

CYPRESS CREEK WATERSHED DATA REPORT

March 2020



THE MEADOWS CENTER
FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

TEXAS STREAM TEAM



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The preparation of this report was prepared in cooperation with, and financed through, grants from the U.S. Environmental Protection Agency through the Texas Commission on Environmental Quality.

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INTRODUCTION

Texas Stream Team

Texas Stream Team is a volunteer-based citizen science water quality monitoring program. Citizen scientist water quality monitoring occurs at predetermined monitoring sites, at roughly the same time of day each month. The information that Texas Stream Team citizen scientists collect is covered under a TCEQ-approved Quality Assurance Project Plan (QAPP) to ensure that a standard set of methods are used. The data may be used to identify surface water quality trends, target additional data collection needs, identify potential pollution events and sources of pollution, and to test the effectiveness of water quality management measures. Texas Stream Team citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards. The data collected by Texas Stream Team provides valuable records, often collected in portions of a water body that professionals are not able to monitor frequently or monitor at all.

For additional information about water quality monitoring methods and procedures, including the differences between professional and volunteer citizen science monitoring, please refer to the following sources:

- [Texas Stream Team Core Water Quality Citizen Scientist Manual](#)
- [Texas Stream Team Advanced Water Quality Citizen Scientist Manual](#)
- [Texas Stream Team Program Volunteer Water Quality Monitoring Program Quality Assurance Project Plan](#)
- [Texas Commission on Environmental Quality \(TCEQ\) Surface Water Quality Monitoring Procedures](#)

The purpose of this report is to provide a summary of the data collected by Texas Stream Team citizen scientists. The data presented in this report should be considered in conjunction with other relevant water quality reports for a holistic view of water quality in the Cypress Creek watershed. Such sources include, but are not limited to, the following:

- Texas Surface Water Quality Standards
- Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)
- Texas Clean Rivers Program (CRP) partner reports, such as Basin Summary Reports and Highlight Reports
- TCEQ Total Maximum Daily Load (TMDL) reports
- TCEQ and Texas State Soil and Water Conservation Board Nonpoint Source Program funded reports, including Watershed Protection Plans (WPPs)

To get involved with Texas Stream Team or for questions regarding this watershed data report contact us at TxStreamTeam@txstate.edu or at (512) 245-1346. Visit our website for more information on our programs at www.TexasStreamTeam.org.

WATERSHED DESCRIPTION

Location

The Cypress Creek watershed lies within Hays County in the Central Texas Hill Country, spans approximately 24,320 acres or 38 square miles, and includes the cities of Woodcreek and Wimberley (Fig. 1). Cypress Creek is a tributary that flows into the Blanco River upstream from RR12 in Wimberley, Texas. The Cypress Creek watershed is part of the larger, regional Hays-Trinity watershed. Jacobs Well, a natural artesian spring, is fed by the Hays-Trinity Aquifer and is located at the head waters of the perennial portion of Cypress Creek (Jones, 2004). The riparian habitat along the banks of Cypress Creek is predominantly comprised of bald cypress, pecan, willow, and sycamore trees, while the upland areas consist of live oak and cedar (Texas Parks & Wildlife Department, 1974). The climate in the Cypress Creek watershed is considered temperate to semi-arid with an annual average precipitation of 34 inches (Hays County Historical Commission, 2011).

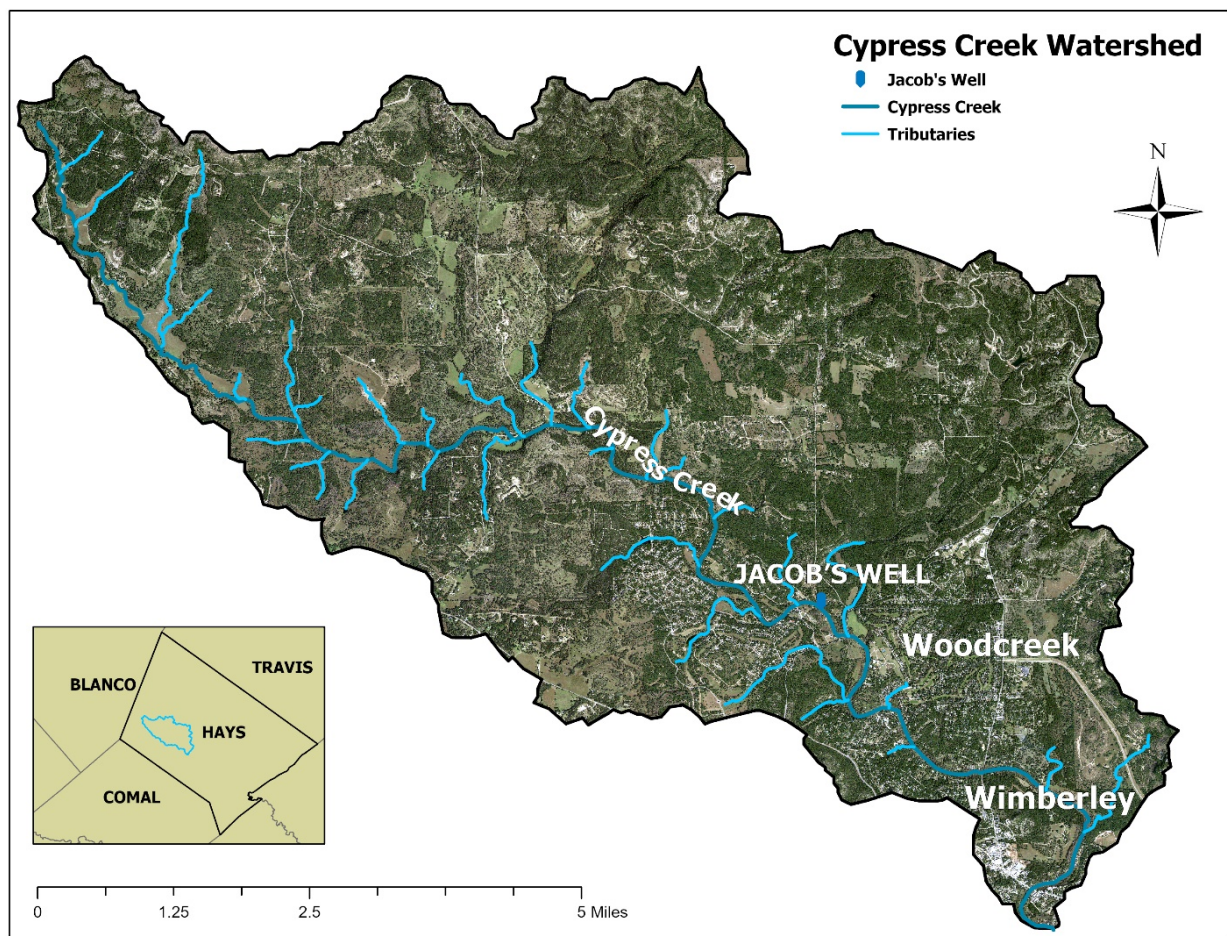


Figure 1. Cypress Creek watershed in Hays County, Texas.

Physical Description

Cypress Creek consists of two distinct sections, the upper, ephemeral Dry Cypress, and the lower, perennial Cypress Creek proper. The upper portion drains the area above Jacob's Well and is driven predominantly by surface runoff from rain events. Jacob's Well, an artesian spring fed by the Trinity Aquifer, serves as the headwaters of the lower portion of Cypress Creek which flows into the Blanco River just upstream of RR12 in Wimberley.

Interactions between surface and groundwater flows in the karstic Cypress Creek watershed are complex. The soils in the Cypress Creek watershed are comprised of shallow clay loams, but the underlying geology is primarily karstic in composition. According to the hydrologic soil classifications, the shallow clays are group D, or low permeability soils. The underlying karstic geology, however, is highly permeable, thus, the groundwater is recharged in various locations throughout the watershed (Jones, 2004). It is estimated that the Trinity Aquifer receives approximately 4.7% of its annual recharge in the form of precipitation. This number was calculated using mean annual rainfall measurements over two 30-year periods, 1961 to 1990 and 1971 to 2000, and the Groundwater Availability Model or GAM (Jones, 2004). While there is a large degree of surface runoff in the area, Cypress Creek is largely a gaining stream and is heavily influenced by the groundwater discharge at Jacobs Well from the Hays-Trinity Aquifer.

Land Use

Land use in the Cypress Creek watershed is comprised predominantly of agriculture/rangeland (75%), with only a small percentage of the land being utilized by residential or urban uses. The ecology of the area makes it difficult for crop farming due to the thin layer of topsoil and semi-arid climate. Most of the land classified as agriculture/rangeland is primarily used for grazing, with no intensive crop farming occurring in the watershed (The Meadows Center for Water and the Environment, 2010). An important distinction to note is that most of the urbanization is in the southern portion of the Cypress Creek watershed, which is the perennial portion of the creek and the most vulnerable. An increase in urbanization typically results in more impervious cover, more rainfall runoff, and ultimately more nonpoint sources of pollution in the water bodies that drain these areas.

Hays County is the 31st fastest growing county in the United States (Texas State Data Center, 2009). From 2000 to 2009 the population of Wimberley and Woodcreek grew approximately 21%. As a result, the population is projected to increase in Hays County by 15% annually according to the Hays County Extension office for Texas AgriLife (Texas AgriLife, 2010).

Much of the area that is available for development is in the 'unincorporated' sections of Hays County. According to the zoning bylaws of Wimberley and Woodcreek, both jurisdictions seek to maintain the "quaint" rural Texas feel of the region. However, according to growth projections there will be growth in the region regardless. Since 75% of the land use within the watershed is associated with agriculture/rangeland, there is plenty of open land that could be developed for residential purposes, pending zoning changes.

History

Cypress Creek was home to the very first grist mill, under the ownership of Pleasant Wimberley in 1847. Subsequently, the mill was expanded to include a sawmill, shingle mill, molasses mill, and cotton gin (Hays County Historical Commission, 2010). The cities of Woodcreek and Wimberley were incorporated in 1984 and 2000, respectively. Woodcreek has a population of 1,300 and is primarily comprised of residential homes intertwined with an 18-hole golf course. Wimberley has a population of 3,797 but includes a much larger community from the surrounding unincorporated areas. Wimberley was historically a mill town but has since become a rural tourist destination and retirement community.

Watershed Protection Plan

In April 2014, the Cypress Creek Watershed Protection Plan was approved by the Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality (TCEQ). The watershed protection plan targets point and non-point sources of E. coli bacteria and other pollutants through monitoring and best management practices geared toward improving water quality and restoring the contact recreation use. The Cypress Creek Watershed Protection Plan aims to ensure the integrity of the creek for generations to come.

Texas Water Quality Standards

The Texas Surface Water Quality Standards establish explicit goals for the quality of streams, rivers, lakes, and bays throughout the state (TCEQ, 2014). The standards are developed to maintain the quality of surface waters in Texas so that it supports public health and protects aquatic life, consistent with the sustainable economic development of the state. Water quality standards have been established to support the uses for the state's surface waters, including aquatic life, recreation, and sources of public water supply (drinking water). Criteria for evaluating support of those uses have been established for dissolved oxygen (DO), temperature, pH, total dissolved solids (TDS), toxic substances, and bacteria.

The Texas Surface Water Quality Standards also contain narrative criteria (verbal descriptions) that apply to all waters of the state and are used to evaluate support of applicable uses. Narrative criteria include general descriptions, such as the existence of excessive aquatic plant growth, foaming of surface waters, taste- and odor-producing substances, sediment build-up, and toxic materials. Narrative criteria are evaluated by using screening levels, if they are available, as well as other information, including water quality studies, existence of fish kills or contaminant spills, photographic evidence, and local knowledge. Screening levels serve as a reference point to indicate when water quality parameters may be approaching levels of concern.

Water Quality Impairments

Cypress Creek is a TCEQ classified segment (1815) that extends from the confluence with the Blanco River in Hays County to a point 6.4 km (4.0 mi) upstream of the most upstream unnamed county road crossing in Hays County. The designated uses for Cypress Creek as described in the Texas Surface Water Quality Standards (TCEQ, 2014) include primary contact recreation, exceptional aquatic life use, public water supply and aquifer protection which applies to the contributing, recharge, and transition zones of the

Edwards Aquifer. Numeric criteria to determine water quality standards attainment of the designated uses are provided in Table 1.

Until recently, Cypress Creek exhibited relatively “good” water quality. The 2018 Texas Integrated Report included Cypress Creek as having a “concern” for depressed DO. Cypress Creek was also assessed in the Draft 2020 Texas Integrated Report and was placed on the 303(d) List (Category 5) of impaired waters. The impairments are for depressed DO and fish and macrobenthic communities in water in the lower seven miles of the segment. The listing category (5c) is described as “additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.”

Table 1. Water quality criteria for Cypress Creek.

Parameter	Criterion	Description
Temperature	30 °C	Maximum value
Dissolved Oxygen (DO)	6.0 mg/L	Minimum 24-hour means and grab screening levels
	4.0 mg/L	Minimum 24-hour values and grab minimums
pH Range	6.5-9.0 SU	Absolute minima and maxima
Total Dissolved Solids (TDS)	400 mg/L*	Maximum annual average
Indicator Bacteria (E. coli)	126 CFU/100mL	Geometric mean
	399 CFU/100mL	Single sample maximum
Chloride (Cl ⁻¹)	50 mg/L	Maximum annual average
Sulfate (SO ₄ ⁻²)	50 mg/L	Maximum annual average

*TDS is calculated from specific conductance (TDS=SC*0.65); the SC criterion is 615 mg/L.

Endangered Species and Conservation Needs

A summary of the number of species per group listed as rare, threatened, or endangered under the authority of Texas state law and/or under the US Endangered Species Act within the Cypress Creek watershed is provide in Table 2. A full list with explanations of the listing categories can be found in Appendix I at the end of this report.

Table 2. State and federally listed species in the Cypress Creek watershed (TPWD 2019).

Taxon	Endangered (Federal or State)	Threatened (Federal or State)	G1 or G2 (Critically Imperiled or Imperiled)	Species of Greatest Conservation Need (TPWD)	Endemic
Amphibians	1	0	1	5	1
Birds	3	8	1	15	0
Crustaceans	0	0	1	1	1
Fish	1	1	0	9	1
Insects	0	0	3	4	0
Mammals	1	2	1	19	0
Mollusks	0	4	4	4	2
Plants	1	0	9	26	15
Reptiles	0	6	1	12	1

WATER QUALITY PARAMETERS

Water Temperature

Water temperature influences the physiological processes of aquatic organisms, and each species has an optimum temperature for survival. Water temperature variations are most detrimental when they occur rapidly, leaving the aquatic community no time to adjust. Additionally, the ability of water to hold oxygen in solution (solubility) decreases as temperature increases. Therefore, high water temperatures increase oxygen-demand for aquatic communities and can become stressful for fish and aquatic insects.

Natural sources of warm water are seasonal, as water temperatures tend to increase during summer and decrease in winter in the Northern Hemisphere. Daily (diurnal) water temperature changes occur during normal heating and cooling patterns. Man-made sources of warm water include power plant effluent after it has been used for cooling or hydroelectric plants that release warmer water. Citizen scientist monitoring may not identify fluctuating patterns due to diurnal changes or events such as power plant releases. While citizen scientist data does not show diurnal temperature fluctuations, it may demonstrate the fluctuations over seasons and years.

Dissolved Oxygen

Oxygen is necessary for the survival of organisms like fish and aquatic insects. The amount of oxygen needed for survival and reproduction of aquatic communities varies according to species composition and adaptations to watershed characteristics like stream gradient, habitat, and available streamflow.

The DO concentrations can be influenced by other water quality parameters such as nutrients and temperature. High concentrations of nutrients can lead to excessive growth of algae. When the algae die, microbes decompose the algae, consume oxygen, and lower the amount of dissolved oxygen in the water. This process is known as eutrophication. Low DO levels may also result from high groundwater

inflows due to minimal groundwater aeration, high temperatures that reduce oxygen solubility, or water releases from deeper portions of dams where DO and thermal stratification occur. Supersaturation typically only occurs underneath waterfalls or dams with water flowing over the top.

pH

The pH scale measures the concentration of hydrogen ions on a range of zero to 14 and is reported in standard units (su). The pH of water can provide useful information regarding acidity or alkalinity. The range is logarithmic; therefore, every one-unit change is representative of a 10-fold increase or decrease in acidity. Acidic sources, indicated by a low pH level, can include acid rain and runoff from acid-laden soils. Acid rain can be caused by coal power plants with minimal contributions from the burning of other fossil fuels and other natural processes, such as volcanic emissions. Soil-acidity can be caused by excessive rainfall leaching alkaline materials out of soils, acidic parent material, crop decomposition creating hydrogen ions, or high-yielding fields that have drained the soil of all alkalinity. Sources of high pH (alkaline) include geologic composition, as in the case of limestone increasing alkalinity and the dissolution of carbon dioxide in water. Carbon dioxide is water soluble, and as it dissolves it forms carbonic acid. The most suitable pH range for healthy organisms is between 6.5 and 9.0.

Specific Conductance and Total Dissolved Solids

Specific conductance is a measure of the ability of a body of water to conduct electricity. It is measured in microsiemens per centimeter ($\mu\text{S}/\text{cm}$). A body of water is more conductive if it has more total dissolved solids (TDS) such as nutrients and salts, which is an indicator of poor water quality if they are overly abundant. High concentrations of salt can inhibit water absorption and limit root growth for vegetation, leading to an abundance of more drought tolerant plants, and can cause dehydration of fish and amphibians. Sources of TDS can include agricultural runoff, domestic runoff, or discharges from wastewater treatment plants. For this report, specific conductance values have been converted to TDS using a conversion factor of 0.65 and are reported as mg/L.

Secchi Disk and Total Depth

The Secchi disk is used to determine the clarity of the water, a condition known as turbidity. The disk is lowered into the water until it is no longer visible, then raised until it is visible. Measurements are recorded at both depths and averaged to determine the Secchi depth. Highly turbid waters pose a risk to wildlife by clogging the gills of fish, reducing visibility, and carrying contaminants. Reduced visibility can harm predatory fish or birds that depend on good visibility to find their prey. Turbid waters allow very little light to penetrate deep into the water, which, in turn, decreases the density of phytoplankton, algae, and other aquatic plants. This reduces the DO in the water due to reduced photosynthesis. Contaminants are most commonly transported in sediment rather than in the water. Turbid waters can result from sediment washing away from construction sites, erosion of farms, or mining operations. Average Secchi disk transparency (a.k.a. Secchi depth) readings that are less than the total depth of the water body typically indicate turbid water. Readings that are equal to total depth indicate clear water.

***E. coli* Bacteria**

E. coli bacteria originate in the digestive tract of endothermic organisms. The EPA has determined *E. coli* to be the best indicator of the degree of pathogens in a water body, which are far too numerous to be tested for directly, considering the number of water bodies tested. A pathogen is a biological agent that causes disease. The water quality standard for contact recreation is based on the geometric mean (geomean) of the *E. coli* measurements taken. A geometric mean is a type of average that incorporates the high variability found in parameters such as *E. coli* which can vary from zero to tens of thousands of CFU/100 mL. The standard for the contact recreation use of a water body such as Cypress Creek is 126 CFU/100 mL. A water body is considered impaired if the geometric mean is higher than the standard.

Orthophosphate

Orthophosphate is the phosphate molecule all by itself. Phosphorus almost always exists in the natural environment as phosphate, which continually cycles through the ecosystem as a nutrient necessary for the growth of most organisms. Testing for orthophosphate detects the amount of phosphate in the water, excluding the phosphate bound up in plant and animal tissue. There are other methods to retrieve the phosphate from the material to which it is bound, but they are too complicated and expensive to be conducted by citizen scientist monitors. Testing for orthophosphate gives us an idea of the degree of phosphate in a water body. It can be used for problem identification, which can be followed up with more detailed professional monitoring, if necessary. Phosphorus inputs into a water body may be caused by the weathering of soils and rocks, discharge from wastewater treatment plants, excessive fertilizer use, failing septic systems, livestock and pet waste, disturbed land areas, drained wetlands, water treatment, and some commercial cleaning products. The effect orthophosphate has on a water body is known as eutrophication and is described above under the “Dissolved Oxygen” section.

Nitrate-Nitrogen

Nitrogen is present in terrestrial or aquatic environments as nitrate-nitrogen, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with TCEQ and other partners. Like phosphorus, nitrogen is a nutrient necessary for the growth of most organisms. Nitrogen inputs to a water body can be from livestock and pet waste, excessive fertilizer use, failing septic systems, and industrial discharges that contain corrosion inhibitors. The effect nitrogen has on a water body is known as eutrophication and is described previously in the “Dissolved Oxygen” section. Nitrate-nitrogen dissolves more readily than orthophosphate, which tends to be attached to sediment, and, therefore, can serve as a better indicator of the possibility of sewage or manure pollution during dry weather.

DATA COLLECTION, MANAGEMENT AND ANALYSIS

Data Collection

The field sampling procedures implemented by trained citizen scientists are documented in Texas Stream Team Core Water Quality Citizen Scientist Manual and the Texas Stream Team Advanced Water Quality Citizen Scientist Manual. The sampling protocols in both manuals adhere closely to the TCEQ Surface Water Quality Monitoring (SWQM) Procedures Manual, Vol. 1 (August 2012). Additionally, data collection follows the Texas Stream Team’s approved Quality Assurance Project Plan (QAPP).

Procedures documented in Texas Stream Team Water Quality Citizen Scientist Manuals and the TCEQ SWQM Procedures Manual outline the steps necessary to prevent contamination of samples, including direct collection into sample containers, when possible. Field quality control samples are collected and analyzed to detect whether contamination has occurred.

Field sampling activities are documented on field data sheets. For all field sampling events the following items are recorded: station ID, location, sampling time, date, and depth, sample collector's name/signature, group identification number, conductivity meter calibration information, and reagent expiration dates are checked and recorded if expired.

For all *E. coli* sampling events, station ID, location, sampling time, date, depth, sample collector's name/signature, group identification number, incubation temperature, incubation duration, *E. coli* colony counts, dilution aliquot, field blanks, and media expiration dates are checked and recorded if expired. Values for all measured parameters are recorded. If reagents or media are expired, it is noted, data are flagged and communicated to Texas Stream Team staff.

Sampling is not permitted with expired reagents and bacteria media; the corresponding values will be flagged in the database and excluded from data reports. Detailed observational data recorded include water appearance, weather, field observations (biological activity and stream uses), algae cover, unusual odors, days since last significant rainfall, and flow severity. Comments related to field measurements, number of participants, total time spent sampling, and total round-trip distance traveled to the sampling site are also recorded for grant reporting and administrative purposes.

Data Management

The citizen scientists collect field data and report the measurement results to Texas Stream Team, either by submitting a hard copy of the form by email/mail or by entering the data electronically directly to our database, Waterways Dataviewer. All data are reviewed to ensure that they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to specified monitoring procedures and project specifications as stated in the approved QAPP.

Data review and verification is performed using a data management checklist and self-assessments, as appropriate to the project task, followed by automated database functions that will validate data as the information is entered into the database. The data are verified and evaluated against project specifications and is checked for errors, especially errors in transcription, calculations, and data input. Potential errors are identified by examination of documentation and by manual and computer-assisted examination of corollary or unreasonable data. Issues that can be corrected are corrected and documented. If there are errors in the calibration log, expired reagents used to generate the sampling data, or any other deviations from the field or *E. coli* data review checklists, the corresponding data are flagged in the database.

Errors, which may compromise the program's ability to fulfill the completeness criteria prescribed in the QAPP, will be reported to the Texas Stream Team program manager. If repeated errors occur, the monitor and/or the group leader will be notified via email or telephone.

Data Analysis

Data are compiled, summarized and compared to state standards and screening levels to provide readers with a reference point for parameters that may be of concern. The assessment performed by TCEQ involves more complicated monitoring methods and oversight than those used by citizen scientists and staff in this report. The citizen water quality monitoring data is not used in the TCEQ assessments mentioned above but are intended to inform stakeholders about general characteristics and assist professionals in identifying areas of potential concern.

All data collected by citizen scientists from the watershed and its tributaries were exported from the Texas Stream Team database and grouped by site. Once compiled, data were sorted, summary statistics were generated and reviewed, and results were graphed in JMP Pro 14.0.0 (SAS Institute Inc., 2018) using standard methods. Statistically significant trends were analyzed further. R-squared is a statistical measure of how close the data are to the fitted regression line. Zero indicates that the model explains none of the variability of the response data around its mean. The p-value is the level of marginal significance within a statistical hypothesis test representing the probability of the occurrence of a given event. The cut off for statistical significance was set to a p-value of ≤ 0.05 . A p-value of ≤ 0.05 means that the probability that the observed data matches the actual conditions found in nature is 95-percent. As the p-value decreases, the confidence that it matches actual conditions in nature increases.

DATA RESULTS

Data from six Texas Stream Team active monitoring sites were analyzed for this project (Fig. 2). Subsequent graphical representations of the data in the remainder of this report include parameter summaries ordered by monitoring site from upstream to downstream as depicted in Figure 2.

Watershed Analysis

The period of record for data analyzed for this report spanned from February 2006 to December 2019. Data from 152 monitoring events conducted at six sites were analyzed. The number of samples, mean, standard deviation, minimum and maximum values are listed in Table 3 for all parameters except for *E. coli* which is represented as the geometric mean.

The total number of measurements for the Texas Stream Team core water quality monitoring parameters, air and water temperature, dissolved oxygen, pH and specific conductance, remained somewhat equal. Substantially fewer results were reported for the advanced parameters *E. coli* and nitrate-nitrogen. When summarized collectively, all mean/geomean values met corresponding water quality criteria.

A total of 152 flow severity records were documented by Texas Stream team citizen scientists from February 2006 to December 2019 (Fig. 3). Most sampling events occurred under low flow (58), normal flow (54), or no flow (36) conditions. Only a couple sampling events took place under flood (1) or high (3) flow conditions.

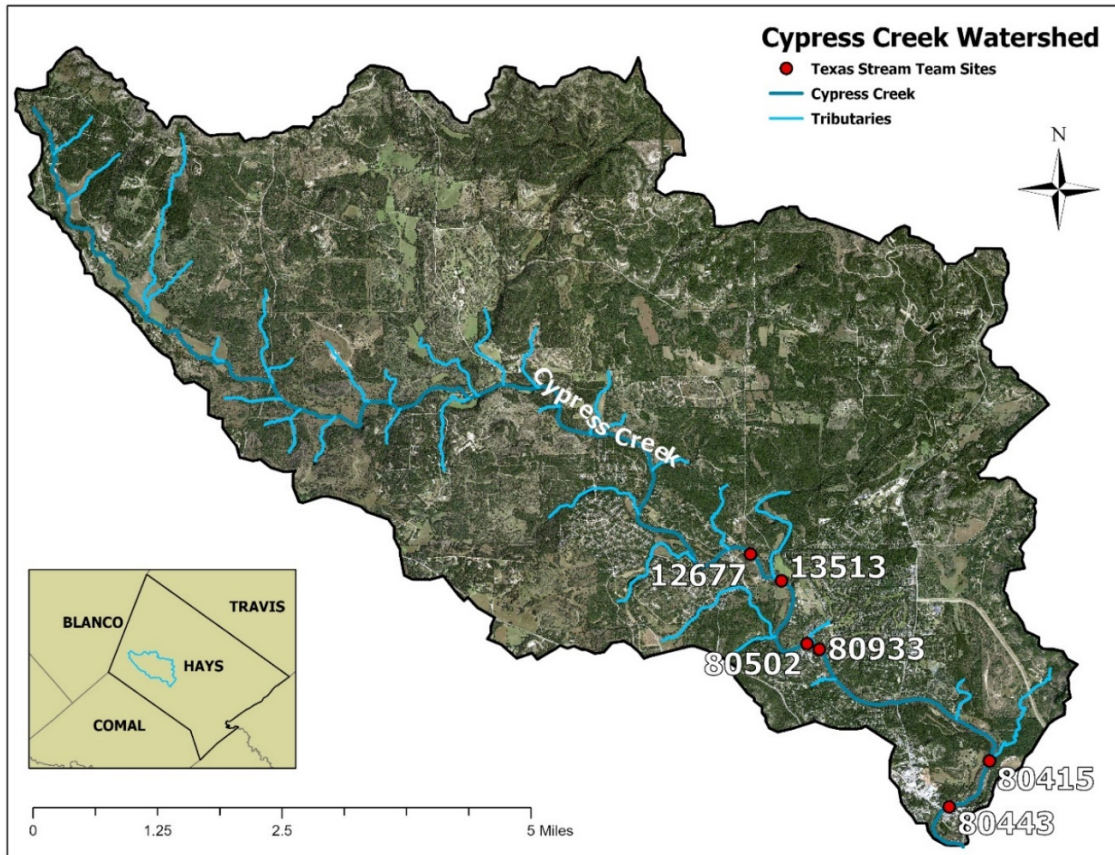


Figure 2. Cypress Creek watershed and active Texas Stream Team monitoring sites.

Table 3. Descriptive statistics for parameters in Cypress Creek February 2006 – December 2019.

Texas Stream Team Data for Cypress Creek				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Air Temperature (°C)	152	20.8±7.3	0	35
Water Temperature (°C)	150	19.9 ± 4.9	0	30
Dissolved Oxygen (mg/L)	146	6.4 ± 1.4	0.39	11.8
pH (su)	149	7.3 ± 0.4	6.5	8.3
Specific Conductance (µS/cm)	152	592 ± 80.0	330	940
E. coli (CFU/100mL)	37	67.7	0	199.9
Nitrate-Nitrogen (mg/L)	1	0.5	0.5	0.5

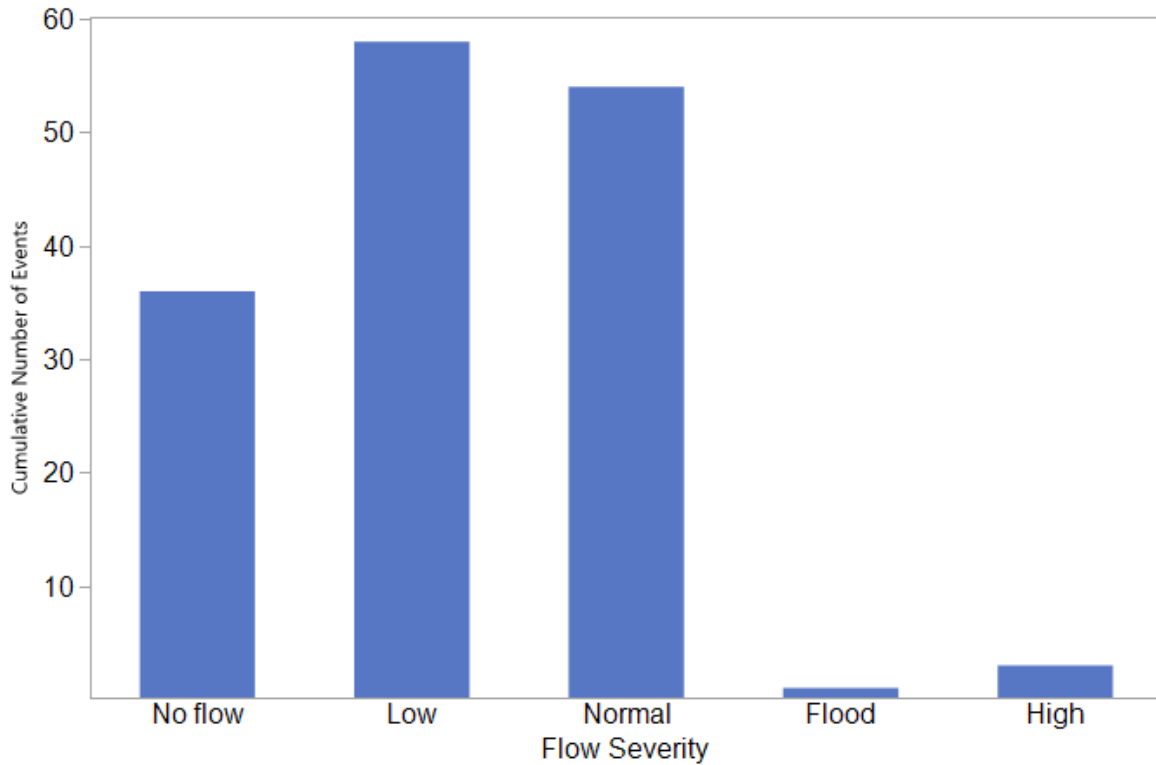


Figure 3. Cumulative number of events for flow severity in Cypress Creek February 2006 to December 2019.

Air and Water Temperature

A total of 152 and 150 air and water temperatures, respectively, were measured in the Cypress Creek watershed between February 2006 and December 2019 (Table 3). Air temperature for all sites averaged 20.8°C, and varied between 0°C and 35°C. The average water temperature for all sites was 19.9°C, well below the water temperature criterion (30°C).

Dissolved Oxygen

Citizen scientists collected a total of 146 DO samples in Cypress Creek. The mean DO was 6.4 mg/L (Table 3). Measurements ranged from a low of 0.39 mg/L to a high of 11.8 mg/L. The average DO for all sites was above the 6.0 mg/L minimum 24-hour average standard and grab screening level.

pH

The pH was measured 149 times in Cypress Creek for this project (Table 3). The mean pH was 7.3 su and the values ranged from 6.5 to 8.3 su. The average pH value for all sites combined fell on or within the absolute minimum and maximum water quality standard (6.5-9.0 su).

Specific Conductance

Citizen scientists collected 152 specific conductance measurements within Cypress Creek (Table 3). The average specific conductance measurement for all sites was 592 µS/cm. Measurements ranged from a

low of 330 $\mu\text{S}/\text{cm}$ to a high of 940 $\mu\text{S}/\text{cm}$. The average specific conductance for all sites was below the state water quality criterion (615 $\mu\text{S}/\text{cm}$).

E. coli Bacteria

E. coli samples were collected at four out of the six sites in Cypress Creek (Table 3). A total of 37 *E. coli* samples were collected with a collective geometric mean of 67.7 CFU/100 mL. The *E. coli* counts ranged from 0 CFU/100 mL to a high of 199.9 CFU/100 mL and the geometric mean was below the water quality standard for contact recreation (126 CFU/100 mL).

Nitrate-Nitrogen

Nitrate-nitrogen concentrations were measured at only one site (First Dam, 80933) in Cypress Creek (Table 3). The recorded value for First Dam was 0.5 mg/L.

SITE ANALYSIS

Water quality monitoring data for each of the six sites in Cypress Creek were analyzed and summarized (Table 4). The two sites with the most measurements were Old Kyle Rd. (n=64) and Jacob's Well (n=55), respectively.

Air and Water Temperature

Average air temperatures for all sites ranged from 18.3 to 26.5°C with the lowest average value at Old Kyle Rd. (18.3°C) and the highest average value at Woodcreek Dr. (26.5°C) (Table 4). Average water temperatures for all sites ranged from 18.6 to 23.6°C with the lowest average value at Old Kyle Rd (18.6°C) and the highest average value at Woodcreek (23.6°C) (Table 3). All measurements for all sites were at or below the water quality criterion (30 mg/L) (Fig. 4).

Specific Conductance (Total Dissolved Solids)

Mean values for specific conductance met the water quality criterion (615 $\mu\text{S}/\text{cm}$) at all sites except Blue Hole (720 $\mu\text{S}/\text{cm}$) (Fig. 5). Individual measurements at Jacob's Well and Old Kyle Rd. were above the water quality criterion, but the average was below.

Dissolved Oxygen

Average dissolved oxygen values for all sites ranged from 5.8 to 7.5 mg/L (Table 4). The lowest value was recorded at Jacob's well (5.8 mg/L) and the highest value at Old Kyle Rd (6.7 mg/L) (Fig. 6). Average values from all six sites met the water quality criteria for grab minimums (4.0 mg/L), but not all sites (Jacob's Well) met the minimum 24-hour mean criterion (6.0 mg/L).

pH

The average pH values for all sites ranged from 7.0 to 7.7 su and were within the low/high criteria (6.5 – 9.0 su) for pH (Table 4). The lowest average value (7.0 su) was from Jacob's Well, while the highest average value was from Old Kyle Rd. (7.7 su). Two individual measurements, one at Jacob's Well (6.46 su) and one at Blue Hole (6.46 su), fell slightly below the minimum water quality criterion (6.5).

E. coli

Three sites in Cypress Creek were sampled by Texas Stream Team citizen scientists for *E. coli* (Table 4, Fig. 7). Geometric means for the three sites with *E. coli* data fell below the contact recreation criterion (126 CFU/100mL). However, some individual measurements of *E. coli* at Jacob's Well and Old Kyle Rd. exceeded the water quality criterion.

Nitrate-Nitrogen

One nitrate-nitrogen value was reported for the First Dam site (80933) (Table 4).

Table 4. Summary statistics for monitoring sites in Cypress Creek.

Texas Stream Team Data by Site for Cypress Creek February 2006 – December 2019						
Parameter	Jacob's Well 12677 n=55 Mean±SD (Range)	CR220 13513 n=3 Mean±SD (Range)	Woodcreek Dr. 80502 n=8 Mean±SD (Range)	First Dam 80933 n=7 Mean±SD (Range)	Blue Hole 80415 n=16 Mean±SD (Range)	Old Kyle Rd. 80443 n=64 Mean±SD (Range)
Air Temperature (°C)	22.6±7.2 (30)	24.7±6.0 (11.5)	26.5±8.8 (23.8)	22.1±6.5 (18)	20.8±6.6 (25)	18.3±6.7 (28)
Water Temperature (°C)	20.3±2.8 (17.5)	20.1±3.1 (6.1)	23.6±5.1 (13.6)	21.7±7.6 (19.8)	20.8±5.1 (17.5)	18.6±5.6 (27)
Dissolved Oxygen (mg/L)	5.8±1.0 (6.0)	6.8±0.6 (1.15)	6.8±0.8 (2.7)	7.5±1.4 (4.1)	6.6±2.3 (9.6)	6.7±1.4 (7.3)
pH (su)	7.0±0.1 (1.0)	7.4±0.4 (0.8)	7.5±0.4 (1.1)	7.2±0.2 (0.5)	7.1±0.2 (1.0)	7.7±0.3 (1.2)
Specific Conductance (µS/cm)	580±74 (561)	510±81.9 (160)	590±11.9 (30)	540±38.6 (100)	720±140.1 (384)	580±32.2 (150)
<i>E. coli</i> (CFU/100mL)	64.0±79.6 (199.9)	-	-	110 (0)	48.4±41.1 (110.0)	90.6±47.0 (160)
Nitrate-Nitrogen (mg/L)	-	-	-	0.5 (0)	-	-

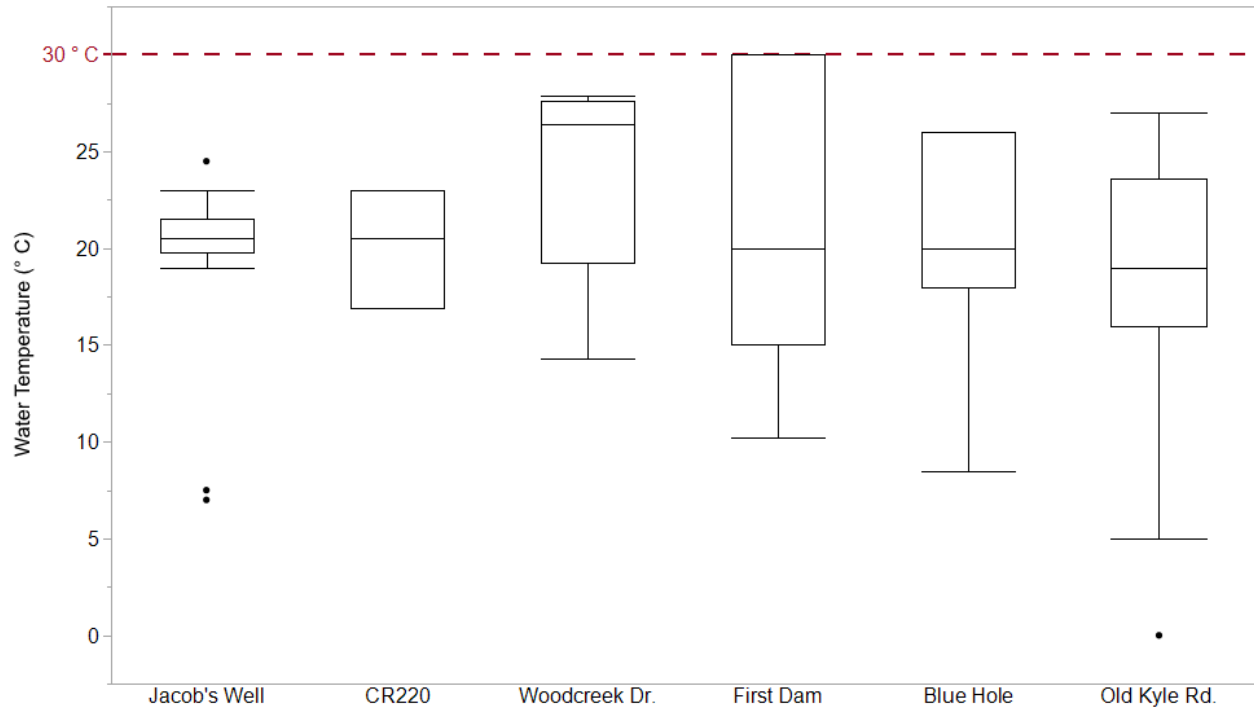


Figure 4. Water temperature (°C) for sites in Cypress Creek February 2006 to December 2019.

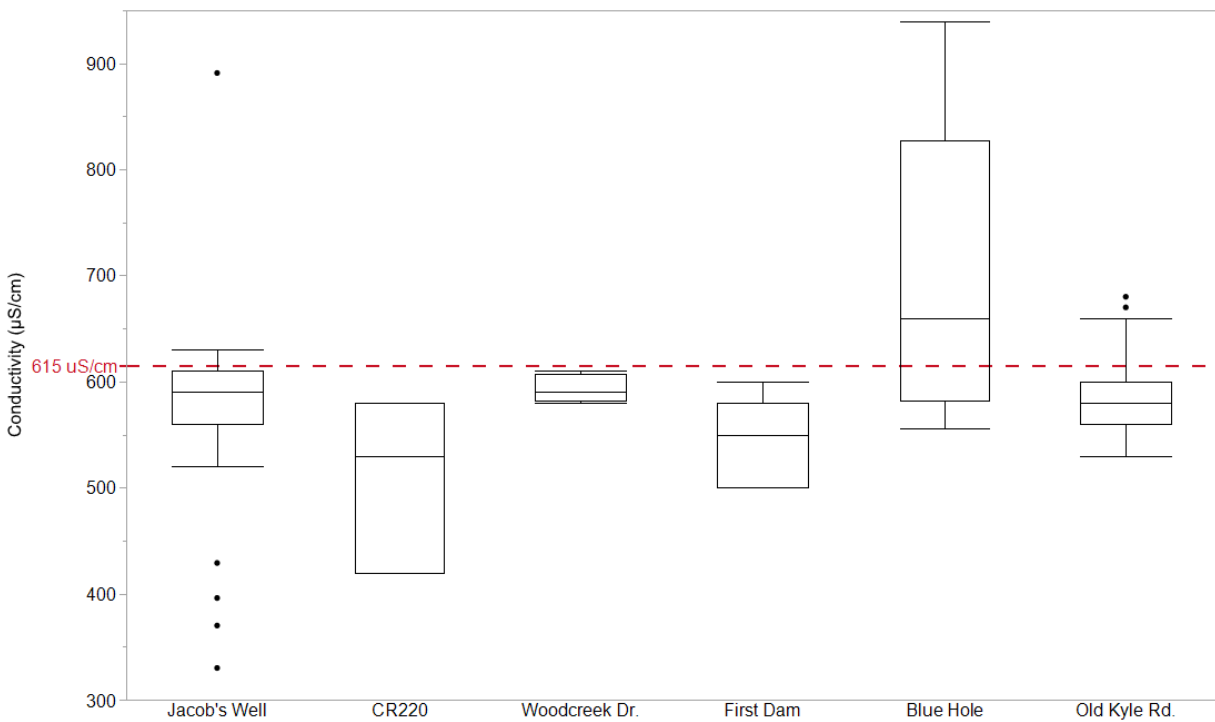


Figure 5. Conductivity (µS/cm) for sites in Cypress Creek February 2006 to December 2019.

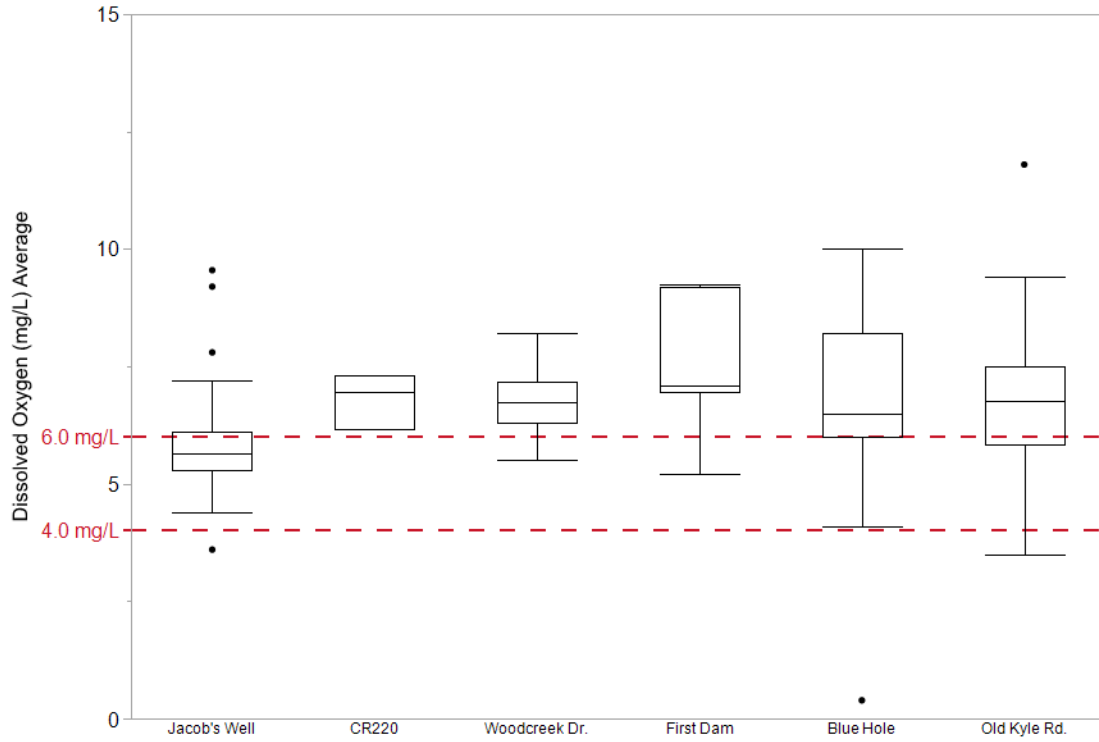


Figure 6. Average dissolved oxygen (mg/L) for sites in Cypress Creek February 2006 to December 2019.

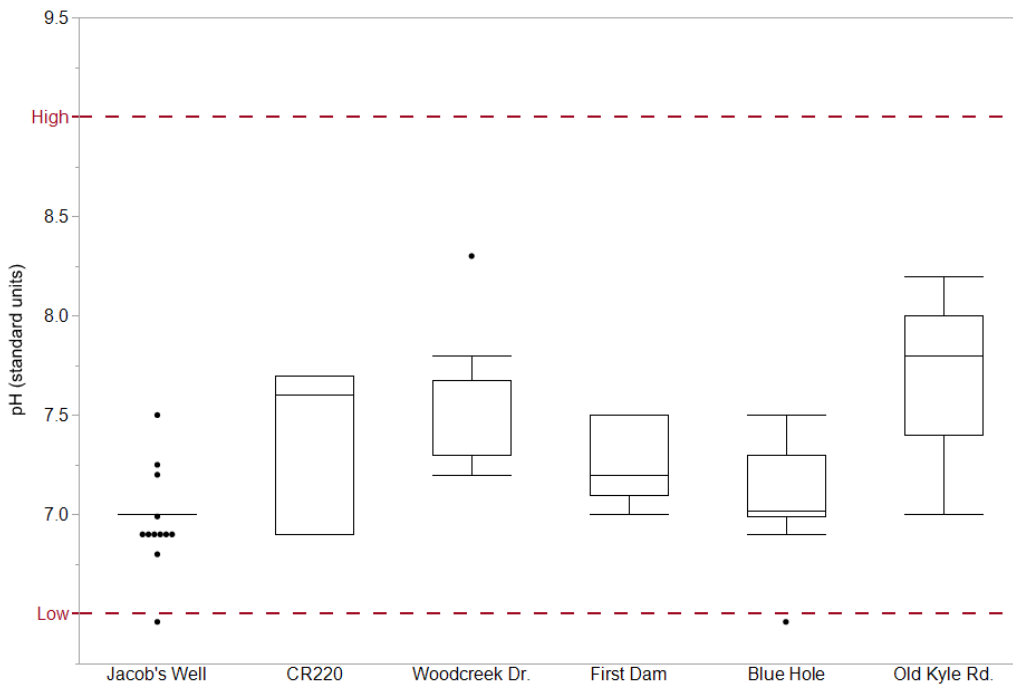


Figure 7. pH (su) values for sites in Cypress Creek February 2006 to December 2019.

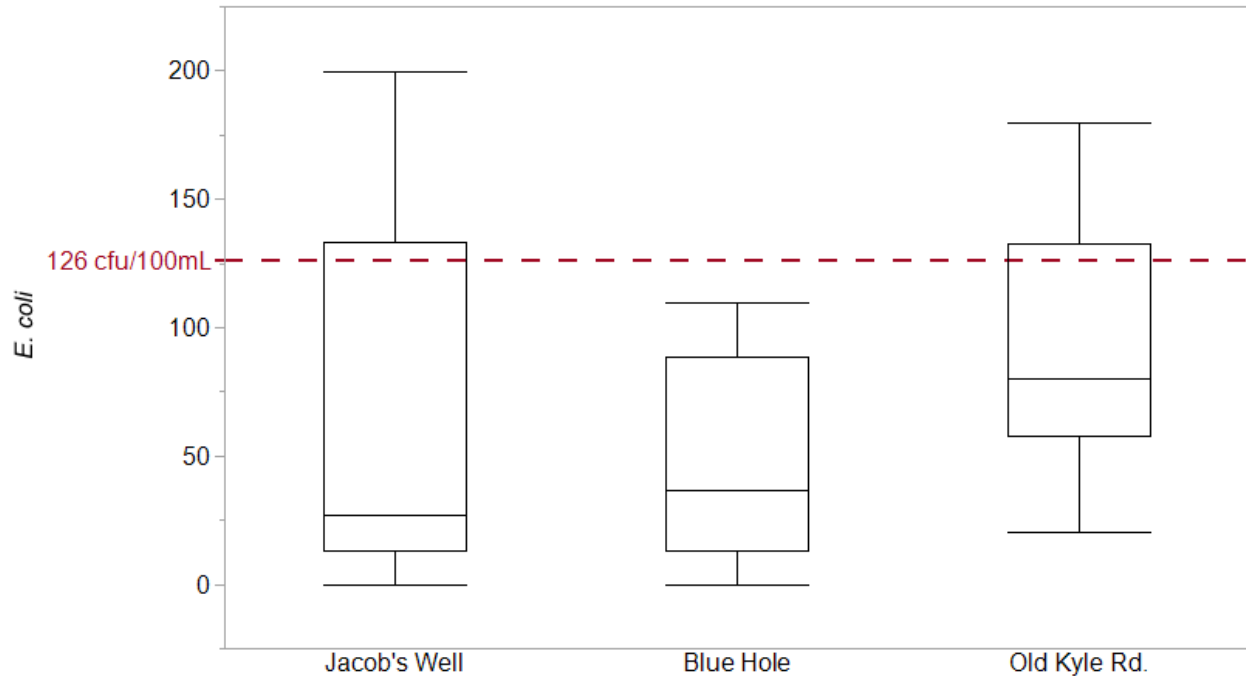


Figure 8. *E. coli* values (CFU/100 mL) for three sites in Cypress Creek February 2006 to December 2019.

WATERSHED SUMMARY

Texas Stream Team citizen scientists monitored water quality parameters from six different sites in Cypress Creek from February 2006 to December 2019, including flow severity, air and water temperature, DO, pH, specific conductance, *E. coli* and nitrate-nitrogen. Data from the six monitoring sites were analyzed and compared to established water quality criteria.

Generally, results presented here support the impairments for depressed DO and, subsequently, for fish and macrobenthic communities in the lower seven miles of the segment. Although no Texas Stream Team data exists for fish and macroinvertebrates in Cypress Creek, if the dissolved oxygen in the water is low, then the organisms living in the water will be affected. The Texas Integrated report listing the impairments states that “additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.” Therefore, it is prudent that Texas Stream Team citizen scientist continue and expand upon the current water quality monitoring efforts in Cypress Creek to further characterize the impairments.

Highlights of the results presented in this report include:

- Sampling was conducted under no flow, low flow and normal flow conditions 98% of the time, therefore the results are representative of those conditions.
- Water temperatures exhibited the least amount of variability at Jacob’s Well, probably a result of the proximity to the ground water source from the aquifer where more stable conditions exist.

- Blue Hole exhibited the most variability and the highest values for specific conductance. Specific conductance is a measure of the water's ability to conduct electricity and is influenced by total dissolved solids in the water. Blue Hole is a popular swimming hole and is located near downtown Wimberley, therefore these factors may play a role in the higher measured values at this location.
- Jacob's Well did not meet the absolute minimum DO criteria for 24-hour means (6.0 mg/L) or 24-hour values (4.0 mg/L). Groundwater typically exhibits lower DO because it originates from the aquifer and is not exposed to atmospheric oxygen. However, keep in mind that 24-hour DO measurements were not collected, only discreet grab measurements.
- The geometric mean for *E. coli* was met at all three sites where measurements were collected. However, single samples at both Jacob's Well and Old Kyle Rd. exceeded the water quality criterion. This should be a noteworthy red flag to heed the warnings.

There are many active Texas Stream Team citizen scientists and groups that monitor water quality in the Cypress Creek watershed. Texas Stream Team staff will continue to support the on-going monitoring efforts currently underway and look forward to training new citizen scientists to expand and grow the water quality monitoring efforts in this area and beyond. The Middle Blanco River Monitors is a new citizen scientist group monitoring water quality and is led by Art Crowe (12crowe@gmail.com).

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APPENDIX

Appendix 1. Endangered, threatened and rare species within the Cypress Creek watershed in Hays County.

Definitions

Federal and State Listing Status: Animal and plant species of conservation concern that are listed under the authority of the U.S. Endangered Species Act or under the authority of Texas state law.

Listing Status	Description
LE	Federally Listed as Endangered
LT	Federally Listed as Threatened
PE	Federally Proposed as Endangered
PT	Federally Proposed as Threatened
C	Federal Candidate for Listing
E	State Listed as Endangered
T	State Listed as Threatened
"blank"	Species of Greatest Concern (SGCN) (no regulatory listing status)

NatureServe Conservation Status: A ranking system developed by The Nature Conservancy and maintained by NatureServe in order to categorize the vulnerability and imperilment of species around the world.

Global Rank	Description
G1	Critically Imperiled: Species is at very high risk of extinction
G2	Imperiled: Species is at high risk of extinction
G3	Vulnerable: Species is at moderate risk of extinction
G4	Apparently Secure: Species is at fairly low risk of extinction
G5	Secure: Species is at very low risk of extinction
GH	Possibly Extinct: No occurrence of the species has been observed in recent history. Some hope of rediscovery
GNR	Unranked: Rank has not yet been assessed

GNA	Not Applicable: A rank is not applicable because this species is not a suitable candidate for conservation activities
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Species of Greatest Conservation Need (SGCN): A statewide list developed and maintained by the Texas Parks and Wildlife Department that includes over 1,300 species of conservation concern. Species of Great Concern are species that are declining, rare, and/or in need of immediate conservation action.

Designation	Description
Yes	Species is declining, rare, and/or in need of conservation action
No	Species is not considered in need of immediate conservation action

Threatened and Endangered Species List

All data was obtained from the Texas Parks and Wildlife Department Rare, Threatened, and Endangered Species of Texas by County online application (Texas Parks and Wildlife, 2019).

Taxon	Scientific Name	Common Name	Federal Listing Status	State Listing Status	Nature Serve Global Rank	Species of Greatest Conservation Need (TPWD)	Endemism
Amphibians	<i>Anaxyrus houstonensis</i>	Houston toad	LE	E	G1	Y	Y
	<i>Anaxyrus woodhousii</i>	Woodhouse's toad			G5	Y	N
	<i>Pseudacris streckeri</i>	Strecker's chorus frog			G5	Y	N
	<i>Pseudacris fouquettei</i>	cajun chorus frog			G5	Y	N

	<i>Lithobates areolatus areolatus</i>	southern crawfish frog			G4	Y	N
Birds	<i>Egretta rufescens</i>	reddish egret		T	G4	Y	N
	<i>Plegadis chihi</i>	white-faced ibis		T	G5	Y	N
	<i>Mycteria americana</i>	wood stork		T	G4	Y	N
	<i>Elanoides forficatus</i>	swallow-tailed kite		T	G5	Y	N
	<i>Haliaeetus leucocephalus</i>	bald eagle		T	G5	Y	N
	<i>Buteo albicaudatus</i>	white-tailed hawk		T	G4	Y	N
	<i>Laterallus jamaicensis</i>	black rail	PT		G3	Y	N
	<i>Grus americana</i>	whooping crane	LE	E	G1	Y	N
	<i>Charadrius melodus</i>	piping plover	LT	T	G3	Y	N
	<i>Charadrius montanus</i>	mountain plover			G3	Y	N
	<i>Calidris canutus rufa</i>	red knot	LT		G4	Y	N
	<i>Leucophaeus pipixcan</i>	Franklin's gull			G4	Y	N
	<i>Athene cunicularia hypugaea</i>	western burrowing owl			G4	Y	N
	<i>Picoides borealis</i>	red-cockaded woodpecker	LE	E	G3	Y	N
	<i>Sternula antillarum athalassos</i>	interior least tern	LE	E	G4	Y	N
Crustaceans	<i>Fallicambarus houstonensis</i>	Houston burrowing crayfish			G2	Y	Y
Fish	<i>Atractosteus spatula</i>	alligator gar			G3	Y	N
	<i>Notropis sabiniae</i>	Sabine shiner			G4	Y	N

	<i>Notropis shumardi</i>	silverband shiner			G5	Y	N
	<i>Erimyzon claviformis</i>	western creek chubsucker		T	G5	Y	N
	<i>Fundulus jenkinsi</i>	saltmarsh topminnow			G3	Y	N
	<i>Paralichthys lethostigma</i>	southern flounder			G5	Y	N
	<i>Notropis atrocaudalis</i>	blackspot shiner			G4	Y	N
	<i>Notropis potteri</i>	chub shiner			G3	Y	N
	<i>Notropis oxyrhynchus</i>	sharpnose shiner	LE		G4	Y	Y
Insects	<i>Bombus pensylvanicus</i>	American bumblebee			G3	Y	N
	<i>Euphyes bayensis</i>	bay skipper			G2	Y	N
	<i>Tricorythodes curvatus</i>	a stout crawler mayfly			G2	Y	N
	<i>Somatochlora margarita</i>	Texas emerald dragonfly			G2	Y	N
Mammals	<i>Blarina carolinensis</i>	southern short-tailed shrew			G5	Y	N
	<i>Myotis austroriparius</i>	southeastern myotis bat			G4	Y	N
	<i>Perimyotis subflavus</i>	tricolored bat			G2	Y	N
	<i>Eptesicus fuscus</i>	big brown bat			G5	Y	N
	<i>Lasiurus borealis</i>	eastern red bat			G3	Y	N
	<i>Lasiurus cinereus</i>	hoary bat			G3	Y	N
	<i>Corynorhinus rafinesquii</i>	Rafinesque's big-eared bat		T	G3	Y	N
	<i>Tadarida brasiliensis</i>	Mexican free-tailed bat			G5	Y	N

	<i>Nyctinomops macrotis</i>	big free-tailed bat			G5	Y	N
	<i>Sylvilagus aquaticus</i>	swamp rabbit			G5	Y	N
	<i>Ictidomys tridecemlineatus</i>	thirteen-lined ground squirrel			G5	Y	N
	<i>Megaptera novaeangliae</i>	humpback whale	LE	E	G4	N	N
	<i>Ursus americanus luteolus</i>	Louisiana black bear		T	G5	Y	N
	<i>Mustela frenata</i>	long-tailed weasel			G5	Y	N
	<i>Neovison vison</i>	mink			G5	Y	N
	<i>Taxidea taxus</i>	American badger			G5	Y	N
	<i>Spilogale putorius</i>	eastern spotted skunk			G4	Y	N
	<i>Conepatus leuconotus</i>	western hog-nosed skunk			G4	Y	N
	<i>Puma concolor</i>	mountain lion			G5	Y	N
	<i>Microtus pinetorum</i>	woodland vole			G5	Y	N
Mollusks	<i>Lampsilis satura</i>	sandbank pocketbook		T	G2	Y	N
	<i>Pleurobema riddellii</i>	Louisiana pigtoe		T	G1	Y	N
	<i>Quadrula houstonensis</i>	smooth pimpleback	C	T	G2	Y	Y
	<i>Truncilla macrodon</i>	Texas fawnsfoot	C	T	G2	Y	Y
Plants	<i>Tauschia texana</i>	Texas tauschia			G3	Y	Y
	<i>Coreopsis intermedia</i>	goldenwave tickseed			G3	Y	N
	<i>Pseudognaphalium austrotexanum</i>	South Texas false cudweed			G3	Y	N

	<i>Helianthus occidentalis ssp. plantagineus</i>	Shinner's sunflower			G5	Y	N
	<i>Hymenoxys texana</i>	Texas prairie dawn	LE	E	G2	Y	Y
	<i>Liatris bracteata</i>	coastal gay-feather			G2	Y	Y
	<i>Rayjacksonia aurea</i>	Houston daisy			G2	Y	Y
	<i>Thurovia triflora</i>	threeflower broomweed			G2	Y	Y
	<i>Amorpha paniculata</i>	panicked indigobush			G2	Y	N
	<i>Physostegia correllii</i>	Correll's false dragon-head			G2	Y	N
	<i>Leitneria pilosa ssp. pilosa</i>	corkwood			G3	Y	N
	<i>Thalictrum texanum</i>	Texas meadow-rue			G2	Y	Y
	<i>Cyperus cephalanthus</i>	giant sharpstem umbrella-sedge			G3	Y	N
	<i>Rhynchospora indianolensis</i>	Indianola beakrush			G3	Y	Y
	<i>Calopogon oklahomensis</i>	Oklahoma grass pink			G3	Y	N
	<i>Spiranthes brevilabris var. brevilabris</i>	Texas ladies'-tresses			G1	Y	N
	<i>Bothriochloa exaristata</i>	awnless bluestem			G4	Y	N
	<i>Chloris texensis</i>	Texas windmill grass			G2	Y	Y
	<i>Sporobolus tharpaii</i>	Tharp's dropseed			G3	Y	Y

	<i>Willkommia texana</i> <i>var. texana</i>	Texas willkommia			G3	Y	Y
	<i>Onosmodium helleri</i>	Heller's marbleseed			G3	Y	Y
	<i>Paronychia setacea</i>	bristle nailwort			G3	Y	Y
	<i>Astragalus wrightii</i>	Wright's milkvetch			G3	Y	Y
	<i>Rhododon ciliatus</i>	Texas sandmint			G3	Y	Y
	<i>Echinacea atrorubens</i>	Topeka purple- coneflower			G3	Y	N
	<i>Spigelia texana</i>	Florida pinkroot			G3	Y	Y
	<i>Cyperus grayioides</i>	Mohlenbrock's sedge			G3	Y	N
Reptiles	<i>Caretta caretta</i>	loggerhead sea turtle	LT	T	G3	Y	N
	<i>Macrochelys temminckii</i>	alligator snapping turtle		T	G3	Y	N
	<i>Malaclemys terrapin littoralis</i>	Texas diamondback terrapin			G4	Y	Y
	<i>Terrapene carolina</i>	eastern box turtle			G5	Y	N
	<i>Terrapene ornata</i>	western box turtle			G5	Y	N
	<i>Gopherus berlandieri</i>	Texas tortoise		T	G4	Y	N
	<i>Apalone mutica</i>	smooth softshell			G5	Y	N
	<i>Ophisaurus attenuatus</i>	slender glass lizard			G5	Y	N
	<i>Phrynosoma cornutum</i>	Texas horned lizard		T	G4	Y	N
	<i>Heterodon nasicus</i>	western hognose snake			G5	Y	N

	<i>Crotalus horridus</i>	timber (canebrake) rattlesnake		T	G4	Y	N
	<i>Pituophis ruthveni</i>	Louisiana pine snake	LT	T	G2	Y	N