strongly correlated with a coefficient of 0.79. Even though DO and chlorophyll nor pH and chlorophyll correlated at a statistically significant level for the entire data set, these parameters correlated in the winter and spring months. For the months of January through April 2020, pH had a statistically significant correlation with chlorophyll at 0.71. DO percent saturation correlated with chlorophyll in February through April with a coefficient of 0.62. These parameters also correlated in August with the same coefficients. This relationship may have been stronger had the sonde been at a fixed depth below the surface. The mean depth of the sonde during the study period was 1.4 meters below the surface.

Regression analyses performed on these data showed statically significant relationships between chlorophyll, pH, and dissolved oxygen. T-tests and the Analysis of Variance agreed with these findings. However, the relationships may be a due to using such a large number of observations from the continuous water quality sondes. Other statistical methods will be performed on the entire data set once the study is complete to confirm these preliminary findings. Figure 42 shows the general agreement between these three parameters throughout the study period.

Figure 43: City of Longview Intake

Four diel studies were performed at the City of Longview Intake and in a swimming area near the dam from June through August 2020. The first deployment was originally scheduled to begin in May 2020, but the field effort was postponed due to heavy rainfall received during that month. Water quality sondes were calibrated and programmed to record data at fifteen-minute intervals and were deployed for a minimum of 24 hours. All but the August 25th deployment recorded data for 46 to 48 hours. The August 25th study was suspended after twenty-four hours due to forecasted high winds and inclement weather from Hurricane Laura.

The instruments were deployed in the upper half-meter of the water column on June 1-3, June 29 through July 1, August 5-7, and August 25-26. With the exception of the June 29 monitoring at the Dam station, all data were valid and met post-deployment calibration tests. The sonde installed at the Dam station on June 29 became detached from its deployment apparatus and could not be located at time of retrieval. Divers recovered the sonde about a month later, but the DO sensor failed the calibration check and as a result, the data were rendered invalid.

In general, pH results were similar at both the City of Longview intake and at the Dam stations. However, pH tended to be much lower at the NETWMWD intake throughout the study period. The pH measurements were highest in the June deployments and lowest in August. At the Longview intake station, the maximum pH of 9.0 s.u. was obtained in the June deployment, while the minimum of 6.7 s.u. was from the August 25th diel. Similarly, the maximum pH at the Dam station was also 9.0 s.u. in June, and the minimum of 6.9 s.u. was obtained during both August studies.

The June deployments had the greatest number of high pH results at both stations. For the Longview station, out of 186 observations about 41 percent of the readings exceeded 8.5 s.u. while almost 62 percent of the pH values were reported above the criterion at the Dam station. The median pH for the Dam was above the criterion at 8.6 s.u. while the Longview median was slightly under the criterion at 8.4 s.u.

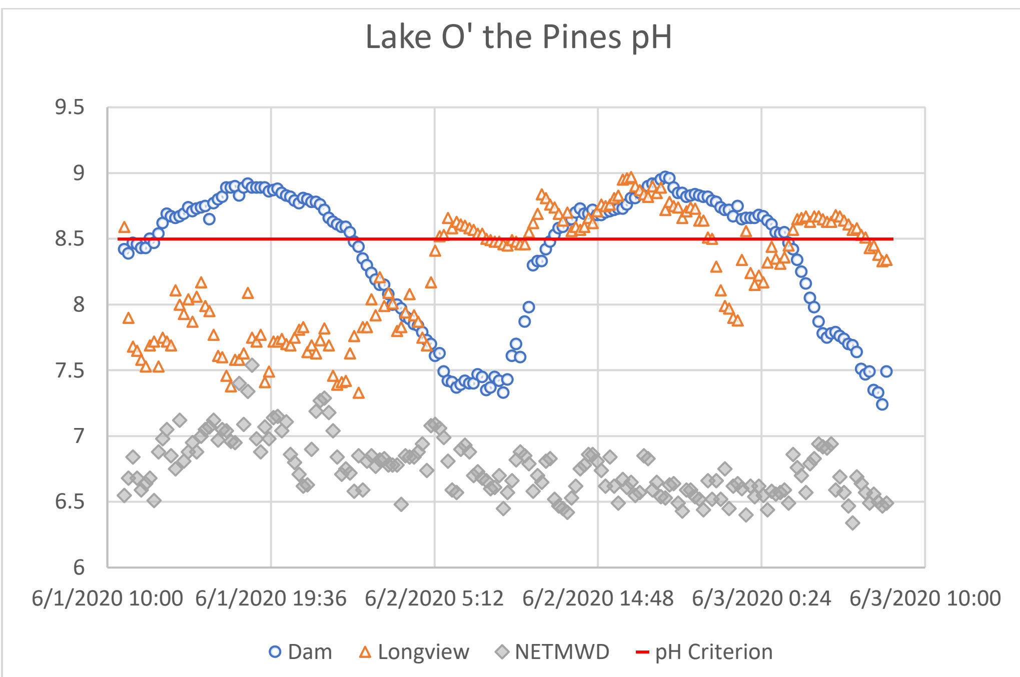

Figure 44: Lake O' the Pines pH

The August deployments had the greatest difference between the maximum and minimum pH at all three stations (*Figure 45*). The greatest range occurred at the Longview intake during the August 5th diel study, with a difference between the pH minimum and maximum value at 2.1 s.u. The maximum pH was 8.8 s.u. with ten percent of the measurements above the criterion.

There was only one high result from the June 29th deployment and none from the August 25th study at the Longview station.

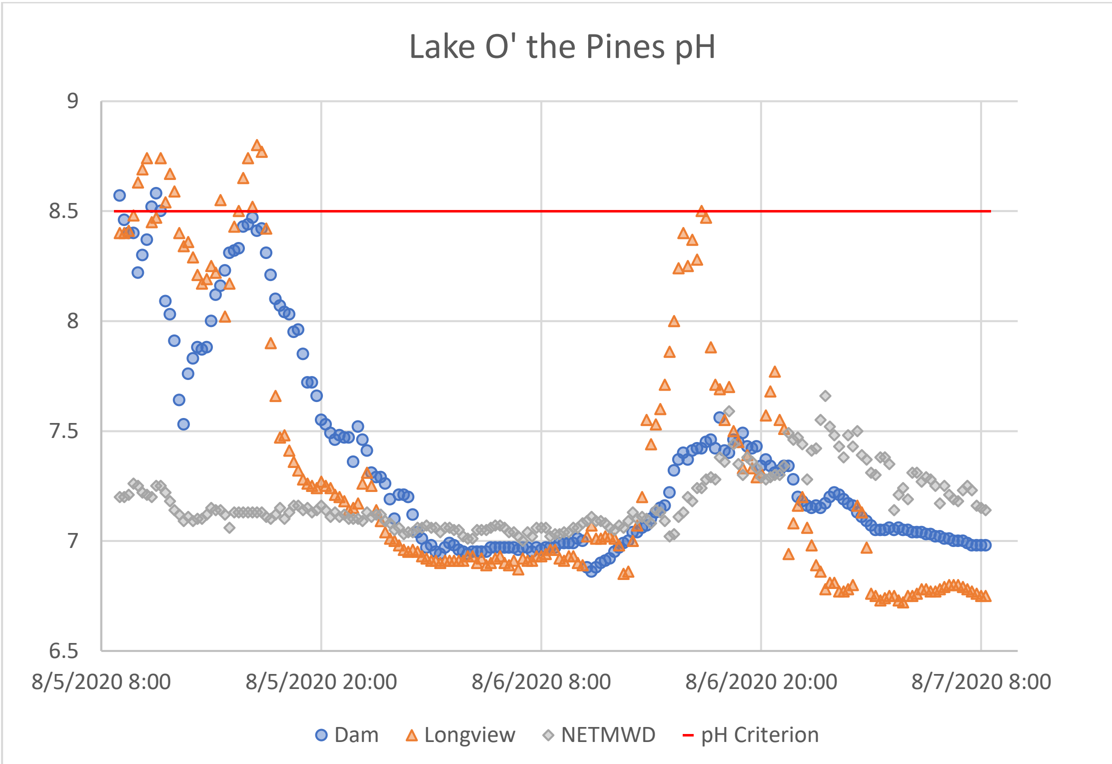

Figure 45: Lake O' the Pines pH

For the Dam station, the greatest pH range of 1.7 s.u. also occurred during the August 5th diel. While only six results were measured above the criterion, the maximum pH of 8.6 s.u. was seventy times higher than the 6.9 s.u. minimum. Even though none of the pH results at the NETMWD station exceeded the criterion during these studies, the greatest range occurred during the August 25th deployment at 1.8 s.u. The maximum pH result reported was 8.8 s.u.

pH Range	Dam	Longview	NETMWD
1-Jun	1.4	1.6	1.2
29-Jun	-	1.0	1.7
5-Aug	1.7	2.1	0.7
25-Aug	0.7	0.7	1.8

Figure 46: Lake O' the Pines: Diel pH Ranges

As found with the continuous monitors, pH and DO percent saturation were well-correlated. All of the high pH values at the Dam and Longview stations occurred while DO was super-saturated (*Figures 47 and 48*).

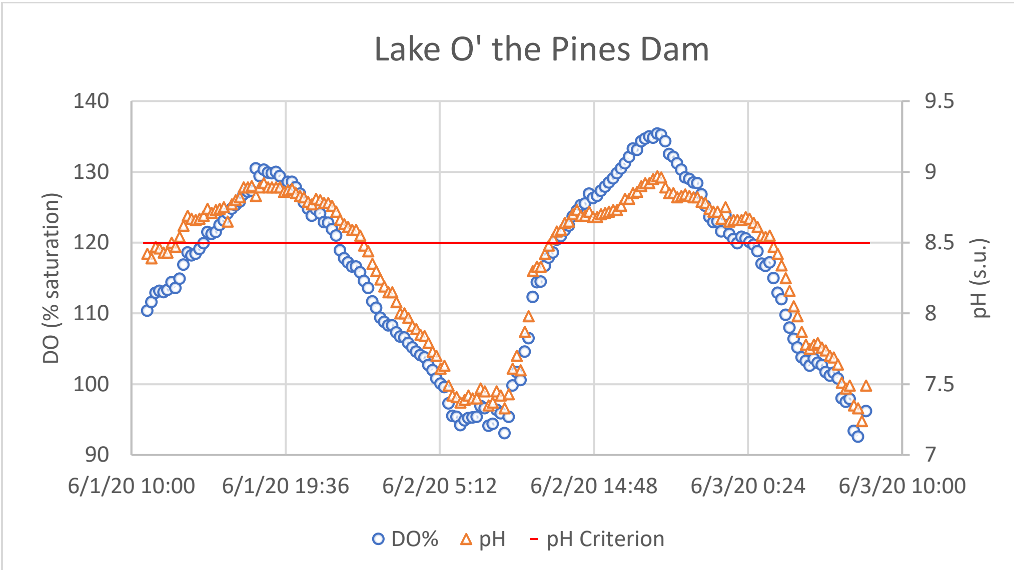

Figure 47: Lake O' the Pines Dam Station: DO percent saturation and pH

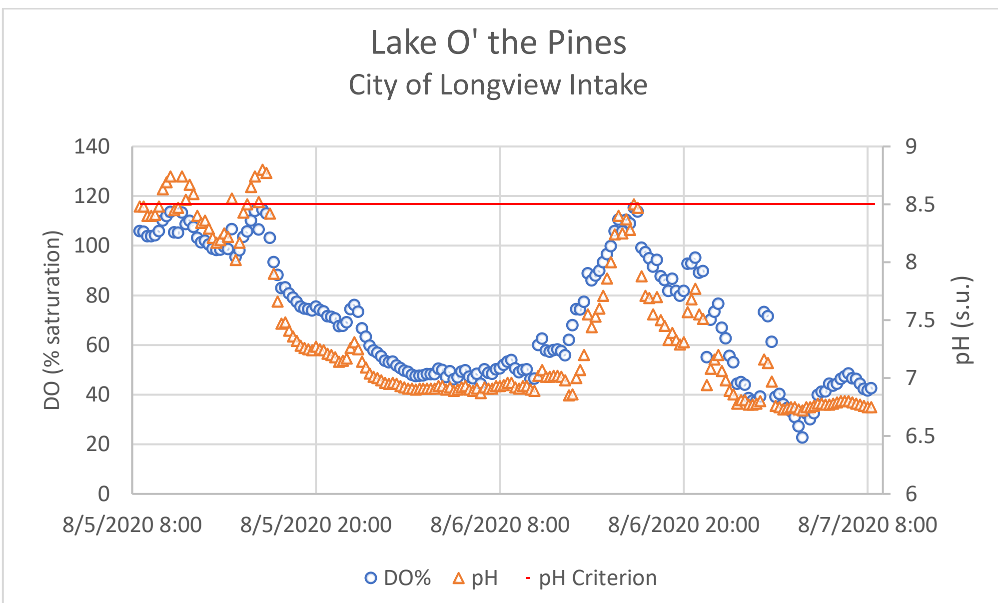

Figure 48: Lake O' the Pines: Longview Intake DO percent saturation and pH

Dissolved oxygen and pH strongly correlated at both diel stations and at the NETMWD intake continuous monitor during all four diel study periods (*Figure 49*). The correlation coefficients ranged from 0.92 to 0.97 suggesting that pH and dissolved oxygen were closely related throughout the study period. The correlation coefficients between DO percent saturation and pH for each of the diel studies were most similar at the City of Longview intake. These parameters had correlation coefficients of 0.97 for three of the deployments and 0.95 during the August 5th diel.

Correlation	Dam	Longview	NETMWD
1-Jun	0.97	0.97	0.96
29-Jun	-	0.97	0.94
5-Aug	0.92	0.95	0.97
25-Aug	0.97	0.97	0.93

Figure 49: Correlation coefficients between DO percent saturation and pH

Figure 50: Lake O' the Pines Swim Area near the Dam

Conclusions

Please note that these are the **preliminary findings** from the first year of the special study.

For the first year of the study, the continuous monitoring sondes revealed that pH did not exceed the 8.5 s.u. criterion very often. At the US 259 station, pH was reported above 8.5 s.u. in only 0.2 percent of the measurements while the NETMWD intake was above the criterion in 1.6 percent of the readings. In the diel studies, high pH was most commonly obtained at the Dam station, exceeding the criterion in almost one-quarter of the samples collected while pH at the City of Longview intake was high in approximately fourteen percent of the samples. Most the high pH values were collected during the June deployments. The City of Longview intake and Dam stations exceeded the criterion in 40.9 percent and 61.7 percent of the results, respectively. None of the pH results exceeded the criterion during the August 25th deployment.

The pH was generally highest in the summer months and the vast majority of high pH values were recorded during this season by the continuous water quality monitors. The summer months also exhibited the greatest diel range between minimum and maximum pH. The highest range for both the City of Longview intake and Dam stations occurred during the August 5th deployment. The Longview intake range was 2.1 s.u. while the Dam station was 1.7 s.u. At the continuous monitors, the pH range at the US 259 station was 2.4 s.u. and 3.1 s.u. at the NETMWD intake.

The preliminary results from the first year of these studies indicate that there is a close relationship between DO percent saturation and pH throughout the reservoir. Nearly all high pH results were collected at a super-saturated dissolved oxygen saturation. Further, DO percent saturation and pH correlated well at both continuous monitoring stations and during the diel studies. A comparison of the data collected at the NETMWD intake with the diel data from the Longview intake and Dam station showed that DO and pH were almost perfectly correlated with coefficients ranging from 0.92 to 0.97.

Chlorophyll was likely a significant cause of the elevated pH in Lake O' the Pines. Chlorophyll was relatively high at the NETWMWD continuous monitoring station and exceeded the 26.7 µg/L screening level in about 35 percent of the readings. One of the notable findings from this station was that chlorophyll exceeded the screening level most often during the winter months and had a statistically significant correlation during this time. However, chlorophyll exhibited its highest values and ranges during the summer months at both continuous monitoring stations.

Regression analyses showed statically significant relationships between chlorophyll, pH, and dissolved oxygen. The Analysis of Variance and T-tests also revealed that the relationships between these parameters were statistically significant. However, this may be due to using a very large number of observations obtained from the continuous monitoring stations. Other statistical analysis methods will be performed to confirm these preliminary findings using the entire data set once the study is completed in August 2021. The results of this analysis will be discussed in a future basin highlights report.

SPECIES OF CONCERN

- **Louisiana Pigtoe**
- **Alligator Snapping Turtle**
- **Western Chicken Turtle**
- **Kisatchie Painted Crawfish**

LOUISIANA PIGTOE

The Northeast Texas Municipal Water District has long recognized the importance and value of biological monitoring in the Cypress Creek Basin. The NETMWD has performed aquatic life monitoring in numerous watersheds over the years to gain an understanding of the biological integrity of the streams within the Basin. At present, over thirty stations have been studied.

Freshwater mussels play an important role in aquatic ecosystems. They provide a food source for many organisms and, as filter feeders, help clean the waters in which they reside by collecting organic particulate, bacteria, and algae, as well as accumulating contaminants in their soft tissues. Because they have limited mobility and are typically long-lived, freshwater mussels are sensitive to changes in their environment and can serve as bioindicators of water quality. Unfortunately, severe declines in freshwater mussel populations have been recently documented.

The decline of freshwater mussel populations has become an important focus for research over the past decade as fifteen Texas species are being considered for listing as threatened or endangered. Current literature suggests that of the three East Texas species under consideration in the ongoing U.S. Fish and Wildlife (USFWS) Species Status Assessment, the Louisiana pigtoe (*Pleurobema riddellii*) is found in the Cypress Creek Basin. The Louisiana pigtoe occurs only in stream and river habitats with low to moderate flow and with silty sand, clay, and sand with gravel substrates. They are often relatively small, but individuals almost five inches in length have been collected in Texas.

The USFWS has recently engaged river authorities and water districts to review and comment on the proposed listings of these East Texas species for the current Species Status Assessment. However, responding to the request is difficult as there is a limited amount of sampling data available in the literature in this area of the state.

At present, TCEQ has not established a mussels sampling protocols; however, all collection methods include tactile sampling, meaning that the sampler must reach into the sediments and feel for the mussels. Depending upon the depth of the water body, sampling may require the use of snorkels and/or diving gear. Since most waters in East Texas are tannin-laden, visibility is often very limited. As a result, mussels sampling is typically labor-intensive and time-consuming.

Fish play a significant role in the life-history of freshwater mussels, as the larvae (glochidia) of most species become encysted on their fish hosts. Research suggests that glochidia will only successfully attach to specific fish species. Glochidia that fail to attach to a suitable host or attach to the wrong location will die. The glochidia will implant into the host fish and develop into juvenile mussels over a period of weeks to months. Once fully developed, the juvenile mussel detaches from the host fish and matures on the stream bed. The dispersal of most mussels is dependent upon the distribution of suitable host fish, and therefore, the distribution of a mussel species is likely heavily influenced by the effectiveness and breadth of host fish utilized (Schwalb *et al*. 2013).

In a 2018 study of wild-caught East Texas fishes (Marshall, et. al.), the Louisiana pigtoe glochidia were found at low prevalence and intensities suggesting that the conservation status of the mussel is strongly influenced by its ability to successfully encounter and attach to a suitable host fish. Glochidia were only found on the Red Shiner (*Cyprinella lutrensis*), Bullhead Minnow (*Pimephales vigilax*), and Blacktail Shiner (*Cyprinella venustra*) making them suitable host species (Ford and Oliver, 2015; Ford, Plants-Paris, Ford, 2020).

Due to this relationship, sampling fish populations and abundance in streams may be used as an indicator for the potential presence or absence of the Louisiana pigtoe. If these host fish species are not present, or not present in relative abundance, then the Louisiana pigtoe is less likely to be found at this location. In this way, the fish sampling data can be used to prioritize watersheds for mussels sampling efforts in order to use mussels sampling funds efficiently.

A review of SWQMIS showed that these potential fish host species have been collected in several streams within the Cypress Creek Basin, although in very low abundance. However, the sampling effort in Tankersley Creek in June and August 2020 indicated that the present techniques and electrofishing technology may yield better sampling efficiencies than that of past decades. The combined total of four sampling events conducted at Tankersley Creek station 10261 in 1997, 1998, and 2003 was 18 individuals representing all four potential host fish species. The June 2020 effort yielded two host species and 28 individuals (blacktail shiner, 25; bullhead minnow, 3). From the August field effort, a total of 92 individuals from three potential fish host species were collected. The fish species included 47 blacktail shiner, 39 bullhead minnow, and six dusky darter. These results indicate that the fish host species for the Louisiana pigtoe are in relative abundance at this station. Two more biological sampling efforts are scheduled at this station in summer 2021.

Figure 51: Louisiana pigtoe (Pleurobema riddellii) photo by US Fish & Wildlife Service

More information about state-threatened freshwater mussels and ongoing studies for species of concern is available at the Texas Comptroller of Public Accounts Natural Resources website.

CYPRESS CREEK BASIN MUSSEL SUMMARY

By: Clinton Robertson, Texas Parks and Wildlife Department

According to Mussels of Texas online database (Randklev et al. 2020), 31 species of mussels are known to have been collected in the Cypress Creek Basin (*Figure 53*). Although the basin has been under-sampled in the last decades, recent mussel sampling efforts by TPWD Inland Fisheries Marshall District and the River Studies Program staff have collected 23 live species. These recent TPWD sampling efforts have included an aquatic/riparian bioassessment (Robertson et al. 2016) and baseline mussel assessments to support the evaluation of environmental flow recommendations established by the Caddo Lake Institute, The Nature Conservancy – Texas, and the USACE. TPWD staff plan to continue monitoring the mussel community at two sites on Big Cypress Bayou to continue the evaluation of the environmental flow recommendations effects to mussel communities.

Southern Hickorynut (*Obovaria arkansasensis*) and Louisiana Pigtoe (*Pleurobema riddellii*) are state-threatened species known to occur in the basin. Louisiana Pigtoe has been the only state-threatened species collected live during these recent TPWD survey efforts. In addition to being state-threatened, Louisiana Pigtoe is currently under consideration for federal listing by the USFWS under the Endangered Species Act. Records of Louisiana Pigtoe from these surveys were utilized by the USFWS to develop a species status assessment report that is being utilized to determine if listing is warranted for this species. While a large portion of the mussel community appears to be present in the basin, additional mussel sampling and assessments are necessary to better understand the current condition of the mussel community in the Cypress Creek Basin.

Figure 52: Underwater photo of a Deertoe mussel (Truncilla truncata) Photo by Clinton Robertson

Figure 53 is the historical species list of freshwater mussels collected in the Cypress Creek Basin as shown in the Mussels of Texas (Randklev et al. 2020). The Southern Hickorynut and Lousiana Pigtoe have a status of ST meaning “State Threatened” in Texas. The Lousiana Pigtoe status is also FP meaning “Federally Proposed” for listing. Species recently collected live during TPWD mussel surveys are indicated by an “X” in the Recently Collected column (Robertson et al. 2016, C. Robertson unpublished data).

Scientific Name	**Common Name**	**Status**	**Recently Collected**
Amblema plicata	Threeridge		X
Arcidens confragosus	Rock Pocketbook		
Cyclonaias nodulata	Wartyback		X
Cyclonaias pustulosa	Pimpleback		X
Fusconaia flava	Wabash Pigtoe		X
Lampsilis hydiana	Louisiana Fatmucket		X
Lampsilis teres	Yellow Sandshell		X
Leaunio lienosa	Little Spectaclecase		
Leptodea fragilis	Fragile Papershell		X
Megalonaias nervosa	Washboard		X
Obliquaria reflexa	Threehorn Wartyback		X
Obovaria arkansasensis	Southern Hickorynut	ST	
Plectomerus dombeyanus	Bankclimber		X
Pleurobema riddellii	Louisiana Pigtoe	ST, FP	X
Potamilus ohiensis	Pink Papershell		
Potamilus purpuratus	Bleufer		X
Pyganodon grandis	Giant Floater		X
Quadrula apiculata	Southern Mapleleaf		X
Quadrula quadrula	Mapleleaf		X
Sagittunio subrostrata	Pond Mussel		X
Strophitus undulatus	Creeper		X
Toxolasma parvum	Lilliput		
Toxolasma texasiense	Texas Lilliput		X
Tritogonia nobilis	Gulf Mapleleaf		
Tritogonia verrucosa	Pistolgrip		X
Truncilla donaciformis	Fawnsfoot		
Truncilla truncata	Deertoe		X
Uniomerus declivis	Tapered Pondhorn		X
Uniomerus tetralasmus	Pondhorn		X
Utterbackia imbecillis	Paper Pondshell		X
Utterbackiana suborbiculata	Flat Floater		

Figure 53: Mussels Species of the Cypress Creek Basin

NORTHEAST TEXAS AQUATIC TURTLE SURVEYS

By Mandi Gordon, Environmental Institute of Houston at the University of Houston – Clear Lake

East Texas, including the Cypress Creek Basin, is home to numerous turtle species, including some currently under review for inclusion on the Endangered Species Act. Specifically, petitions to list the western chicken turtle (*Deirochelys reticularia miaria*) and the alligator snapping turtle (*Macrochelys temminckii*) under the Endangered Species Act have been submitted to the U.S. Fish and Wildlife Service with significant 90-Day Findings. Currently, the western chicken turtle is endangered in Missouri and is a species of greatest conservation need in Louisiana and Oklahoma but holds no protection in Texas. A final Endangered Species Act listing decision is planned for the western chicken turtle in 2024. Conversely, the alligator snapping turtle is recognized as a threatened species in Texas and is protected in multiple states. The USFWS plans to release their Species Status Assessment in 2021 for public review and will propose a final Endangered Species Act listing decision.

The Environmental Institute of Houston at the University of Houston–Clear Lake (EIH-UHCL) is currently developing partnerships with private landowners and stakeholders in East Texas to conduct surveys for the western chicken turtle and alligator snapping turtle throughout their historic range. These surveys are funded by the Texas Comptroller of Public Accounts Natural Resources Program and are aimed at providing the U.S. Fish and Wildlife Service with the most current and relevant data necessary for pending SSA and ESA listing decisions.

Western chicken turtles are ephemeral wetland habitat dwellers associated with watersheds throughout east Texas. This cryptic species exhibits a seasonal activity pattern, with most activity occurring in the spring and early summer months. Due to their cryptic nature and narrow window of opportunity for observation, surveys for the western chicken turtle are aimed at testing a suite of traditional and novel sampling techniques for detection of the species. These include trapping surveys, visual surveys, environmental DNA (eDNA) sampling, unmanned aerial vehicle (UAV) surveys, and canid scent surveys.

In 2020, EIH-UHCL was restricted to sampling within a 150-mile radius of campus due to COVID travel restrictions. Sampling was conducted monthly at 27 sites from March through July. Four sites yielded positive detections of western chicken turtles via eDNA, canid scent surveys, and visual surveys. These positive detections are a promising start to this developing east Texas-wide survey. The project will be expanding sampling efforts in to northeast Texas, including areas within the Cypress Creek Basin in 2021 and 2022. If you or someone you know are aware of western chicken turtles present on your (or their) property, EIH-UHCL would love to hear about it! Additionally, EIH-UHCL has developed an online reporting tool for compilation of historic reports from citizen scientists throughout the species range. The reporting tool will be active until early 2023 and can be accessed via the following link: https://arcg.is/11yWyn. If you have observed a western chicken turtle, please report your sighting via this reporting tool today!

Alligator snapping turtles are the largest freshwater turtle in North America, with some records of individuals weighing over 200 lbs. Due to the impending Species Status Assessment and Endangered Species Act listing decisions, research pertaining to population structure and distribution are critical for future conservation of the species. Trapping surveys for the alligator snapping turtle are scheduled to commence in Spring 2021 and will be conducted seasonally through the end of 2022. These surveys are aimed at providing baseline population data in areas where surveys are not currently being conducted. The goal of EIH-UHCL's alligator snapping turtle program is to "fill the gaps" in population distribution data via genetic analyses and routine trapping efforts. If you know of an area where alligator snapping turtles are prevalent and are willing to allow EIH-UHCL access to your property, please contact EIH-UHCL for more information.

Academic and private stakeholder partnerships are integral in the collection of holistic and pertinent data for the conservation of these and other species in Texas. For questions related to these ongoing surveys, please contact Mandi Gordon (gordon@uhcl.edu; 281-283-3794). More information about EIH-UHCL can be found online at eih.uhcl.edu.

Figure 54: Left: a 65 lbs. female alligator snapping turtle near Houston, TX. Upper right: A male western chicken turtle basking near Port Arthur, TX. Bottom right: QR code for direct connection to western chicken turtle online reporting tool.

KISATCHI PAINTED CRAWFISH

Crayfish, in general, are keystone species that may indicate the health of a watershed, and nearly half of crayfish species are vulnerable, threatened, or endangered. The Kisatchie painted crayfish (*Faxonius maletae)* has few historical records and is believed to be restricted to the Kisatchie Bayou and Bayou Teche watersheds in Louisiana and the Cypress Creek watershed in Texas. Historical collecting locations were obtained from TPWD, and recent field surveys determined that the Kisatchie painted crayfish was absent from 60 percent of its historical range in Texas.

It is characterized by an olive carapace or hard, upper shell and the red marks on the chelae (claws), legs, and above the eyes. The size of Kisatchie painted crayfish appears to be influenced by water depth. Individuals found in deep water have been documented to reach lengths of 101.6 mm, while those found in shallow water rarely reach lengths over 50.8 mm.

Little is known about the habitat requirements of the Kisatchie painted crayfish. They were historically collected in freshwater streams with sand, gravel, mud, or silt; however, the Texas habitat tended to be more stagnant and muddier than in Louisiana. The Kisatchie painted crayfish may prefer streams with varying water depth, heavy leaf litter, and cobble-lined stream bottoms.

Figure 55: Kisatchie painted crayfish (*Faxonius maletae) Photo by Steve Shively, USDA Forest Service*

Figure 56: Alligator snapping turtle caught on Caddo Lake

From the *2017 Cypress Creek Basin Highlights Report*:

This picture of an Alligator Snapping Turtle that was foul hooked on a trotline at Caddo Lake in the spring of 2016 caused quite a sensation on the internet. Its weight was estimated to be around 100 pounds. Catching an Alligator Snapping Turtle on Caddo Lake is not a rare event; although, they are not usually this large. The turtle was released unharmed after the photo was taken.

Information about these species of concern is also available at the NETMWD website or at the USFWS website. If you see an individual that you suspect is one of these species, please take a photo and contact the NETMWD at 903-639-7538. Please include the date, time, and location of the sighting.

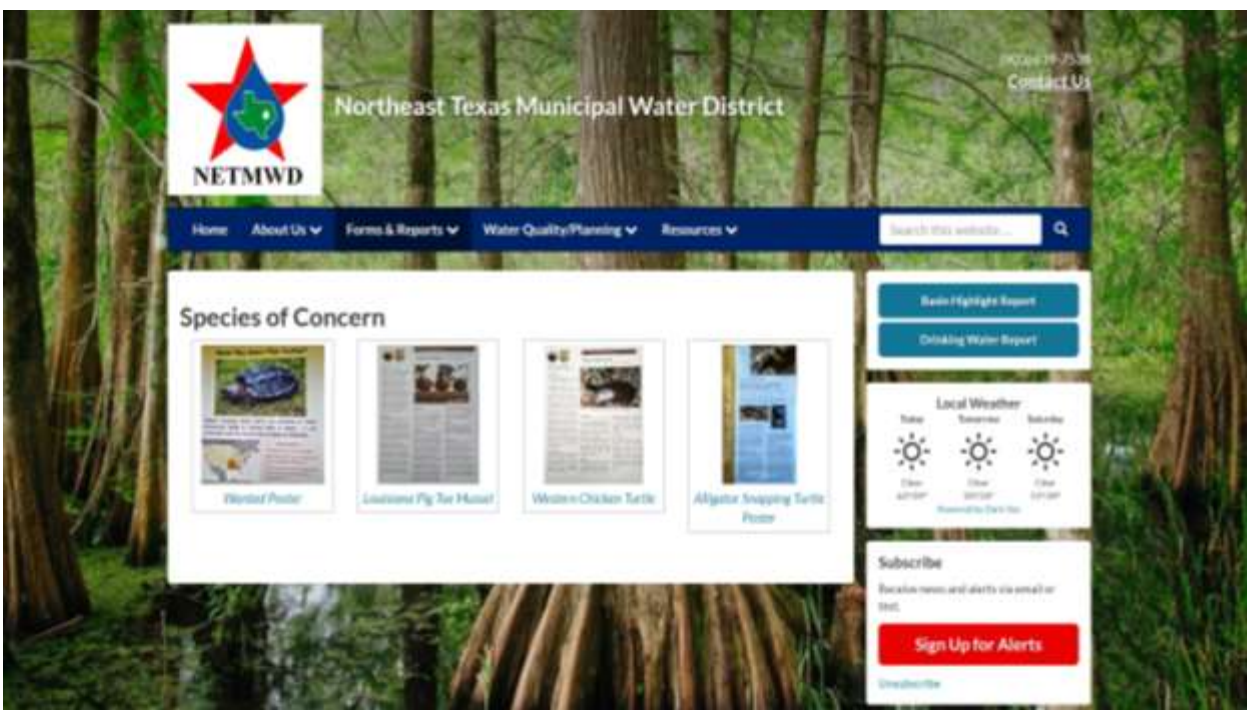

Figure 57: Species of Concern Screenshot from the NETMWD website

INVASIVE AQUATIC VEGETATION

INVASIVE AQUATIC VEGETATION UPDATE

By: Tim Bister, Texas Parks and Wildlife Department

Invasive aquatic vegetation remains a threat to reservoirs in the Cypress Creek Basin, and the TPWD is actively managing these species. The following is a summary of invasive aquatic plant coverage and management of the public reservoirs in the basin in 2020:

Caddo Lake was surveyed in September 2020. TPWD documented 1,323 acres of hydrilla, 29 acres of water hyacinth, 5 acres of alligatorweed, 8 acres of Indian hygrophila, 37 acres of crested floating heart, and 1,549 acres of giant salvinia. Herbicide treatments were conducted on 7,862 acres of giant salvinia throughout the year. Giant salvinia weevils were also used as part of an integrated management approach. Caddo Biocontrol Alliance released 168,122 weevils and TPWD released 10,766 individuals.

Figure 58: Aquatic vegetation along Boat Road F in Caddo Lake

Figure 59: left - Giant Salvinia (photo by TPWD); right - Salvinia weevil (photo by USDA)

Lake O' the Pines had small coverages of alligatorweed (less than one acre) and water hyacinth (nine acres) in the 2020 annual survey. Hydrilla coverage increased to 535 acres. The largest threat to the reservoir remains giant salvinia. While the coverage of giant salvinia was estimated at 243 acres during TPWD's annual survey in August/September 2020, over 700 acres of giant salvinia was treated with herbicide in September and October.

A drawdown for spillway maintenance in 2019 and 2020 suppressed hydrilla growth in **Ellison Creek Reservoir**. TPWD documented two acres of alligatorweed and giant salvinia was discovered by TPWD in the upper end of the reservoir during a routine fish population survey in October 2020. There was an estimated thirty acres of giant salvinia present which is currently being managed with herbicide applications.

Lake Bob Sandlin had a low amount of invasive vegetation present in 2020. Only two acres of alligatorweed was present. In past years there has been hydrilla and water hyacinth in the reservoir, but these species were not seen in the recent survey.

Lake Cypress Springs has remained relatively free of invasive vegetation. In 2020, TPWD estimated one acre of alligatorweed. Hydrilla has not been detected for many years.

Lake Gilmer had less than one acre of alligatorweed and hydrilla at the time of TPWD's annual survey in August 2020, but hydrilla growth had rebounded by the fall. Giant salvinia was discovered at the boat ramp in September and was removed by hand and treated with a subsequent herbicide application.

Lake Welsh contained 336 acres of hydrilla and seven acres of alligatorweed.

Approximately twelve acres of giant salvinia was discovered in **New Mount Pleasant City Lake (Town Lake)** in November 2020. TPWD is working to control the plant with herbicide treatments.

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APPENDICES

- Nitrate Special Study Laboratory Results
- Sulfate Special Study Laboratory Results

NITRATE SPECIAL STUDY LABORATORY RESULTS

Note: All results are reported in mg/L. Values in red exceeded the criterion or screening level.

Nitrate (as N)					
Date	10264	10263	10261	10272	10266
18-Jul-18	0.211	57.3	25.3	0.011	7.26
15-Aug-18	0.107	95.1	70.6	0.228	10.9
17-Sep-18	0.129	121	74.6	0.0403	8.61
23-Oct-18	0.16	2.08	3.12	0.266	4.62
7-Nov-18	0.13	4.11	3.13	0.109	1.22
12-Dec-18	0.176	2.78	2.46	0.159	0.948
9-Jan-19	0.258	3.41	2.95	0.152	1.4
13-Feb-19	0.0372	1.61	1.55	0.114	0.528
18-Mar-19	0.115	1.84	2.68	0.0458	1.3
17-Apr-19	0.438	11.2	9.52	0.121	0.463
15-May-19	0.397	4.04	2.87	0.196	1.09
12-Jun-19	0.062	0.062	0.062	0.215	3.73

Ammonia Nitrogen (as N)					
Date	10264	10263	10261	10272	10266
18-Jul-18	0.187	0.277	0.0566	<0.0200	0.0286
15-Aug-18	0.126	0.475	0.289	0.0753	<0.0200
17-Sep-18	0.115	0.166	0.277	0.0476	0.127
23-Oct-18	<0.0200	<0.0200	0.0222	0.0206	<0.0200
7-Nov-18	<0.0200	<0.0200	<0.0200	<0.0200	<0.0200
12-Dec-18	0.0397	0.0831	0.0665	<0.0200	0.042
9-Jan-19	<0.0200	0.115	0.0331	0.0212	0.0223
13-Feb-19	0.0551	0.0776	0.0936	0.14	0.122
18-Mar-19	0.0382	0.052	0.0543	0.0247	0.056
17-Apr-19	0.0883	0.0658	0.122	0.146	0.0804
15-May-19	0.047	0.0458	0.0641	0.0339	0.0427
12-Jun-19	0.061	8.75	0.986	0.0521	0.0426

Nitrite (as N)					
Date	10264	10263	10261	10272	10266
18-Jul-18	0.0471	0.127	0.098	<0.0100	0.0373
15-Aug-18	0.036	0.348	0.517	0.0157	0.0421
17-Sep-18	0.0366	0.22	0.749	0.0267	0.231
23-Oct-18	0.0188	0.0203	0.0424	0.0359	0.0287
7-Nov-18	<0.0100	0.013	0.0121	0.022	0.0179
12-Dec-18	0.0296	0.0568	0.0575	0.0362	0.0294
9-Jan-19	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
13-Feb-19	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
18-Mar-19	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
17-Apr-19	0.0895	0.0528	0.0772	0.0195	0.0242
15-May-19	0.0479	<0.0100	<0.0100	0.0358	<0.0100
12-Jun-19	<0.0100	0.0615	<0.0100	<0.0100	<0.0100

Total Kjeldahl Nitrogen					
Date	10264	10263	10261	10272	10266
18-Jul-18	1.12	1.24	1.17	0.59	0.81
15-Aug-18	0.88	3.26	1.54	0.95	0.72
17-Sep-18	1.07	3.11	0.69	1.2	1.1
23-Oct-18	0.52	0.89	0.87	0.51	0.81
7-Nov-18	0.75	1.03	1.41	1.54	0.94
12-Dec-18	0.81	1.08	1.08	0.62	0.67
9-Jan-19	0.66	0.96	0.83	0.33	0.52
13-Feb-19	0.77	1.18	1.21	1.09	0.97
18-Mar-19	0.93	0.99	0.91	0.77	0.5
17-Apr-19	0.47	0.81	0.83	0.57	0.64
15-May-19	0.86	1.56	0.8	0.71	0.64
12-Jun-19	0.91	12	<0.2	0.59	0.91

NITRATE SPECIAL STUDY LABORATORY RESULTS (continued)

Total Nitrogen						
Date	**10264**	**10263**	**10261**		**10272**	**10266**
18-Jul-18	1.33	58.67	26.57		0.6	8.11
15-Aug-18	0.99	98.71	72.66		1.19	11.66
17-Sep-18	1.2	124.33	76.04		1.27	9.94
23-Oct-18	0.68	2.99	4.03		0.81	5.46
7-Nov-18	0.88	5.15	4.55		1.67	2.18
12-Dec-18	0.99	3.92	3.6		0.82	1.65
9-Jan-19	0.92	4.37	3.78		0.48	1.92
13-Feb-19	0.81	2.79	2.76		1.2	1.5
18-Mar-19	1.05	2.83	3.59		0.82	1.8
17-Apr-19	0.91	12.06	10.43		0.71	1.13
15-May-19	1.26	5.6	3.67		0.94	1.73
12-Jun-19	0.97	12.12	1.05		0.81	4.64

Total Phosphorus (as P)						
Date	**10264**	**10263**	**10261**		**10272**	**10266**
18-Jul-18	0.189	0.657	1.92		0.176	0.47
15-Aug-18	0.148	0.952	0.322		0.121	0.313
17-Sep-18	0.104	1.82	0.523		0.118	0.523
23-Oct-18	<0.0200	0.407	0.312		0.141	0.161
7-Nov-18	0.0902	0.112	0.348		0.272	0.237
12-Dec-18	<0.0800	<0.0800	0.15		0.0815	0.441
9-Jan-19	<0.0800	2.49	0.326		<0.0800	0.111
13-Feb-19	<0.0800	1.35	0.389		0.125	0.12
18-Mar-19	<0.0800	0.107	0.195		<0.0800	0.0931
17-Apr-19	0.171	0.218	<0.0800		<0.0800	0.113
15-May-19	3.09	0.321	0.379		0.239	0.239
12-Jun-19	<0.0800	2.09	0.22		<0.0800	0.0983

SULFATE SPECIAL STUDY LABORATORY RESULTS

Sulfate				
Date	**10264**	**10263**	**10261**	**10310**
11-Nov-19	55.8	96.1	89.4	86.3
11-Dec-19	64.2	84.7	76.9	71.7
20-Jan-20	46.9	72.2	66.8	19.7
17-Feb-20	41.9	58.2	21.4	20.3
17-Mar-20	45.4	55.9	54.6	25.4
21-Apr-20	54.4	77.6	75.2	20.8
20-May-20	54	60.7	55.1	23.7
15-Jun-20	72.1	111	90.2	27.6
17-Aug-20	35.6	92.5	72.3	73.4
16-Sep-20	38.5	90.7	80.6	68.9
14-Oct-20	33.7	98.8	82.2	80.4
17-Nov-20	28.3	102	92.2	82

Nitrate (as N)				
Date	**10264**	**10263**	**10261**	**10310**
11-Nov-19	0.17	61.8	58.4	42.8
11-Dec-19	0.13	48.1	38.8	36.7
20-Jan-20	0.29	17.3	11	0.758
17-Feb-20	0.33	5.44	1.41	0.449
17-Mar-20	0.10	2.5	2.13	0.494
21-Apr-20	0.06	11.1	7.55	0.421
20-May-20	0.80	7.39	5.42	0.574
15-Jun-20	0.25	97.3	68	6.26
17-Aug-20	0.07	82.7	49.1	50.7
16-Sep-20	0.07	62.8	56.8	42.9
14-Oct-20	0.11	80.5	59.7	**56.5**
17-Nov-20	0.16	65.3	60.4	52.8

Nitrite (as N)				
Date	**10264**	**10263**	**10261**	**10310**
11-Nov-19	<0.0100	<0.250	<0.250	<0.250
11-Dec-19	<0.0100	<0.0100	<0.0100	<0.0100
20-Jan-20	<0.0100	<0.0100	<0.0100	<0.0100
17-Feb-20	<0.0100	<0.0100	<0.0100	<0.0100
17-Mar-20	<0.0100	<0.0100	<0.0100	0.0226
21-Apr-20	<0.0100	<0.0100	<0.0100	<0.0100
20-May-20	0.0959	0.0736	0.056	<0.0100
15-Jun-20	<0.0100	<0.0100	<0.0100	<0.0100
17-Aug-20	<0.0100	<0.0100	<0.0100	<0.0100
16-Sep-20	<0.0100	<0.0100	<0.0100	<0.0100
14-Oct-20	<0.0100	<0.0100	<0.0100	<0.0100
17-Nov-20	<0.0100	<0.0100	0.193	<0.0100

Chloride				
Date	**10264**	**10263**	**10261**	**10310**
11-Nov-19	27.6	145	117	103
11-Dec-19	38.9	121	106	102
20-Jan-20	17	58.2	48.8	11.1
17-Feb-20	15.8	36.4	11.8	10.6
17-Mar-20	16.3	30.7	31.7	13.3
21-Apr-20	18.7	71.9	62.5	11.1
20-May-20	19.9	39.9	35.3	12.4
15-Jun-20	36.1	171	126	23
17-Aug-20	26.3	88.2	86.8	89.8
16-Sep-20	21.3	120	101	87
14-Oct-20	22.3	112	93.3	100
17-Nov-20	23.8	115	101	95.2

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