UPPER CIBOLO CREEK WATERSHED DATA REPORT

April 2018

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INTRODUCTION

Texas Stream Team (TST) is a volunteer-based citizen science water quality monitoring program. Citizen scientists collect surface water quality data that may be used in the decision-making process to promote and protect a healthy and safe environment for people and aquatic inhabitants. Citizen scientist water quality monitoring occurs at predetermined monitoring sites, at roughly the same time of day each month. Citizen scientist water quality monitoring data provides a valuable resource of information by supplementing professional data collection efforts where resources are limited. The data may be used by professionals to identify 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.

TST citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards. Citizen scientists use different methods than the professional water quality monitoring community. TST does not utilize those methods due to higher equipment costs, training requirements, and stringent laboratory procedures that are required of the professional community. However, the data collected by TST provides valuable records, often collected in portions of a water body that professionals are not able to monitor frequently or monitor at all. This long-term data set is available and may be considered by the surface water quality professional community to facilitate management and protection of Texas water resources. For additional information about water quality monitoring methods and procedures, including the differences between professional and volunteer monitoring, please refer to the following sources:

- Texas Stream Team Volunteer Water Quality Monitoring Manual
- Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring Procedures

The information that TST citizen scientists collect is covered under a TCEQ-approved Quality Assurance Project Plan (QAPP) to ensure that a standard set of methods are used. All data used in watershed data reports are screened by TST for completeness, precision, and accuracy, in addition to being scrutinized for data quality objectives and with data validation techniques.

The purpose of this report is to provide analysis of data collected by TST citizen scientists. The data presented in this report should be considered in conjunction with other relevant water quality reports in order to provide a holistic view of water quality in this water body. Such sources include, but are not limited to, the following potential resources:

- 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 Programs funded reports, including Watershed Protection Plans (WPPs)

Questions regarding this watershed data report should be directed to TST at (512) 245-1346.

WATERSHED LOCATION AND PHYSICAL DESCRIPTION

Location and Physical Description

Cibolo Creek emerges from Brown Spring and Champee Spring located in southwestern Kendall County, about ten miles northwest of Boerne. Cibolo Creek runs southeast through the City of Boerne and continues for 100 miles. The creek crosses five counties, forming the Bexar-Comal and Bexar-Guadalupe county lines, crosses Wilson County, and empties into the San Antonio River five miles northwest of Karnes City. Upper Cibolo Creek (TCEQ Segment 1908), the focus of this report, also receives flow from Frederick Creek, Menger Creek, and Ranger Creek. The Upper Cibolo Creek Watershed lies within the headwaters of the San Antonio River Basin. The San Antonio River Basin drains 4,134 $mi.^2$ from the northeast corner of Bandera County to its confluence with the Guadalupe River near the Gulf Coast. Downstream of Boerne, Cibolo Creek provides significant groundwater recharge through fractures in the streambed to both the Trinity and Edwards aquifers and is often dry during normal streamflow conditions. This report focuses on the Upper Cibolo Creek Watershed, the $77mi^2$ drainage area surrounding the upper 23 miles of Cibolo Creek.

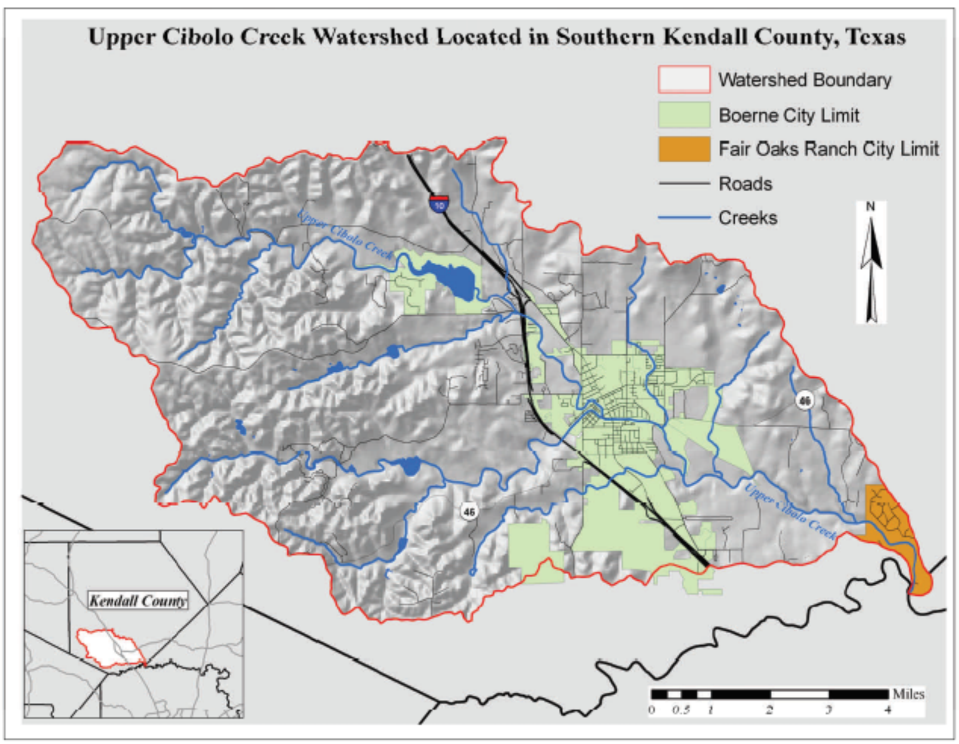

Figure 1: Upper Cibolo Creek Watershed location (TCEQ 2012)

The Upper Cibolo Creek watershed is an area of ecological, hydrological, and geological significance. The area along Upper Cibolo Creek within the Cibolo Nature Center and the Cibolo Preserve is composed of diverse habitats where the creek contains long open runs, deep shaded pools, riffles, springs, groundwater recharge features, and exposed fossil beds typically found deep within the earth’s surface. Stream flow and annual precipitation infiltrates sinkholes, fissures, and caverns of the limestone substrate to recharge the Trinity Aquifer (TCEQ 2013).

The Upper Cibolo Creek Watershed ranges in elevation from 1,245 ft. (380m) to 2,012 ft. (613m) above sea level (Figure 2). The western portion of the watershed above, Champee and Brown springs, has the highest elevations while the extreme downstream reach of the watershed near the confluence with Balcones Creek is the lowest point. Topography varies throughout the watershed with the western portion characterized as steep hilly terrain with small box canyons. Topography in the eastern portion of the watershed reduces to low rolling hills interspersed with flat areas containing woodlands and small pastures (TCEQ 2013).

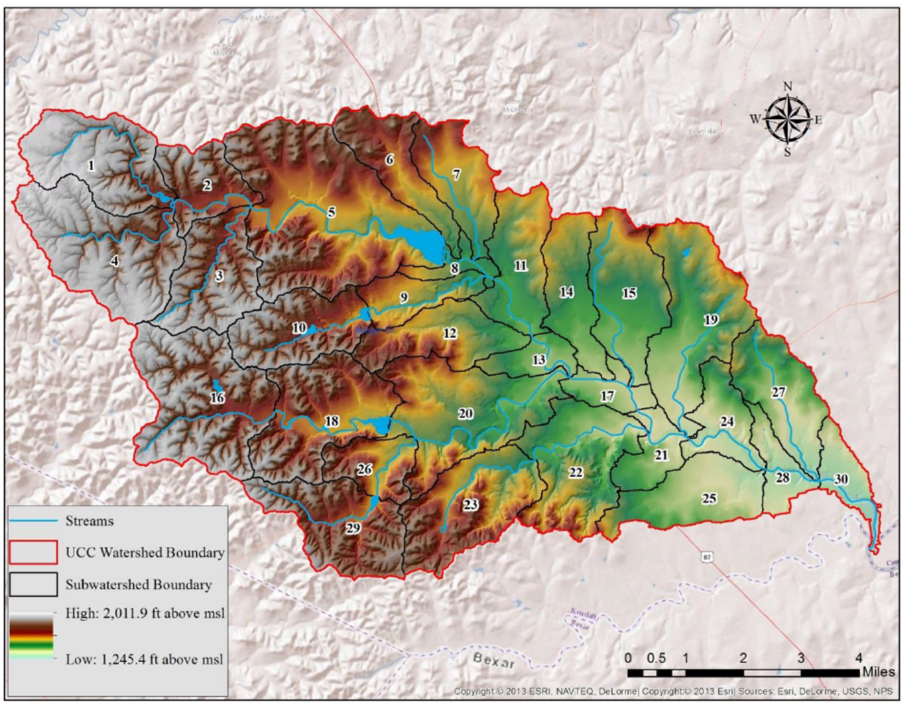

Figure 2: Digital elevation model for the Upper Cibolo Creek Watershed (TCEQ 2013)

Ecoregion

The Upper Cibolo Creek flows through Kendall County within the Balcones Canyonlands ecoregion which forms the southeastern boundary of the Edwards Plateau. The southern Edwards Plateau was shaped through uplift and subsidence along the Balcones Fault Zone, separating central Texas from the coastal plain by over 1000 feet in elevation (Spearing 1991). The Balcones Canyonlands are highly dissected through the solution of springs, streams, and rivers working both above and below ground to creating many karst features such as canyons, sinkholes, and caverns (Griffith et al., 2007).

Climate

The Upper Cibolo Creek Watershed is described as having a subtropical, subhumid climate characterized by hot summers and mild, dry winters (Larkin and Bomar, 1983). Boerne has an average temperature of 34ºF in January and 94ºF in July (NOAA 2009). The City of Boerne receives an annual average of 36 inches of precipitation. Although rainfall is generally distributed evenly throughout the year, higher amounts of precipitation occur in May, June, September, and October (Reeves 1967). The maximum recorded precipitation for one year was 64.17 inches in 1992; the minimum was 10.29 in 1954.

Land Use

Land owners within the watershed predominately use their property for light ranching, hunting, and recreation. Many small ranchettes are scattered throughout the watershed, and some large acreage ranches can be found in the headwaters region. In several locations, large tracts of ranchland are being divided into smaller holdings or developed into residential subdivisions. These changes are frequently associated with new land management strategies and oftentimes greatly increase the amount of impermeable surfaces within subwatersheds. The popularity of the Texas Hill Country as a retirement destination and the northward expansion of the greater San Antonio area will continue to influence these trends. In general, regional population growth will result in the conversion of rural properties to commercial and residential areas. The resulting change in landcover type from grasslands and forested areas to urbanized environments will likely have a negative impact on water quality and quantity. The region around Upper Cibolo Creek is mostly rural, with some ranch and recreational use (City of Boerne). However, development and suburbanization are increasing, which pose a potential threat to water quality (City of Boerne).

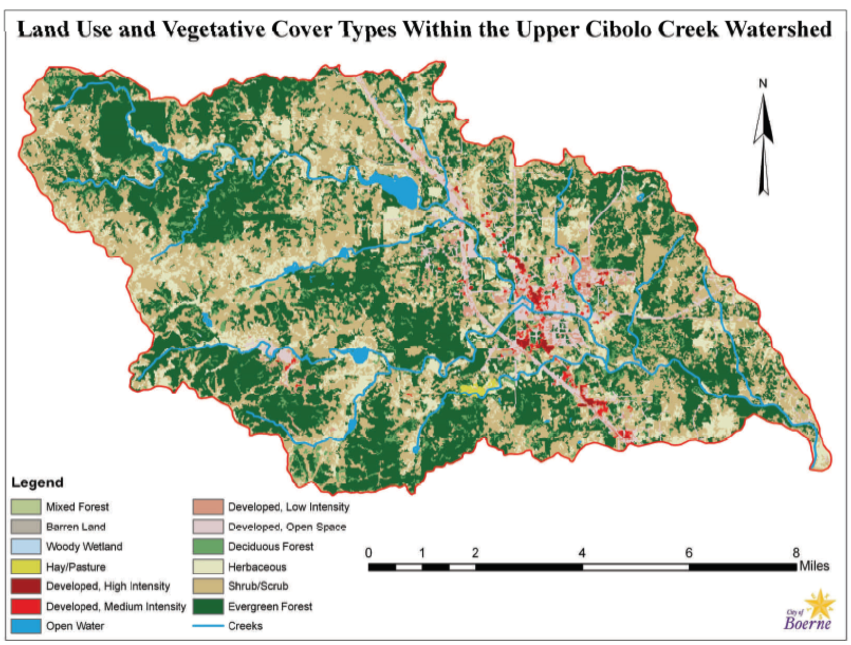

Figure 3 : Upper Cibolo Creek Watershed land use

History

Upper Cibolo Creek has had many names in its history. Before European settlement it was called "Xoloton" by Coahuiltecan Indians and "Bata Coniquiyoqui" by Tonkawa Indians (TSHA). Several Spanish settlers also had names for it, Father Damian Massanet called it "Santa Crecencia," Domingo Terán de los Ríos named it "San Ygnacio de Loyola," and Domingo Ramón called it "San Xavier" in 1716 (TSHA). Eventually, the area became known as "Cibolo," and Marqués de San Miguel de Aguayo called it Arroyo del Cibolo in 1721 (TSHA). After the annexation of Texas in 1845, the first permanent settlements were gradually established, beginning with Schertz, Boerne (originally Tusculum), La Vernia, and Bulverde (originally Pieper Settlement) (TSHA).

Water Quality Impairments

Upper Cibolo Creek has a history of elevated bacteria levels that often exceed state standards established for safe contact recreation. Beginning in 1999, Upper Cibolo Creek (Segment 1908) was listed on the Texas Water Quality Inventory and 303(d) List of impaired waterbodies for depressed dissolved oxygen (DO) and elevated levels of fecal coliform bacteria. From 2000-2004, Upper Cibolo Creek was only listed for depressed DO, and from 2006-2010, it was listed only for bacteria. The 2016 Draft 303(d) List once again indicates bacteria impairments in the upstream reaches of Upper Cibolo Creek, which was first listed for bacteria impairments (recreational uses) in 2006. Chloride was also listed as an impairment for Upper Cibolo Creek Segment 1908_01, 1908_02, 1908_03. Screening level data collected during these assessments have also indicated concerns for elevated nutrient levels, primarily orthophosphorus.

Wastewater Treatment Facility Discharge

Waste water treatment facilities (WWTFs) are considered direct discharges of pollutant loads and can be a continuous source of bacteria or nutrient loading unless they are permitted as no discharge facilities. The City of Boerne operates the only permitted WWTF that discharges wastewater into Cibolo Creek or its tributaries and is currently the only point source of pollution located in the watershed.

These facilities are operated under Texas Pollutant Discharge Elimination System (TPDES) permit WQ0010066-001 which discharges wastewater to Currey Creek, and then to Cibolo Creek. The City of Boerne has constructed a new Wastewater Treatment and Recycling Center (WWTRC) (TPDES permit WQ0010066-002) with a discharge location near the mouth of Menger Creek. The new WWTRC began operation in April 2013. Lerin Hills Municipal Utility District obtained a permit (TPDES WQ0014712-001) to discharge wastewater to a tributary of Frederick Creek, but to date the facility has not been built and no wastewater is being discharged. Another WWTF in the watershed is operated by the Kendall West Utility LLC., but this is a no-discharge facility which applies effluent as irrigation to Tapatio Springs Golf Resort.

On-Site Sewage Facilities

Bacteria and nutrient loads from on-site sewage facilities (OSSF) are considered a nonpoint source of pollution. OSSFs typically treat waste from single residences that are not connected by a sanitary sewer line to a WWTF. Geographic Information System (GIS) was used to locate OSSFs throughout the watershed by identifying improved residential structures outside of known sewer service areas. The City of Boerne estimated that 2,344 OSSFs are located within the Upper Cibolo Creek Watershed, and their locations are shown in Figure 4 (TCEQ 2013).

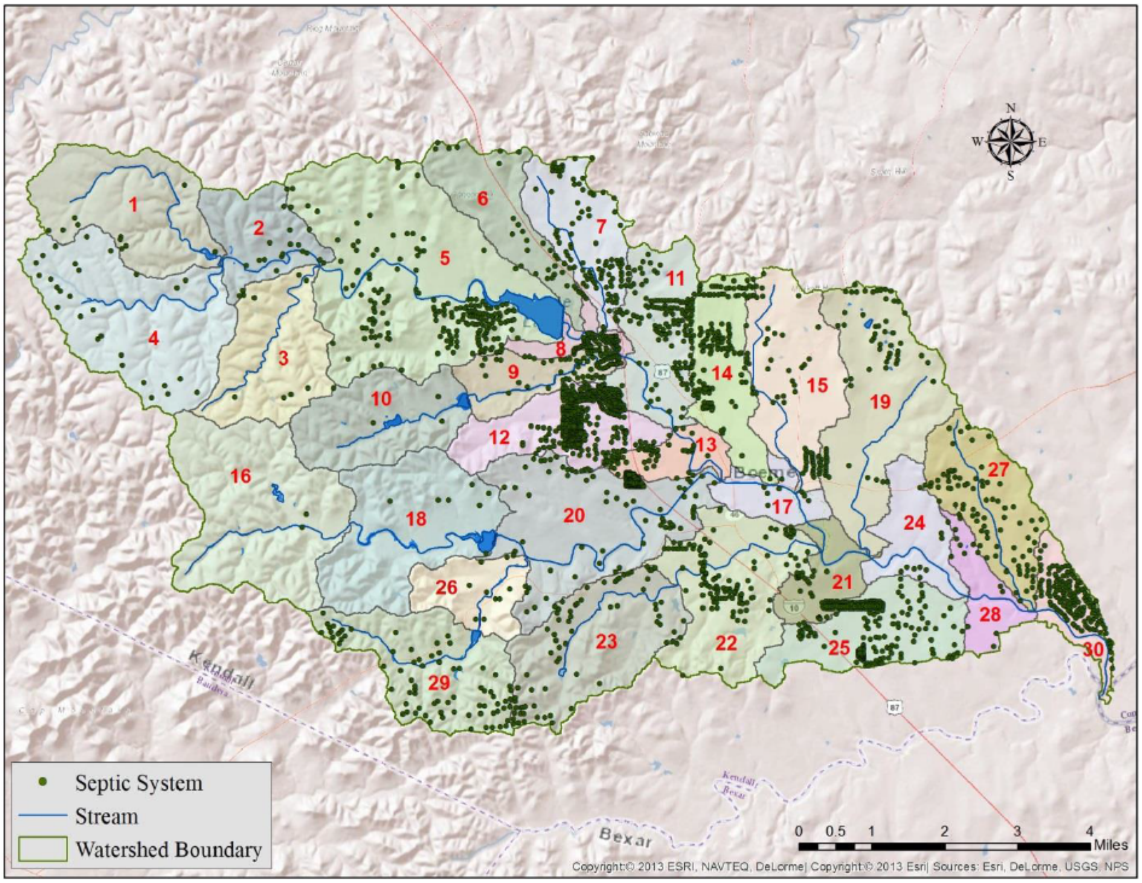

Figure 4: Upper Cibolo Creek Watershed on-site sewage facilities (OSSFs) (TCEQ 2013)

Watershed Protection Plan

The Upper Cibolo Creek Watershed Partnership (Partnership) was formed in 2010 to address persistent bacteria impairments within Upper Cibolo Creek and promote stakeholder participation in the watershed planning process. The Partnership framework ensures the views of local citizens, special interest groups, businesses, landowners, and governing bodies are represented. Partnership stakeholders developed a primary goal for the WPP that included (at a minimum) meeting the appropriate water quality standards established for bacteria to ensure safe contact recreation. Stakeholders were also encouraged to proactively address any pollutants that might threaten or impair the physical, chemical, biological, or ecological integrity and designated uses of Upper Cibolo Creek and its watershed (TCEQ 2013).

In September of 2013, the Upper Cibolo Creek WPP was accepted by the Environmental Protection Agency (EPA) and the TCEQ (City of Boerne). The WPP targets point and nonpoint sources of bacteria and other pollutants through monitoring and best management practices to improve water quality and restore its contact recreation use (TCEQ "Upper Cibolo Creek Watershed Protection Plan").

Endangered Species and Conservation Needs

Kendall County federal and state listed endangered or threatened species include:

Table 1: Endangered species located within Kendall County

ARACHNIDS	Braken Bat Cave Meshweaver
AMPHIBIANS	Cascade Caverns Salamander
	Blanco River Springs Salamander
	Cascade Caverns Salamander
	Comal Blind Salamander
	Texas Salamander
BIRDS	American Peregrine Falcon
	Arctic Peregrine Falcon
	Bald Eagle
	Black-capped Vireo
	Golden-cheeked Warbler
	Interior Least Tern
	Mountain Plover
	Peregrine Falcon
	Sprague's Pipit
	Western Burrowing Owl
	Whooping Crane
	Zone-tailed Hawk
CRUSTACEANS	Cascade Cave Amphipod
	Long-legged Cave Amphipod
FISHES	Guadalupe Bass
	Headwater Catfish
MAMMALS	Black Bear
	Cave Myotis Bat
	Gray Wolf
	Red Wolf
	Plains Spotted Skunk
MOLLUSKS	False Spike Mussel
	Golden Orb
	Texas Fatmucket
	Texas Pimpleback
REPTILES	Cagle's Map Turtle

	Spot-tailed Earless Lizard
	Texas Garter Snake
	Texas Horned Lizard
INSECTS	A mayfly (Baetodes alleni)
	A mayfly (Allenhyphes michaeli)
PLANTS	Basin Bellflower
	Big Red Sage
	Boerne Bean
	Buckley Tridens
	Darkstem Noseburn
	Glass Mountains Coral-root
	Hairy Sycamore-leaf Snowbell
	Hall's Prairie Vlover
	Heller's Marbleseed
	Hill Country Wild-mercury
	Plateau Milkvine
	Scarlet Leather-flower
	Spreading Leastdaisy
	Sycamore-leaf Snowbell
	Texas Amorpha
	Texas Fescue
	Texas Seymeria
	Tree Dodder

WATER QUALITY PARAMETERS

Water Temperature

Water temperature influences the physiological processes of aquatic organisms, and each species has an optimum temperature for survival. High water temperatures increase oxygen-demand for aquatic communities and can become stressful for fish and aquatic insects. 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.

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 stream flow. The TCEQ Water Quality Standards document lists daily minimum DO criteria for specific water bodies and presumes criteria according to flow status (perennial, intermittent with perennial pools, and intermittent), aquatic life attributes, and habitat. These criteria are protective of aquatic life and can be used for general comparison purposes.

Table 2: Daily minimum dissolved oxygen requirements for aquatic life

Aquatic Life Sub-category	Daily Minimum Dissolved Oxygen (mg/L)
Exceptional	4.0
High	3.0
Intermediate	3.0
Limited	2.0
Minimal	1.5

The DO concentrations can be influenced by other water quality parameters such as nutrients and temperature. High concentrations of nutrients can lead to excessive surface vegetation growth and algae, which may starve subsurface vegetation of sunlight, and, therefore, limit the amount of DO in a water body due to reduced photosynthesis. This process, known as eutrophication, is enhanced when the subsurface vegetation and algae die, and oxygen is consumed by bacteria during decomposition. 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 stratification occurs. Supersaturation typically only occurs underneath waterfalls or dams with water flowing over the top.

Specific Conductivity and Total Dissolved Solids

Specific conductivity is a measure of the ability of a body of water to conduct electricity. It is measured in microsiemens per cubic centimeter ($\mu S/cm^3$). A body of water is more conductive if it has more Total Dissolved Solids (TDS) such as nutrients and salts, which indicates poor water quality if they are overly abundant. High concentrations of nutrients can lower the level of DO, leading to eutrophication. 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 conductivity values have been converted to TDS using a conversion factor of 0.65 and are reported as mg/L.

pH

The pH scale measures the concentration of hydrogen ions on a range of 0 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 1-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 is mostly 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 dissolving 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.

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, and the depth is recorded. 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 readings indicate turbid water. Readings that are equal to total depth indicate clear water. Low total depth observations have a potential to concentrate contaminants.

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 amount of water bodies tested. A pathogen is a biological agent that causes disease. The standard for *E. coli* impairment 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 contact recreational use of a water body such as the Upper Cibolo Creek Watershed is 126 CFU/100 mL. A water body is considered impaired if the geometric mean is higher than this 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 itself, 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 volunteer 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. Just like phosphorus, nitrogen is a nutrient necessary for the growth of most organisms. Nitrogen inputs into a water body may be 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 (page 14). Nitrate-Nitrogen dissolves more readily than orthophosphate, which tend to be attached to sediment, and, therefore, can serve as a better indicator of the possibility of sewage or manure pollution during dry weather.

Texas Surface Water Quality Standards

The Texas Surface Water Quality Standards establish explicit goals for the quality of streams, rivers, lakes, and bays throughout the state. 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 identify appropriate uses for the state's surface waters, including aquatic life, recreation, and sources of public water supply (or drinking water). The criteria for evaluating support of those uses include DO, temperature, pH, 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.

DATA ANALYSIS METHODOLOGIES

Data Collection

The field sampling procedures are documented in TST Water Quality Monitoring Manual and its appendices, or the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012). Additionally, all data collection adheres to TST's approved Quality Assurance Project Plan (QAPP).

Table 3: Sample storage, preservation, and handling requirements

Parameter	Matrix	Container	Sample Volume	Preservation	Holding Time
E. coli	Water	Sterile Polystyrene (SPS)	100	Refrigerate at 4°C*	6 hours
Nitrate-Nitrogen/Nitrogen	Water	Plastic Test Tube	10 mL	Refrigerate at 4°C*	48 hours
Orthophosphate/Phosphorous	Water	Glass Mixing Bottle	25 mL	Refrigerate at 4°C*	48 hours
Chemical Turbidity	water	Plastic Turbidity Column	50 mL	Refrigerate at 4°C*	48 hours

*Preservation performed within 15 minutes of collection.

Processes to Prevent Contamination

Procedures documented in TST Water Quality Monitoring Manual and its appendices, or the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012) outline the necessary steps to prevent contamination of samples, including direct collection into sample containers, when possible. Field quality control samples are collected to verify that contamination has not occurred.

Documentation of Field Sampling Activities

Field sampling activities are documented on the field data sheet. 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 and communicated to TST.

Sampling is not encouraged with expired reagents and bacteria media; the corresponding values will be flagged in the database and excluded from data reports. Detailed observational data is recorded, including 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 and administrative purposes.

Data Entry and Quality Assurance

Data Entry

The citizen scientists collect field data and report the measurement results on TST approved physical or electronic datasheets. The physical datasheet is submitted to the TST and local partner, if applicable. The electronic datasheet is accessible in the online Waterways Dataviewer and, upon submission and verification, is uploaded directly to the TST database.

Quality Assurance and Quality Control

All data is 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. The respective field, data management, and quality assurance officer (QAO) data verification responsibilities are listed by task in the Section D1 of the QAPP, available on the TST website.

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 is 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 is flagged in the database.

When the QAO receives the physical data sheets, they are validated using the data validation checklist, and then entered into the online database. Any errors are noted in an error log and the errors are flagged in the TST database. When a monitor enters data electronically, the system will automatically flag data outside of the data limits and the monitor will be prompted to correct the mistake or the error will be logged in the database records. The certified QAO will further review any flagged errors before selecting to validate the data. After validation, the data will be formally entered into the database. Once entered, the data can be accessible through the online Dataviewer.

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

Data Analysis Methods

Data is compared to state standards and screening levels, as defined in the Surface Water Quality Monitoring Procedures, to provide readers with a reference point for amounts/levels of parameters that may be of concern. The assessment performed by TCEQ and/or designation of impairment involves more complicated monitoring methods and oversight than used by volunteers and staff in this report. The citizen water quality monitoring data is not used in the assessments mentioned above but are intended to inform stakeholders about general characteristics and assist professionals in identifying areas of potential concern.

Standards and Exceedances

The TCEQ determines a water body to be impaired if more than 10% of samples, provided by professional monitoring, from the last seven years, exceed the standard for each parameter, except for *E. coli* bacteria. When the observed sample value does not meet the standard, it is referred to as an exceedance. At least ten samples from the last seven years must be collected over at least two years with the same reasonable amount of time between samples for a data set to be considered adequate. The 2018 Texas Surface Water Quality Standards report was used to calculate the exceedances for the Upper Cibolo Creek Watershed, as seen on page 20 in Table 4.

Methods of Analysis

All data collected from Upper Cibolo Creek and its tributaries were exported from the TST database and were then grouped by site. Data was reviewed and, for the sake of data analysis, only one sampling event per day, per site was selected for the entire study duration. If more than one sampling event occurred per day, per site, the most complete, correct, and representative sampling event was selected.

Once compiled, data was sorted and graphed in Microsoft Excel 2010 using standard methods. Upstream to downstream trends and trends over time were analyzed using a linear regression analysis in Minitab v 15. Statistically significant trends were added to Excel to be graphed. R-squared is a statistical measure of how close the data a to the fitted regression line. 0% 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%. As the p-value decreases, the confidence that it matches actual conditions in nature increases.

For this report, specific conductivity measurements, gathered by volunteers, were converted to TDS using the TCEQ-recommended conversion formula of specific conductivity 0.65. This conversion was made so that volunteer gathered data could be more readily compared to state gathered data. Geomeans were calculated for *E. coli* data for trends and for each monitoring site. Due to the variability, the geometric mean is used to summarize bacteria data.

Table 4: TCEQ designated stream segments and standards, as applicable to citizen water quality data in this report (other standards may exist for these water bodies).

			Aquatic Life Use (H)		Recreation Use (PCR1)		General Use			
Sub-segment No.	Segment Name	Description	Dissolved Oxygen grab screening level (mg/L)	Dissolved Oxygen grab minimum (mg/L)	E. coli single sample (CFU/100mL)	E. coli geometric mean (CFU/100mL)	Water Temp (°C)	High pH (SU)	Low pH (SU)	TDS (mg/L)
1908_01	Upper Cibolo Creek	Extends from the confluence with Balcones Creek to approximately 2 miles upstream of Hwy 87 in Boerne.	5.0	4.0	394	126	33	9.0	6.5	600
1908_02	Upper Cibolo Creek	Begins approximately 2 miles upstream of Hwy 87 and extends to just upstream of Champee Spring.	5.0	4.0	394	126	33	9.0	6.5	600

UPPER CIBOLO CREEK WATERSHED DATA ANALYSIS

Upper Cibolo Creek Maps

Numerous maps were prepared to show spatial variation of the parameters. The parameters mapped include DO, pH, TDS, and *E. coli*. There is also a reference map showing the locations of all active sites.

Added reference points in all maps, layers showing monitoring sites, cities, counties, and major highways were included. All shapefiles were downloaded from reliable federal, state, and local agencies.

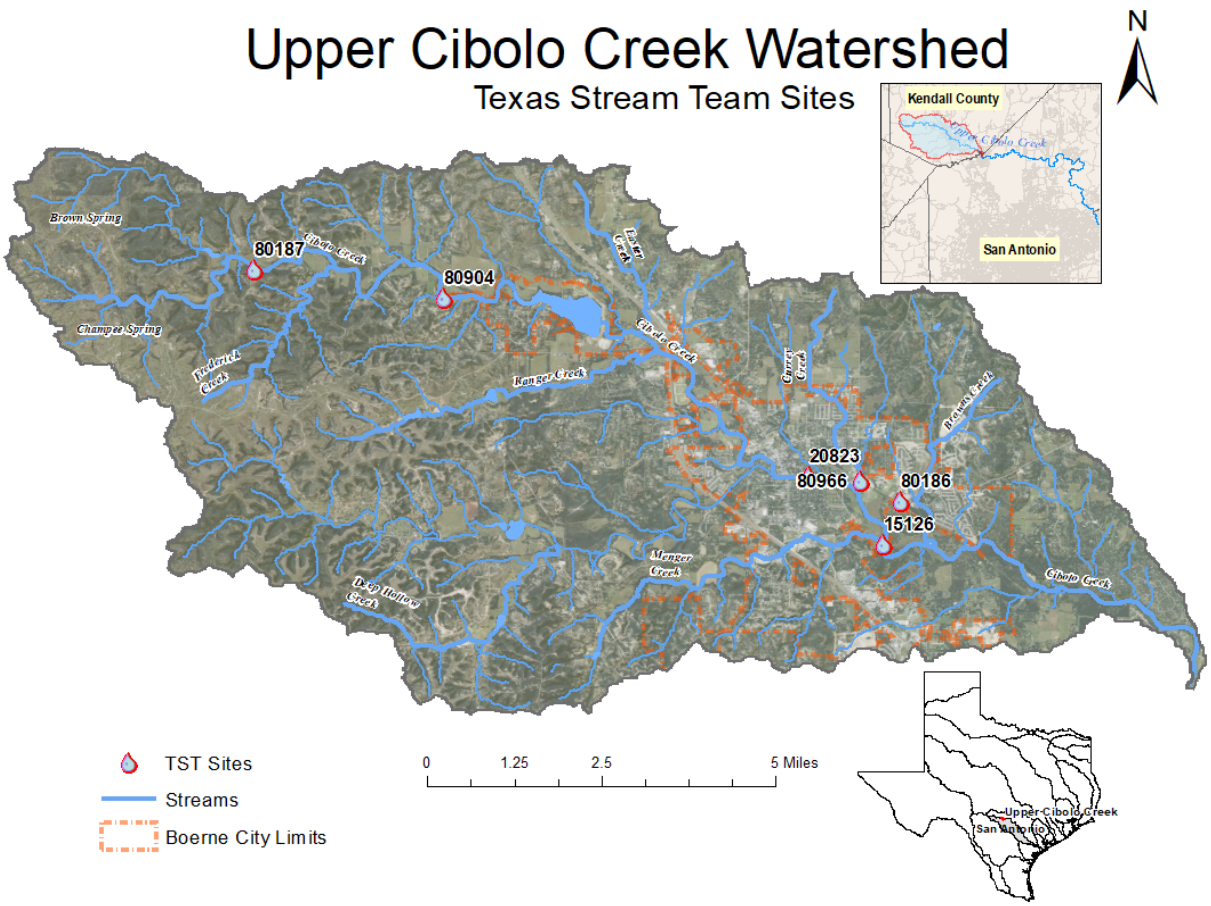

Figure 5: Upper Cibolo Creek Watershed and active TST sites

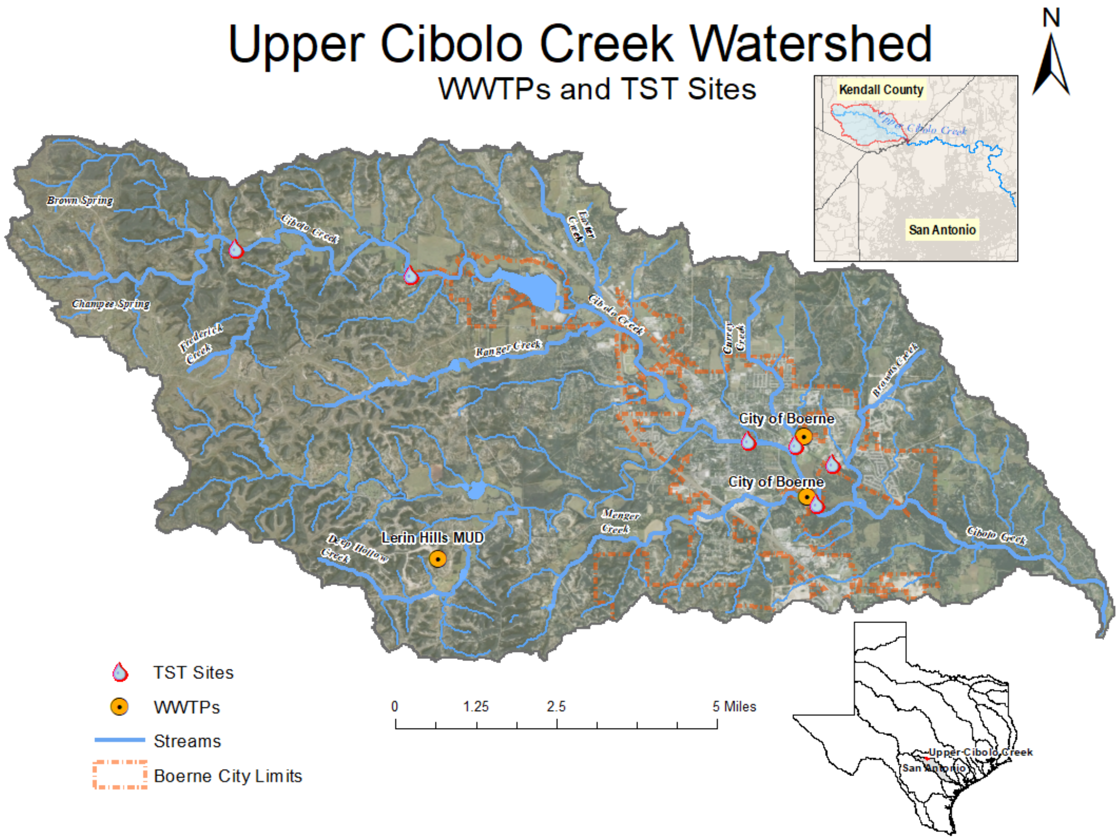

Figure 6: Upper Cibolo Creek with TST sites and WWTP outfalls

Upper Cibolo Creek Watershed Trends over Time

Sampling Trends over Time

Sampling along Upper Cibolo Creek began in September of 1996 and continues to this day. A total of 642 individual monitoring events from six sites were analyzed. There was no monitoring during 1997 and 1998, nor in the new monitoring sites we added in 2012. Monthly monitoring occurred on a consistent basis throughout the years. The time of sampling ranged from 07:10 to 20:08 with a bimodal distribution in the time of sampling. The most common time of day for sampling occurred between 09:00 and 10:00 and then again in the afternoon around 15:00 to 16:00.

Table 5: Descriptive parameters for all sites in the Upper Cibolo Creek Watershed

Upper Cibolo Creek Watershed September 1996 – April 2018				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	619	386 ± 140	85	734.5

Parameter (cont.)	Number of Samples (cont.)	Mean ± Standard Deviation (cont.)	Min (cont.)	Max (cont.)
Water Temperature (°C)	636	20.1 ± 5.7	4.5	34.5
Dissolved Oxygen (mg/L)	616	6.8 ± 2.0	1.0	13.7
pH (su)	618	7.8 ± 0.3	6.9	8.8
Turbidity (JTU)	186	4 ± 8	0	70
E. coli (CFU/100mL)	97	68 ± 669	1	3540
Nitrate-Nitrogen (mg/L)	192	7.3 ± 6.5	0.0	15.0
Orthophosphate (mg/L)	192	4.3 ± 5.4	0.0	28.0

There were a total of 642 sampling events between 9/24/1996 and 4/19/2018. Mean is listed for all parameters except for *E. coli* which is represented as the geomean.

Trend Analysis over Time

Air and Water Temperature

A total of 627 and 636 air and water temperatures, respectively, were collected in the Upper Cibolo Creek watershed between 1996 and 2018. Water temperature exceeded the TCEQ optimal temperature of 32.2°C only twice during this time. Air temperature varied between 0 and 37°C.

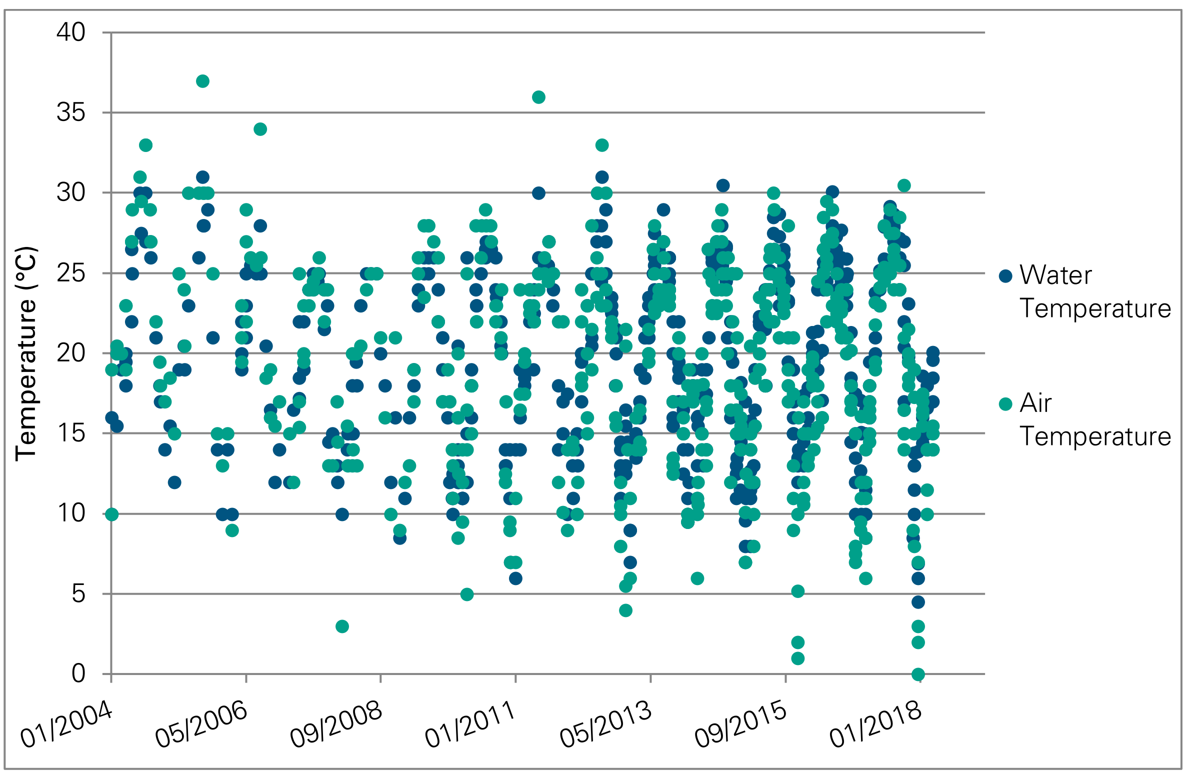

Figure 7: Air and water temperature over time at all sites within the Upper Cibolo Creek Watershed

Total Dissolved Solids

Citizen scientists collected 619 TDS samples within the watershed. The average TDS measurement for all sites was 386 mg/L. There was a significant increase in TDS concentrations over time detected in this watershed (P-Value = 0.015). However, the low R^2 value of 0.0338 indicates that this relationship only accounts for about 3.4% of the variation in the data.

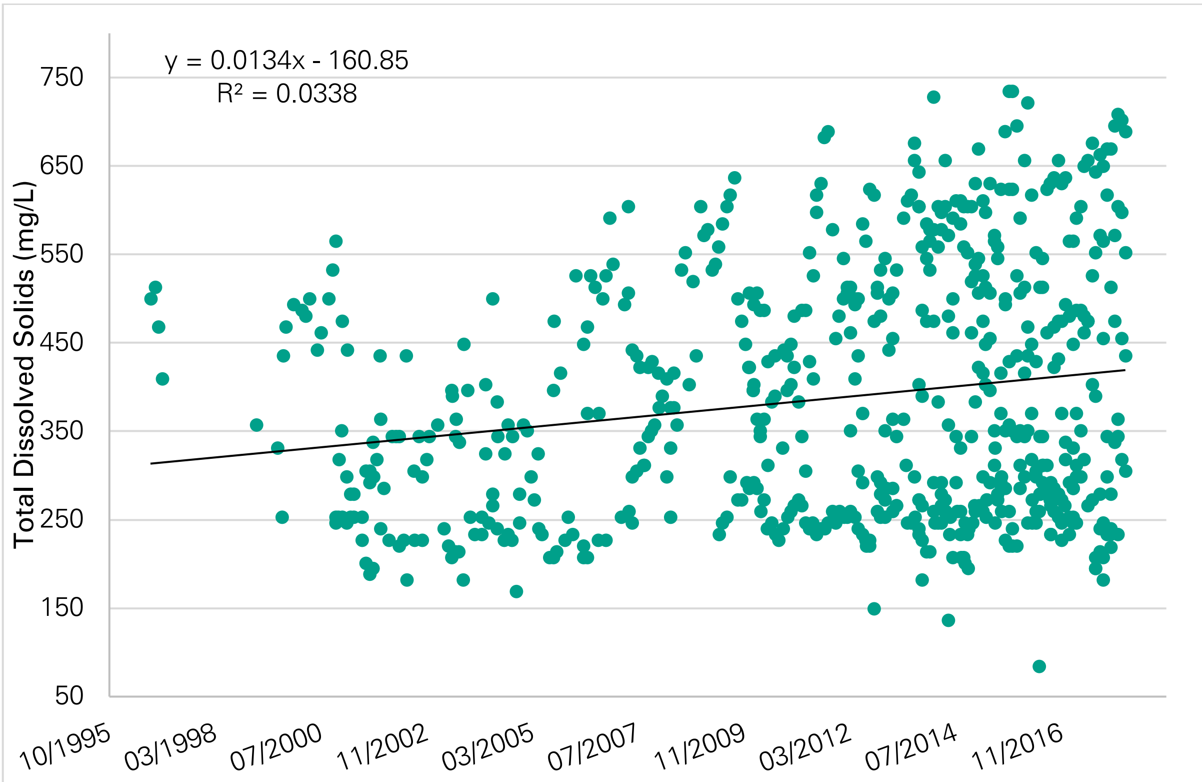

Figure 8: Total dissolved solids over time at all sites within the Upper Cibolo Creek Watershed

Dissolved Oxygen

Citizen scientists collected a total of 616 DO samples in the Upper Cibolo Creek Watershed. The DO measurements were completed for 96% of all monitoring sites. The mean DO was 6.8 mg/L and it ranged from a low of 1.0 mg/L in May of 2011, to a high of 13.7 mg/L in June of 2003. There was a significant decrease in DO concentrations over time detected in this watershed (P-Value = <0.0001). The R^2 value of 0.1291 indicates that this relationship accounts for about 13% of the variation in the data. Plants and algae add a substantial amount of DO via photosynthesis, resulting in the diurnal trends of high DO levels observed during the daylight hours, peaking in the late afternoon, and decreasing after dark. This pattern is shown in Table 9.

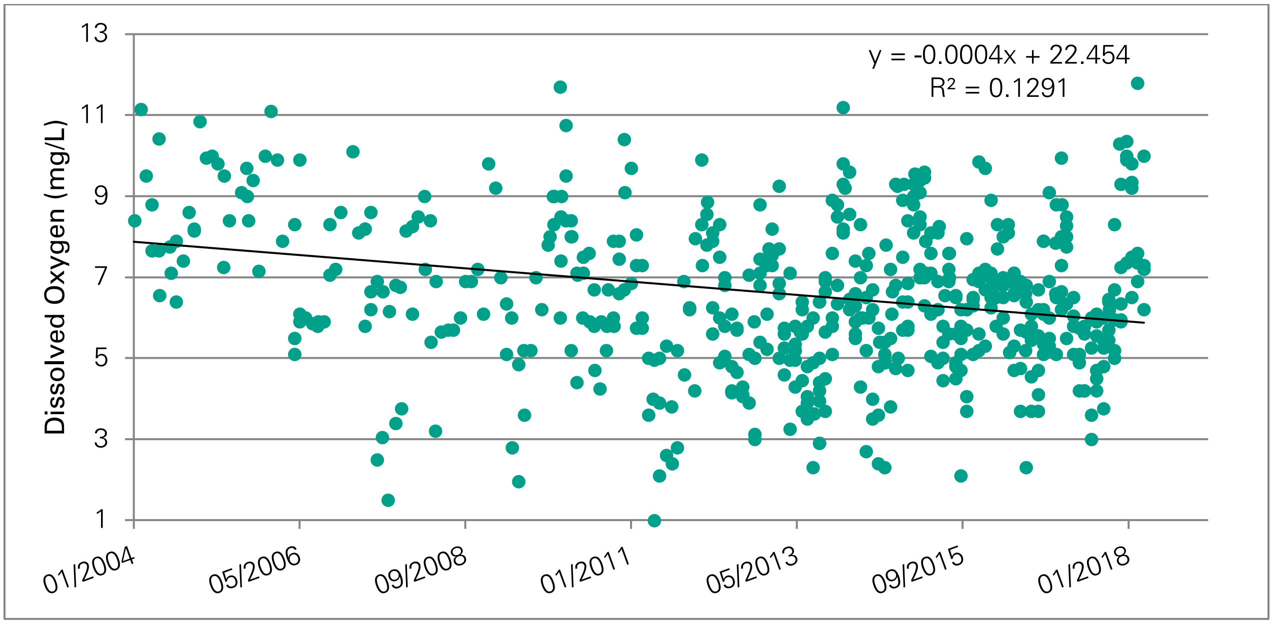

Figure 9: Dissolved oxygen and water temperature over time at all sites in the Upper Cibolo Creek Watershed

pH

The pH was measured for 93.1% of all sampling events in the watershed. The mean pH was 7.8 and it ranged from 6.9 to 8.8 for all sites. There was a significant decrease in pH over time observed in the watershed (p = < 0.0001). The low R^2 value of 0.0841 indicates that this relationship explains only about 8.4% of the variation in the data.

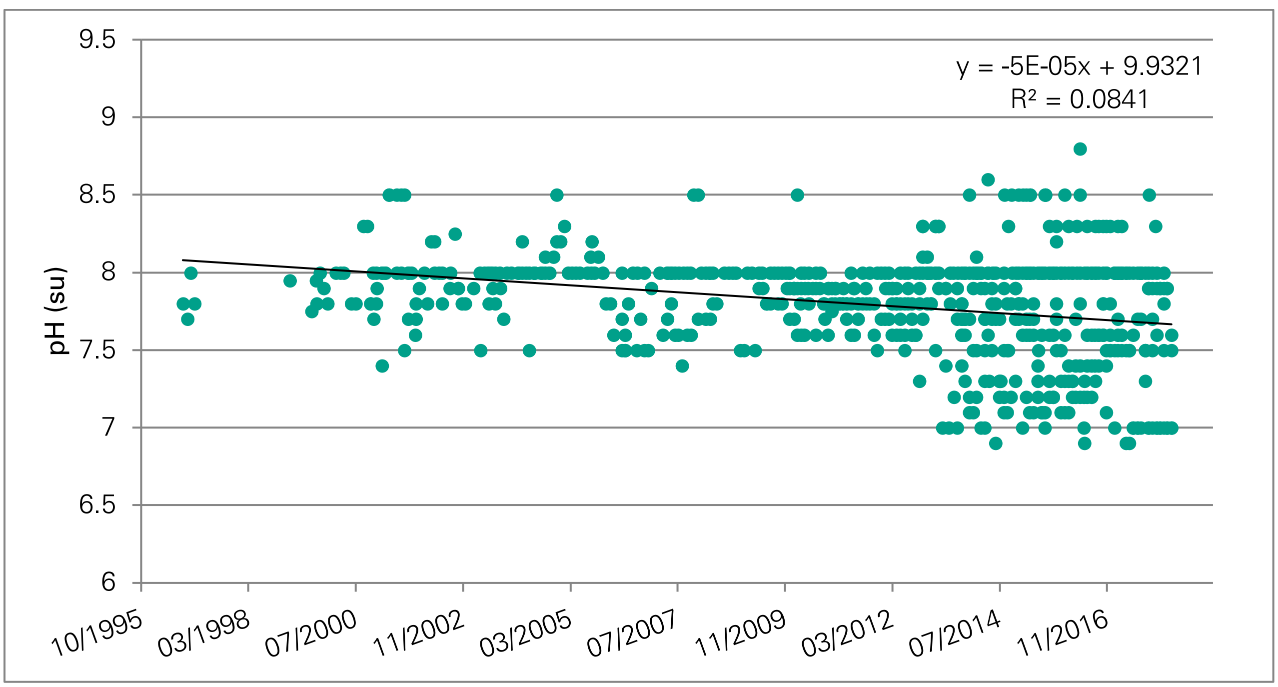

Figure 10: pH over time at all sites within the Upper Cibolo Creek Watershed

Turbidity

The turbidity was measured for 29% of all sampling events in the watershed. The mean turbidity was 4 and it ranged from 0 to 70 for all sites. There was a significant decrease in turbidity over time observed in the watershed (P-Value = < 0.0001). The R^2 value of 0.027 indicates that this relationship explains only about 2.7% of the variation in the data.

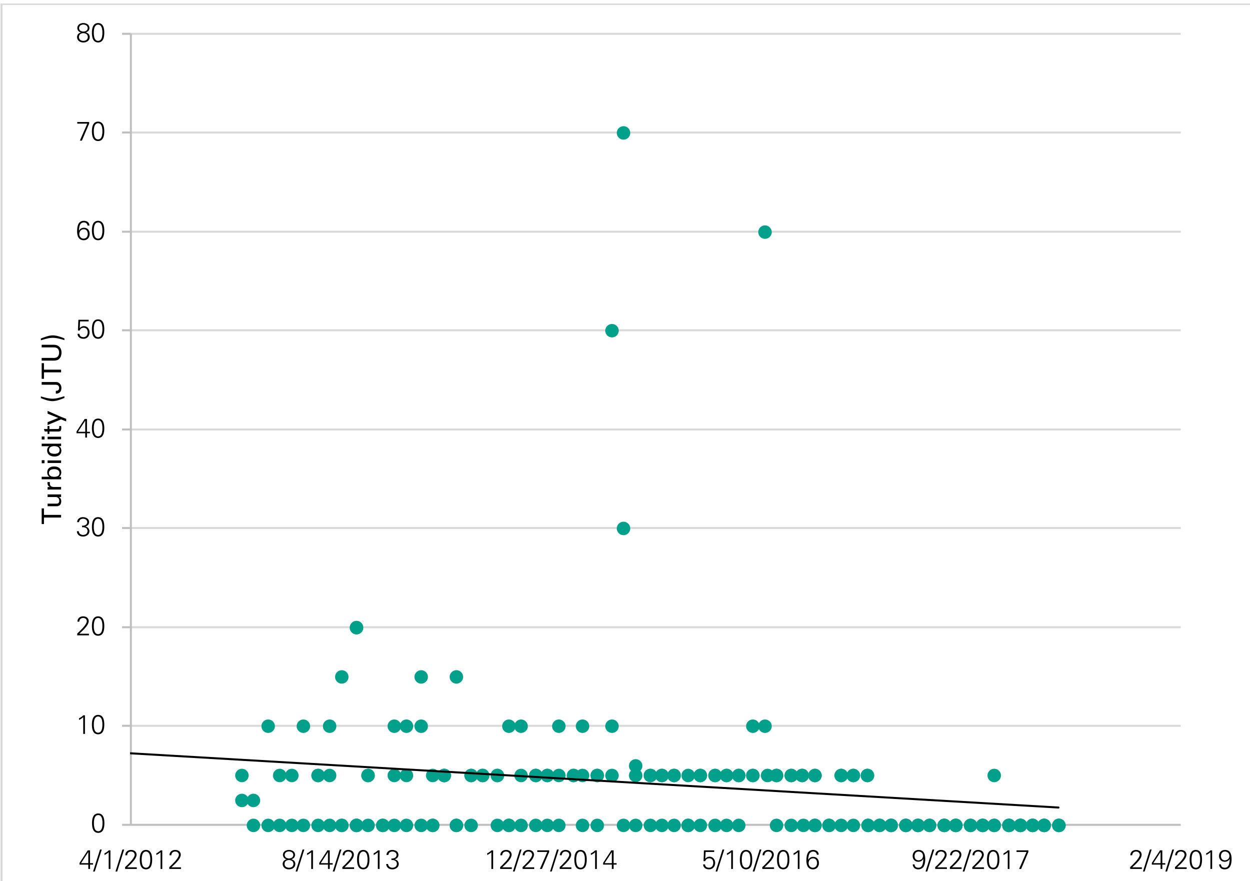

Figure 11: Turbidity over time at all sites within the Upper Cibolo Creek Watershed

E. coli Bacteria

E. coli samples were taken at all of the selected sites in the Upper Cibolo Creek Watershed. A total of 97 *E. coli* samples were taken. The geomean for *E. coli* was 68 CFU/100 mL. The *E. coli* counts ranged from 0 CFU/100 mL to a high of 3540 CFU/100 mL in June of 2015. There was no significant trend in *E. coli* over time detected (P-Value = 0.886). The R^2 value of 0.0195 indicates that this relationship explains only about 1.9% of the variation in the data.

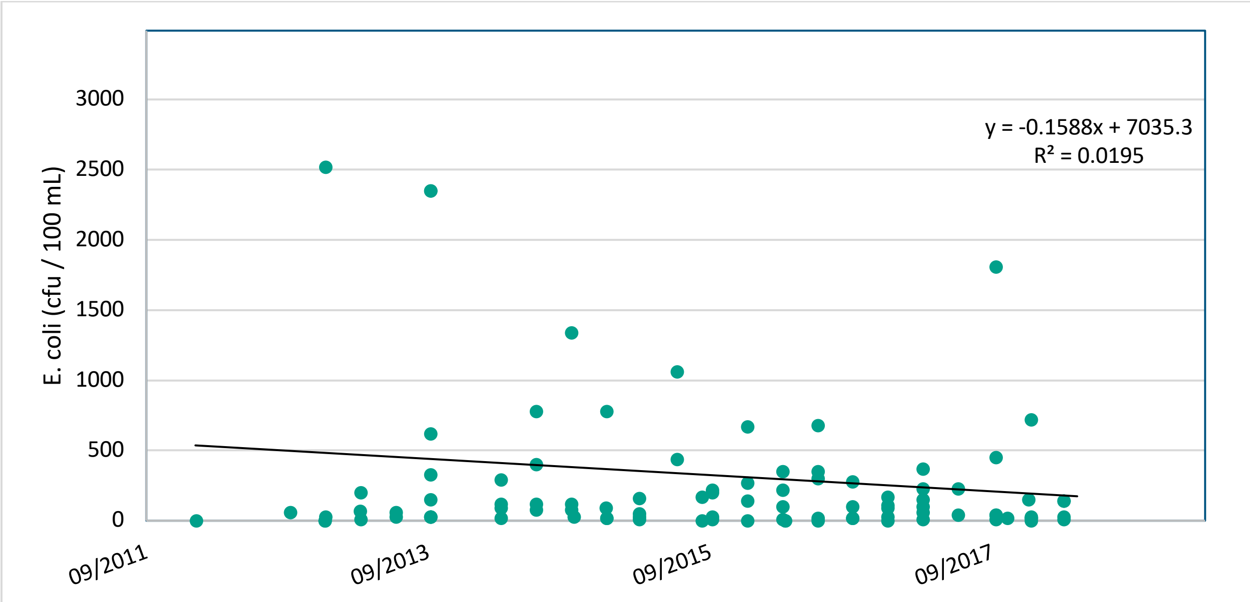

Figure 12: *E. coli* over time at all sites within the Upper Cibolo Creek Watershed

Nitrate-Nitrogen

Nitrate-Nitrogen concentrations were taken at all of the selected sites in the Upper Cibolo Creek Watershed. A total of 192 nitrate-nitrogen samples were taken. The mean nitrate-nitrogen concentration in the watershed was 7.3 mg/L and nitrate-nitrogen ranged from 0.0 mg/L to a high of 15.0mg/L. There was a significant increase in nitrate-nitrogen over time observed in this watershed (P-Value = < 0.0001). The R^2 value of 0.0003 indicates that this relationship explains about 0.03% of the variation in the data.

Figure 13: Nitrate-Nitrogen over time at all sites within the Upper Cibolo Creek Watershed

Orthophosphate

Orthophosphate samples were taken at all of the selected sites in the Upper Cibolo Creek Watershed. A total of 192 orthophosphate samples were taken. The mean concentration for orthophosphate in the watershed was 4.3 mg/L. Orthophosphate concentrations ranged from 0 mg/L to a high of 28.0 mg/L in December of 2015. There was a significant increase in orthophosphate concentrations over time observed in the watershed ($p = 0.834$). The R^2 value of 0.0002 indicates that this relationship explains about 0.02 % of the variation in the data.

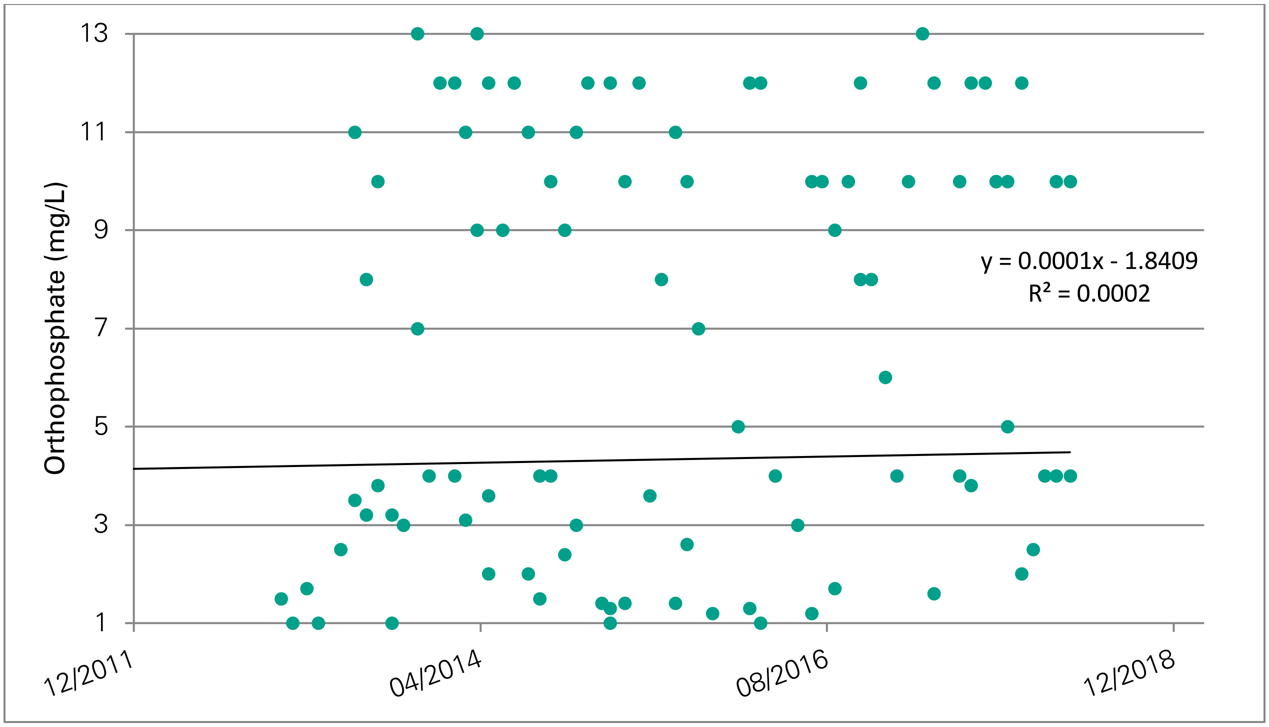

Figure 14: Orthophosphate over time at all sites within the Upper Cibolo Creek Watershed

UPPER CIBOLO CREEK UPSTREAM TO DOWNSTREAM TRENDS

The following sites were included in the upstream to downstream trend analysis:

80187 – Cibolo Creek @ The Upper Cibolo Creek Road Fifth Crossing

80904 – Cibolo Creek Upstream of Boerne Lake

20823 – Upper Cibolo Creek @ River Road Park

15126 - Cibolo @ Menger Creek

Total Dissolved Solids

There was a significant increase in TDS concentrations as one moves downstream in the watershed (P-Value = 0.940). The R^2 value of 0.4952 indicates that this relationship explains about 50% of the variability in the data.

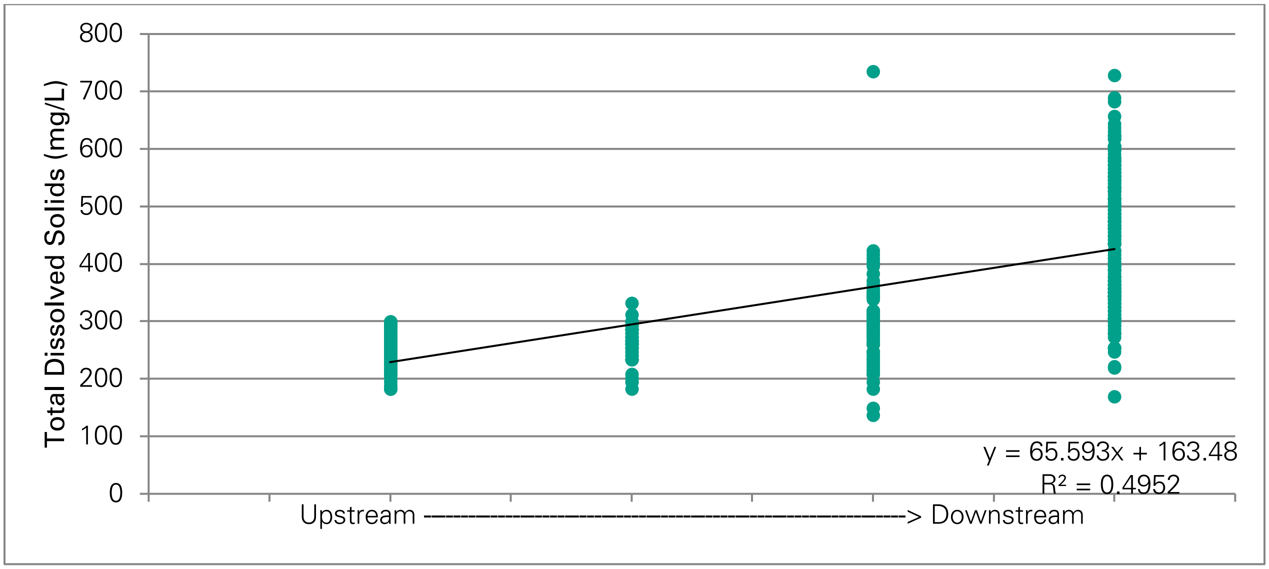

Figure 15: Upstream vs. downstream trends in total dissolved solids in the Upper Cibolo Creek Watershed

Dissolved Oxygen

There was no significant relationship in DO concentrations as one moves downstream in the watershed (P-Value = < 0.0001). The R^2 value of 0.0244 indicates that this relationship explains about 2.4% of the variability in the data.

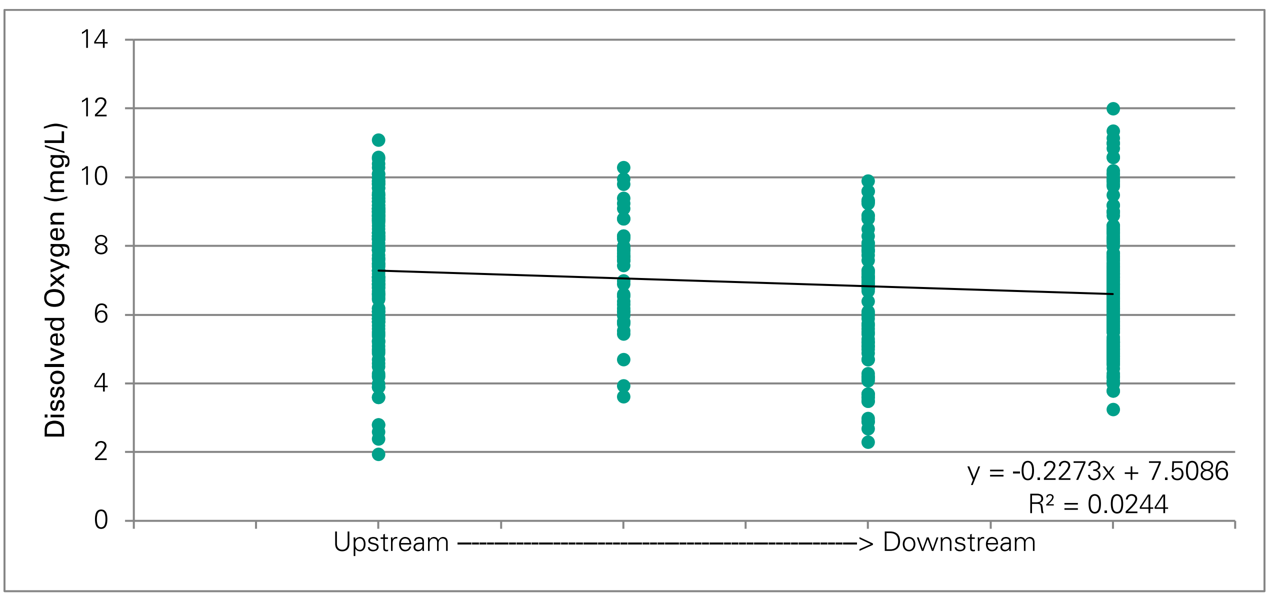

Figure 16: Upstream vs. downstream trends in dissolved oxygen in the Upper Cibolo Creek Watershed

pH

There was a significant decrease in pH observed as one moves downstream in the watershed (P-Value = 0.006). The R^2 value of 0.0223 indicates that this relationship explains about 2.2% of the data.

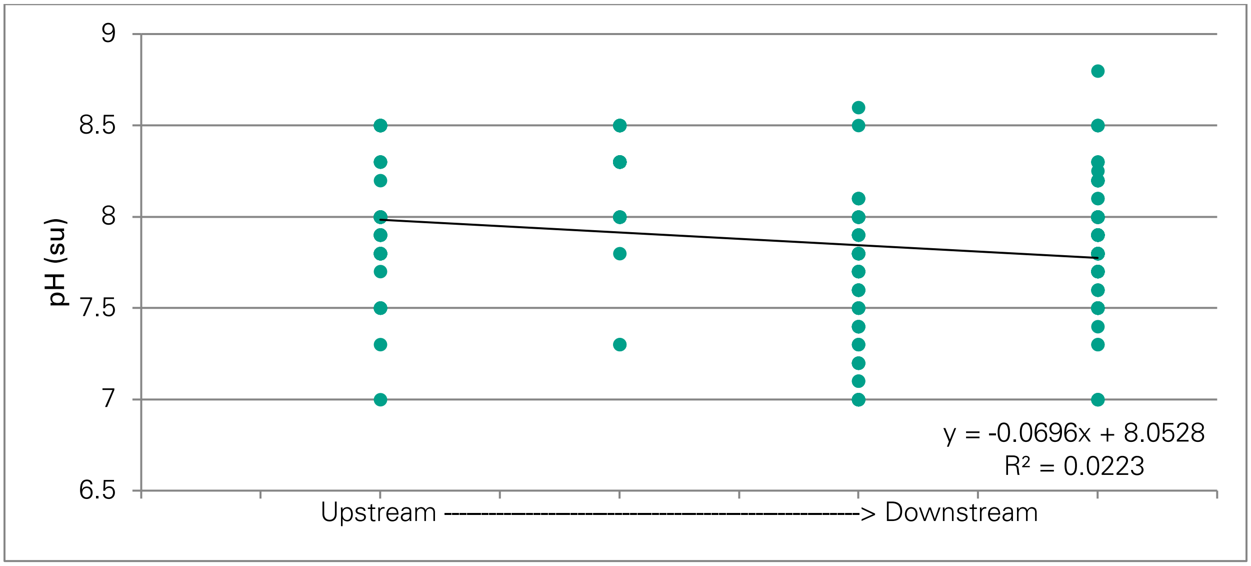

Figure 17: Upstream vs. downstream trends in pH in the Upper Cibolo Creek Watershed

E. coli

There was a significant increase in *E. coli* observed as one moves downstream in the watershed (P-Value = 0.162). The R^2 value of 0.0395 indicates that this relationship explains about 4% of the data.

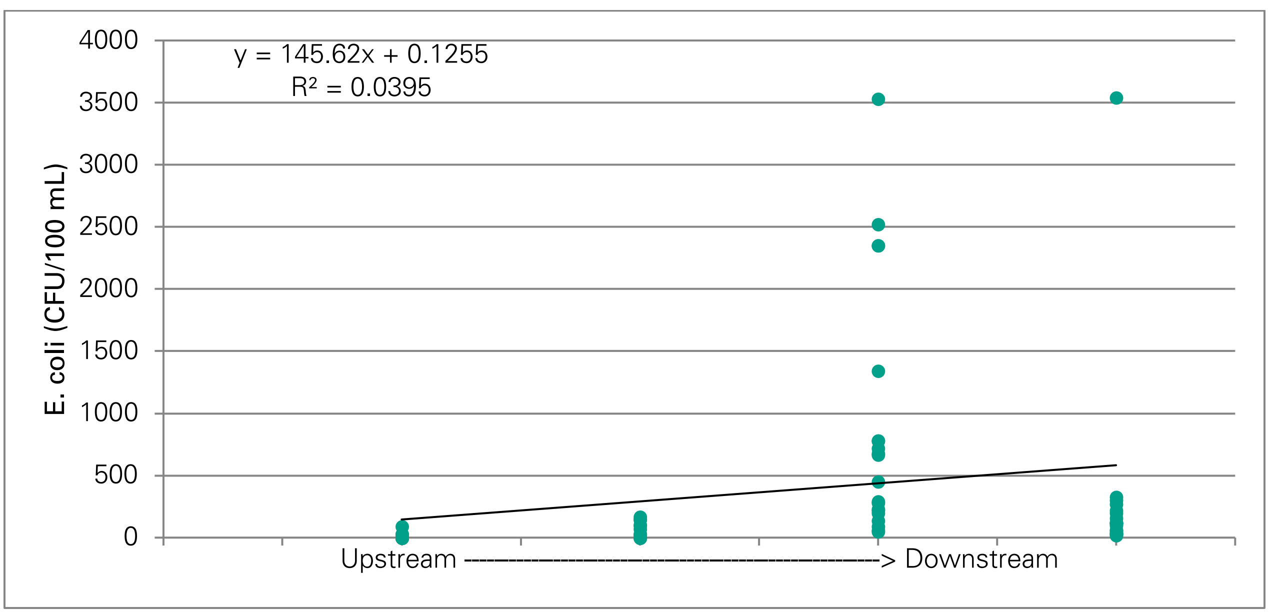

Figure 18: Upstream vs. downstream trends in *E. coli* in the Upper Cibolo Creek Watershed

Nitrate-Nitrogen

There was a significant increase in nitrate-nitrogen observed as one moves downstream in the watershed (P-Value = 0.750). The R^2 value of 0.3943 indicates that this relationship explains about 39.4% of the data.

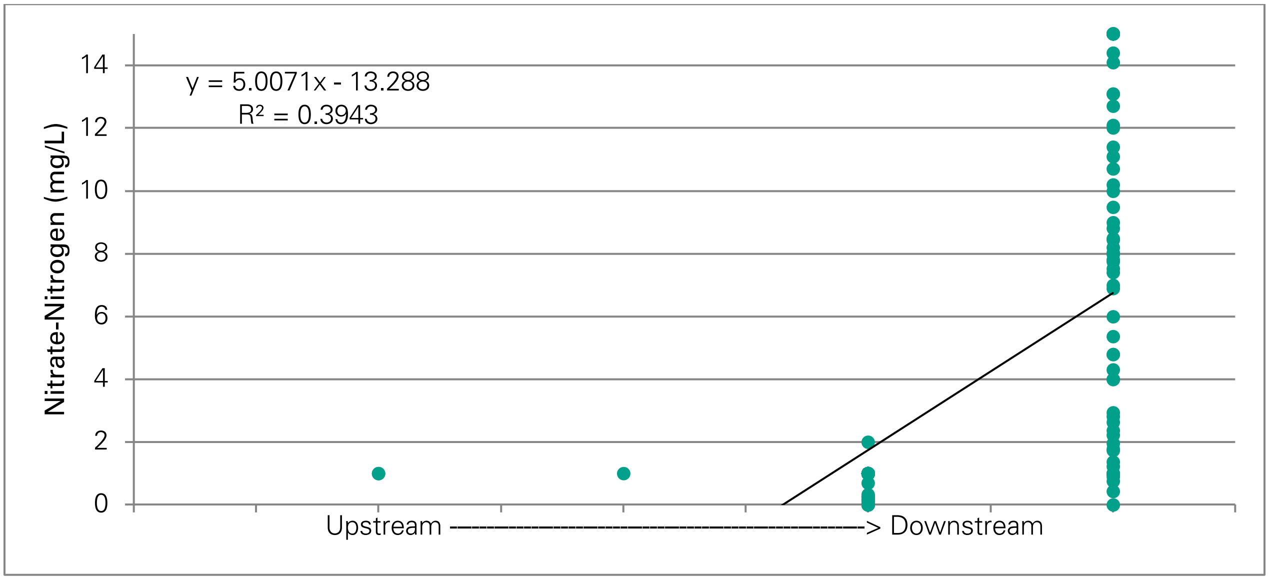

Figure 19: Upstream vs. downstream trends in nitrate-nitrogen in the Upper Cibolo Creek Watershed

Orthophosphate

There was a significant increase in orthophosphate observed as one moves downstream in the watershed (P-Value = 0.784). The R^2 value of 0.247 indicates that this relationship explains about 24.7% of the data.

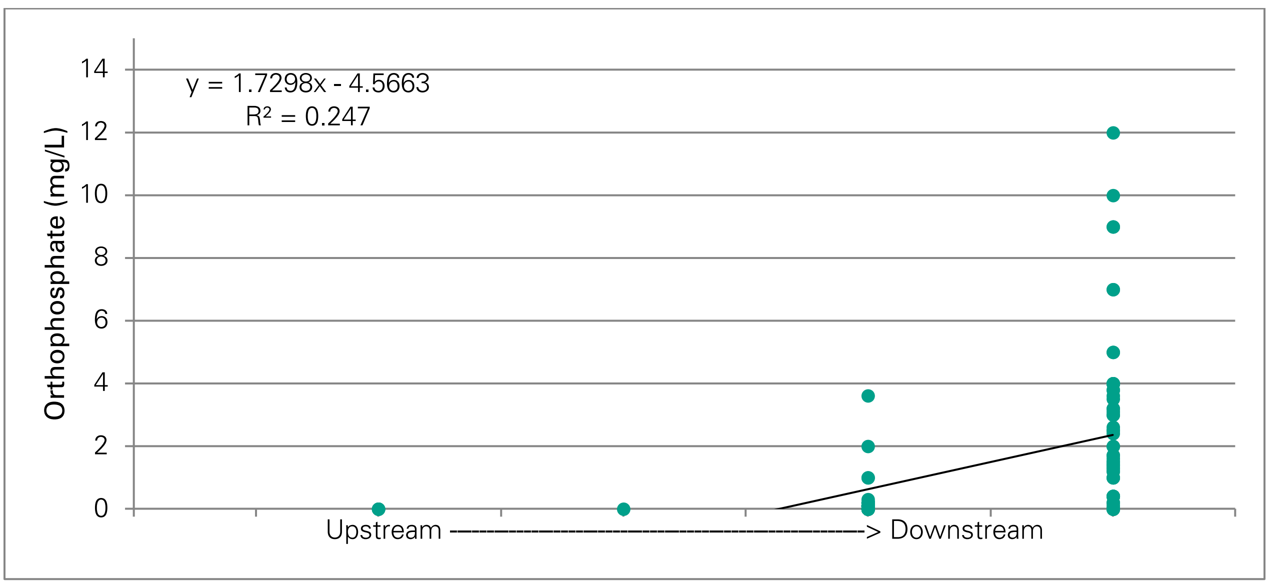

Figure 20: Upstream vs. downstream trends in orthophosphate in the Upper Cibolo Creek Watershed

UPPER CIBOLO CREEK WATERSHED SITE BY SITE ANALYSIS

The following sections will provide a brief summarization of analysis by site. The average minimum and maximum values are reported in order to provide a quick overview of the watershed. The TDS, DO, and pH values are presented as an average, plus or minus the standard deviation from the average. The *E. coli* is presented as a geomean. Please see Table 5, on the following page, for a quick overview of the average results.

As previously mentioned in the 'Water Quality Parameters' section, TDS is an important indicator of turbidity and specific conductivity. The higher the TDS measurement, the more conductive the water is. A high TDS result can indicate increased nutrients present in the water. Site 80966 had the highest overall average for TDS, with a result of 613 ± 89 mg/L. Site 80187 had the lowest average TDS, with a result of 246 ± 24 mg/L.

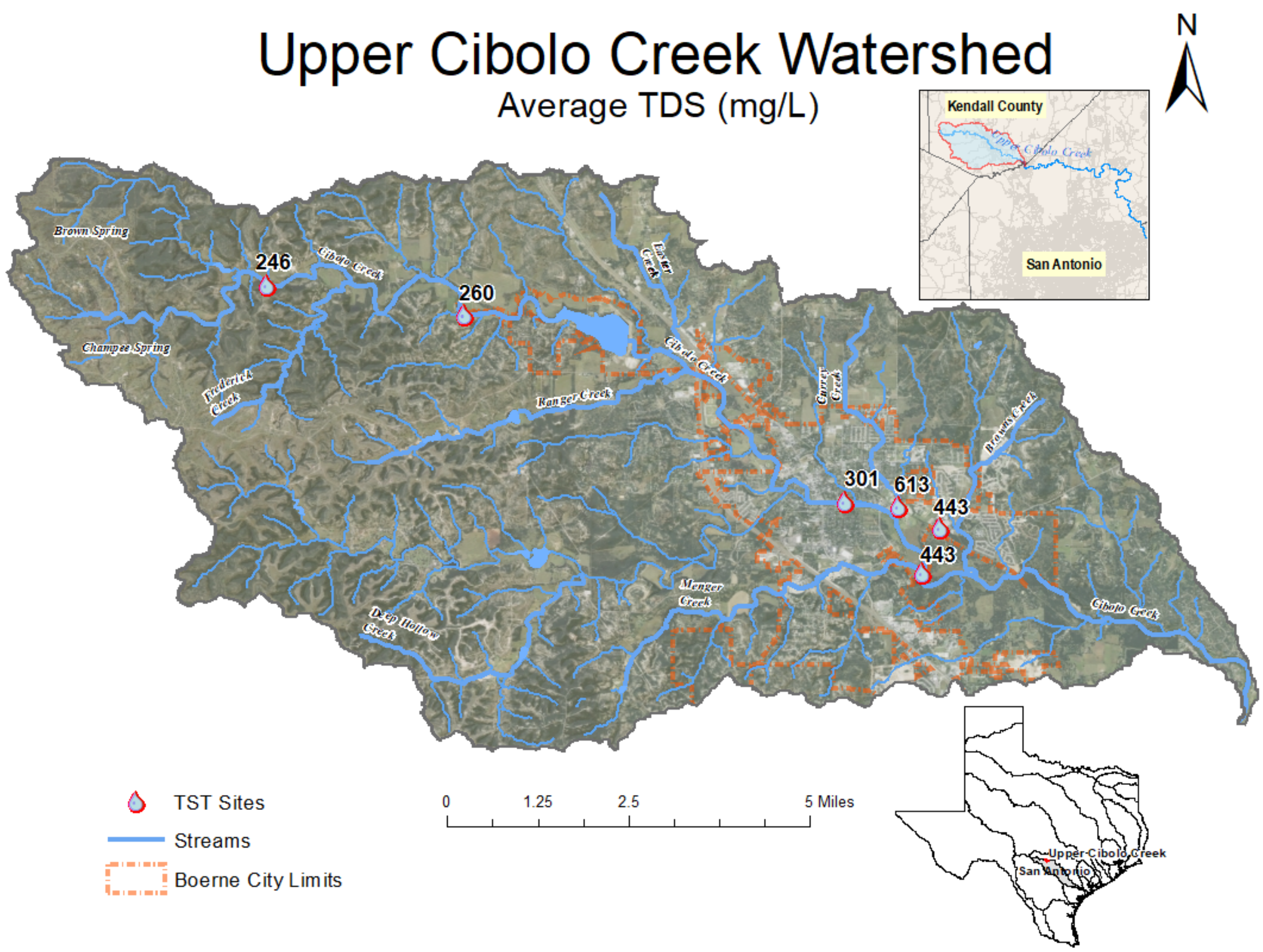

Figure 21: Map of the average total dissolved solids for sites in the Upper Cibolo Creek Watershed

The DO measurement can help to understand the overall health of the aquatic community. If there is a large influx of nutrients into the water body then there will be an increase in surface vegetation growth, which can then reduce photosynthesis in the subsurface, thus decreasing the level of DO. Low DO can be dangerous for aquatic inhabitants, which rely upon the DO to breathe. The DO levels can also be impacted by temperature; a high temperature can limit the amount of oxygen solubility, which can also lead to a low DO measurement. Site 20823 had the lowest average DO reading, with a result of 6.3 ± 2.0 mg/L. Site 80187 had the highest average DO reading, with a result of 7.3 ± 2.0 mg/L.

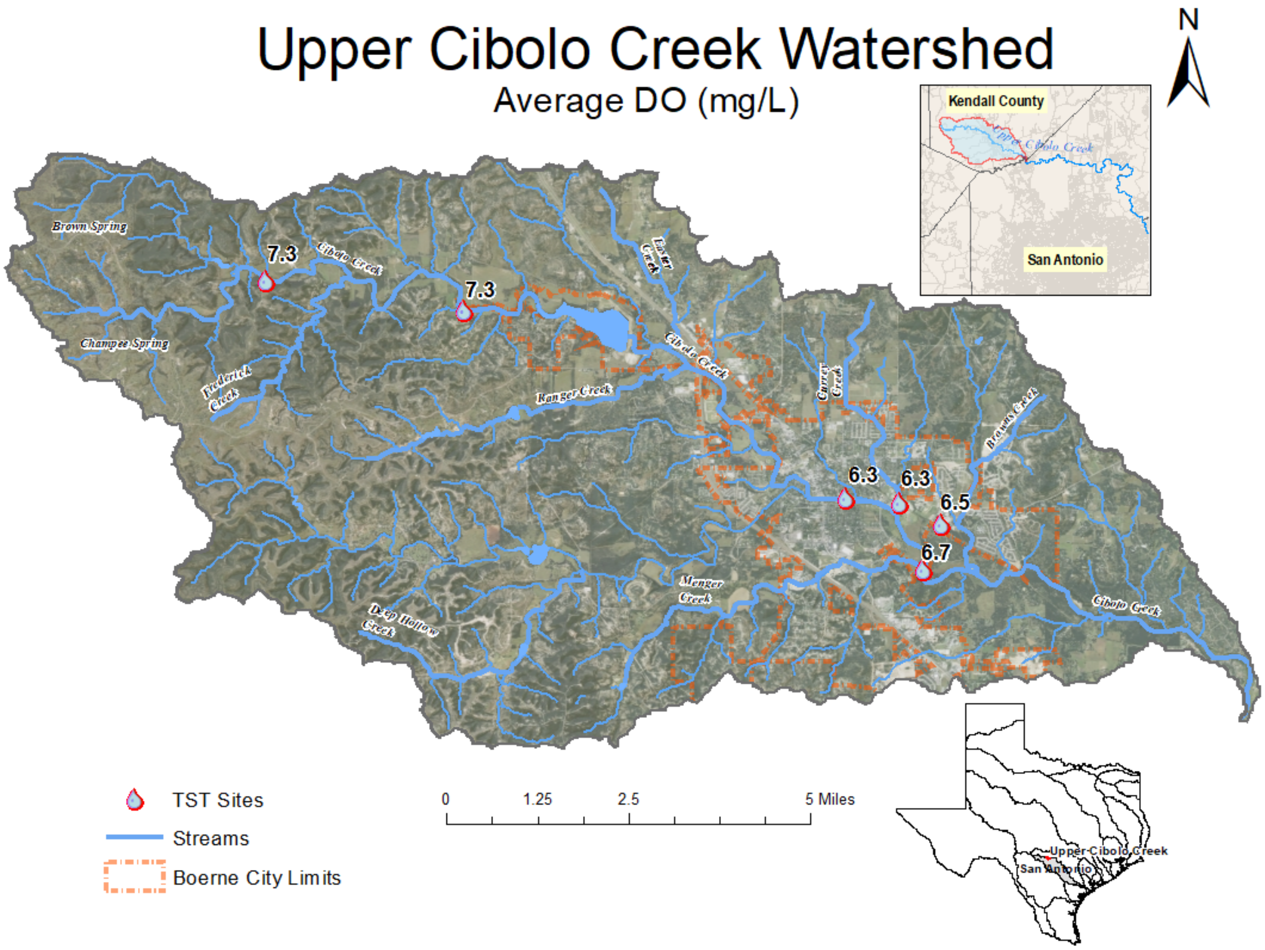

Figure 22: Map of the average dissolved oxygen concentration for sites in the Upper Cibolo Creek Watershed

The pH levels are an important indicator for the overall health of the watershed as well. Aquatic inhabitants typically require a pH range between 6.5 and 9 for the most optimum environment. Anything below 6.5 or above 9 can negatively impact reproduction or can result in fish kills. There were no reported pH levels outside of this widely accepted range. Site 80904 had the highest average pH level, with a result of 8.2 ± 0.3. Site 80966 had the lowest average pH level, with a result of 7.3 ± 0.3.

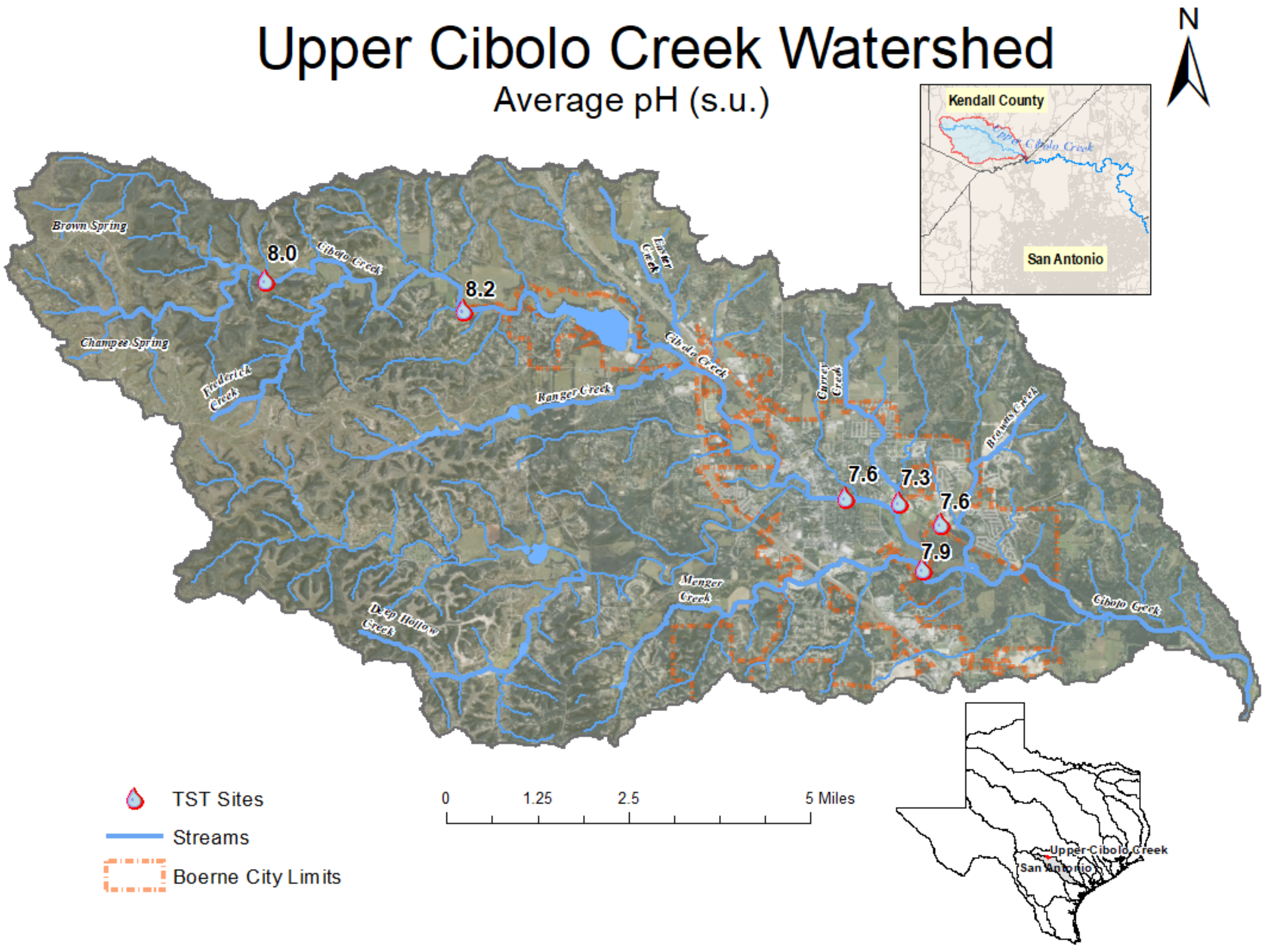

Figure 23: Map of the average pH for sites in the Upper Cibolo Creek Watershed

E. coli can be used as an indicator of the degree of pathogens in a water body. Its presence above the TCEQ surface water quality standard for a single sample (394 CFU/100 mL) or geometric mean (126 CFU/100 mL) indicates a possible human health risk for primary contact recreation. There were a few sampling events at Sites 80966, 80186, and 15126 with elevated *E. coli* levels reported above the standard for a single sample and the geometric mean at Site 20823 was above 126 CFU/100 mL. Site 20823 had an *E. coli* geomean of 460 ± 978 CFU/100 mL.

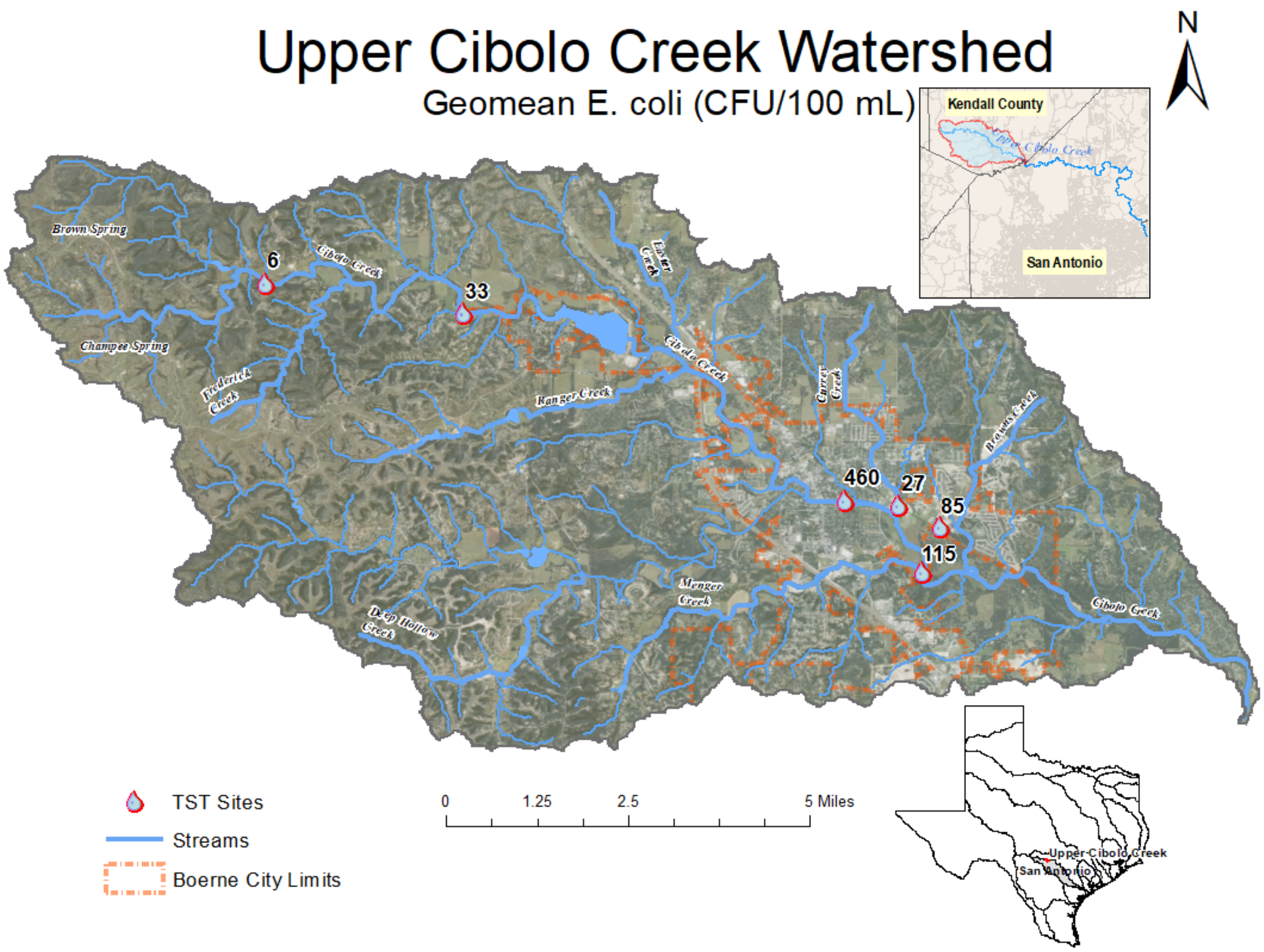

Figure 24: Map of the *E. coli* geomean for sites in the Upper Cibolo Creek Watershed

Nitrates are essential plant nutrients, but in excess amount they can cause significant water quality problems. Excess nitrates can cause hypoxia (low DO) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors. Site 80186 had the minimum average nitrate-nitrogen concentration with 0.55 mg/L. Site 80966 had the highest average nitrate-nitrogen concentration with 14.77 mg/L.

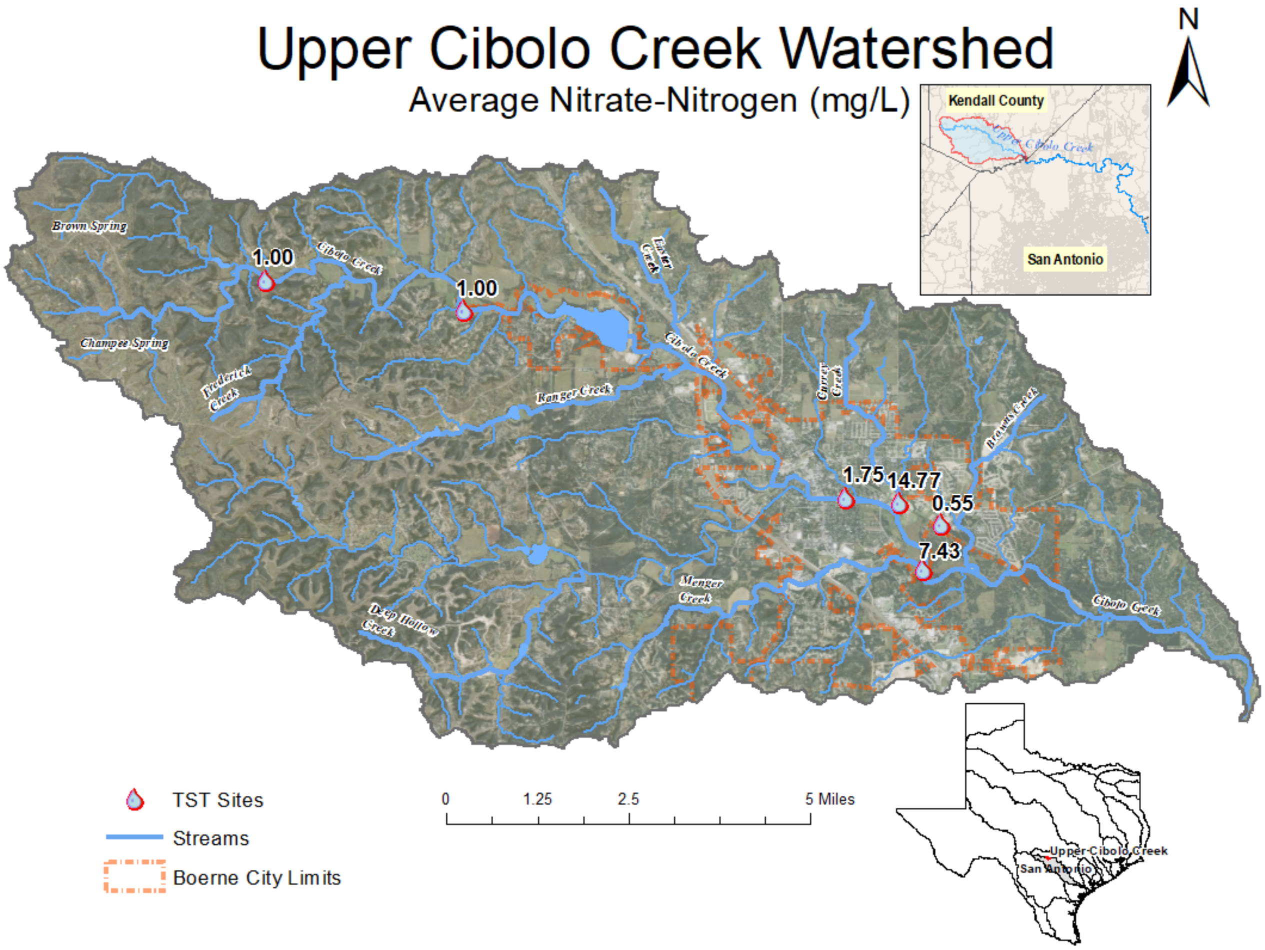

Figure 25: Map of the average nitrate-nitrogen for sites in the Upper Cibolo Creek Watershed

Dense algal blooms or rapid plant growth can occur in waters rich in phosphorus, a limiting nutrient for eutrophication since it is typically in shortest supply. Sources are human and animal wastes and fertilizers. The EPA water quality criteria state that orthophosphates should not exceed 0.10 mg/L in streams or flowing waters not discharging into lakes or reservoirs to control algal growth. There were several sampling events, at Sites 20823, 80966, and 15126 with orthophosphate concentrations reported above 0.10 mg/L. Other sites, including 80187 and 80904, did not indicate is a presence of orthophosphate concentrations within their samples. Sites 80966 and 15126 had average orthophosphate concentrations of 10.84 ± 4.43 mg/L and 2.66 ± 2.61 mg/L, respectively.

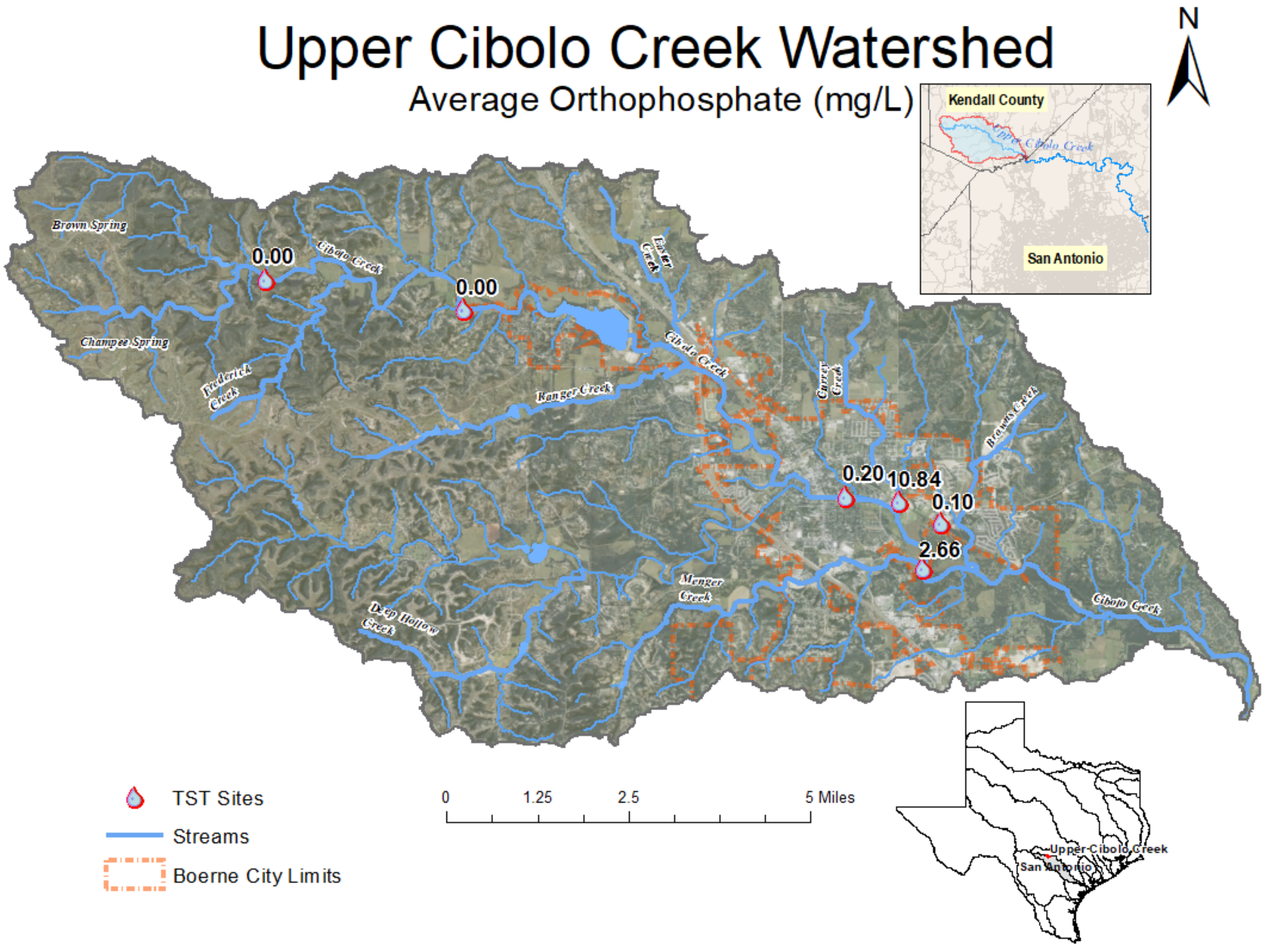

Figure 26: Map of the average orthophosphate for sites in the Upper Cibolo Creek Watershed

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, discharges, and other sources. Turbidity often increases sharply during rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of stormwater runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of streambanks and channels. Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in developing watersheds. However, turbidity is closely related to stream flow and velocity and should be correlated with these factors. Sites 20823, 80966, and 15126 were measured extensively for chemical turbidity. The two lowest average turbidity measurements occurred at Sites 80186 and 15126 at 0 ± 0 JTU and 1.82 ± 9.19 JTU. The highest average turbidity measurement occurred at Site 20823 at 6.21 ± 7.66 JTU.

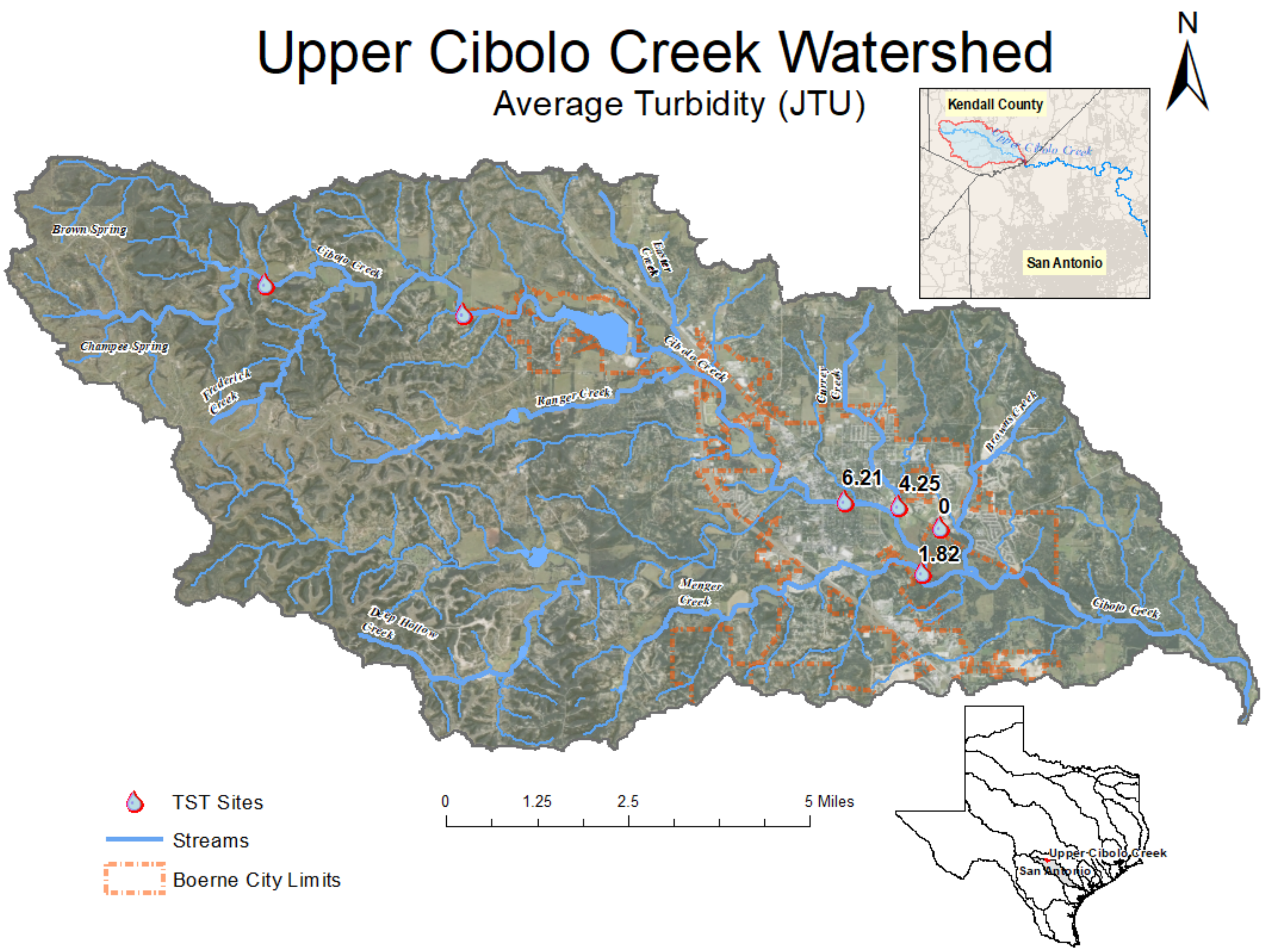

Figure 27: Map of the average turbidity for sites in the Upper Cibolo Creek Watershed

Please see Table 6 below for a summary of average results at all sites. It is important to note that there was variation in the number of times each site was tested, the time of day at which each site was tested, and the time of month the sampling occurred. While this is a quick overview of the results, it is important to keep in mind that there is natural diurnal and seasonal variation in these water quality parameters. TST citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards.

Table 6: Average values for all Upper Cibolo Creek Watershed sites

Site Number	TDS (mg/L)	DO (mg/L)	pH (su)	Turbidity (JTU)	*E.coli* (CFU/100 mL) *geomean	Nitrate-Nitrogen (mg/L)	Orthophosphate (mg/L)
80187	246 ± 24	7.3 ± 2.0	8.0 ± 0.2	N/A	6 ± 25	1 ± 0	0 ± 0
80904	260 ± 32	7.3 ± 1.5	8.2 ± 0.3 (max)	N/A	33 ± 60	1 ± 0	0 ± 0
20823	301 ± 79	6.3 ± 2.0	7.6 ± 0.4	6.21 ± 7.66	460 ± 978	0.75 ± 0.43	0.20 ± 0.51
80966	613 ± 89	6.3 ± 0.7	7.3 ± 0.3 (min)	4.25 ± 7.95	27 ± 237	15.0 ± 2.0	11.0 ± 4.0
80186	443 ± 76	6.5 ± 2.6	7.6 ± 0.2	0 ± 0	85 ± 414	0.55 ± 0.28	0.10 ± 0.10
15126	443 ± 111	6.7 ± 1.7	7.9 ± 0.3	1.82 ± 9.19	115 ± 767	7.43 ± 4.92	2.66 ± 2.61

Site 80187– Upper Cibolo Creek @ the Upper Cibolo Creek Road Fifth Crossing

Site Description

This site is located in the upper reaches of Upper Cibolo Creek at the fifth crossing of Upper Cibolo Creek Road. The land in this area consists of some cleared farmland and the banks of the river have a mix of live oak and juniper trees.

Sampling Information

This site was sampled 144 times between 10/27/2000 and 2/15/2018. The time of sampling for this site ranged from 08:05 to 20:08.

Table 7: Descriptive parameters for Site 80187

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	141	246 ± 24	182	299
Water Temperature (°C)	143	20.2 ± 6.1	6.0	31.0
Dissolved Oxygen (mg/L)	137	7.3 ± 2.0	2.0	11.1
pH (su)	141	8.0 ± 0.2	7.0	8.5

Parameter (cont.)	Number of Samples (cont.)	Mean ± Standard Deviation (cont.)	Min (cont.)	Max (cont.)
E. coli (CFU/100ml)	11	6 ± 25	1	90
Nitrate-Nitrogen (mg/L)	2	1 ± 0	1	1
Orthophosphate (mg/L)	3	0 ± 0	0	0

Site was sampled 144 times between 10/27/2000 and 2/15/2018.

Air and Water Temperature

Air temperatures were taken 142 times with water temperatures taken 143 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 36°C in June of 2011, and the lowest temperature of 5°C in March of 2010. The mean water temperature was 20.2°C and the water temperature ranged from a low of 6°C recorded in January of 2011 to a high of 31°C in August of 2001, June of 2003, and July of 2012.

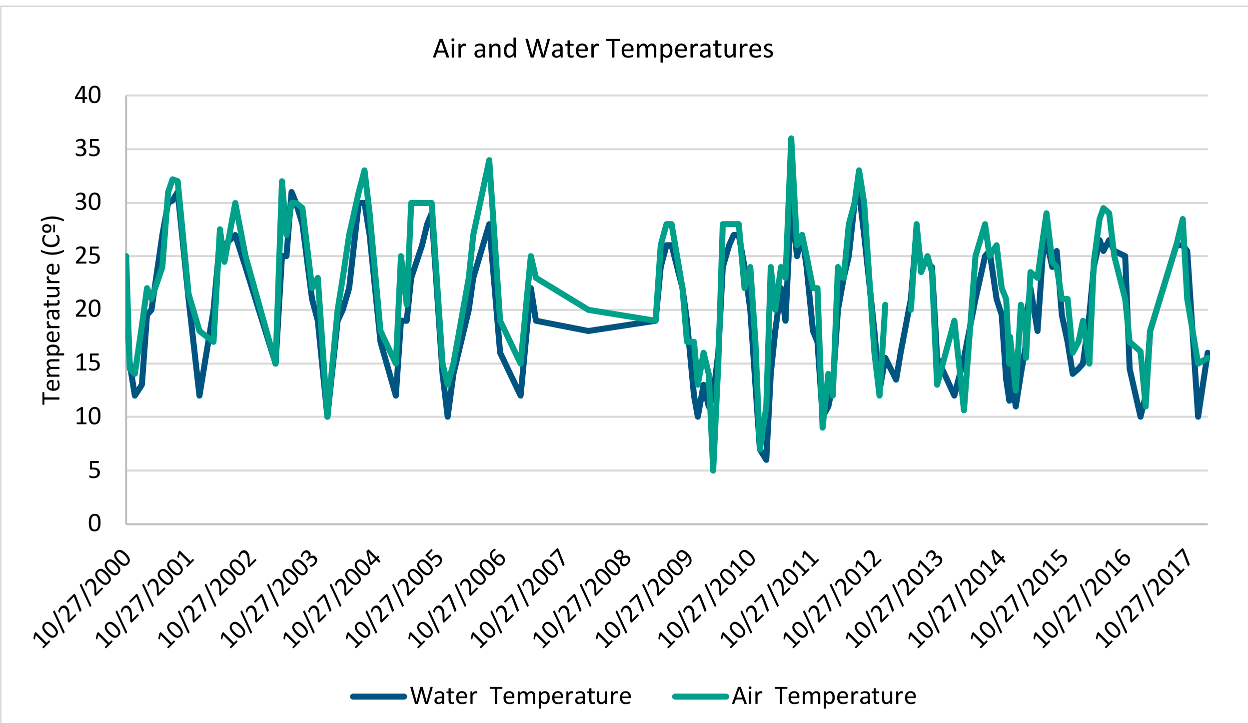

Figure 28: Air and water temperature at Site 80187

Total Dissolved Solids

Citizen scientists sampled TDS at this site 141 times between 10/27/2000 and 2/15/2018. The mean TDS concentration was 246 mg/L. The concentration of TDS ranged from a minimum of 182 mg/L in May of 2002 and August of 2003 to a maximum of 299 mg/L in July of 2009, February of 2005, and January of 2016. There was a significant increase in TDS concentrations over time observed at this site (P-Value = 0.015). The R^2 value of 0.1027 indicated that this relationship explains about 10.3% of the variation in the data.

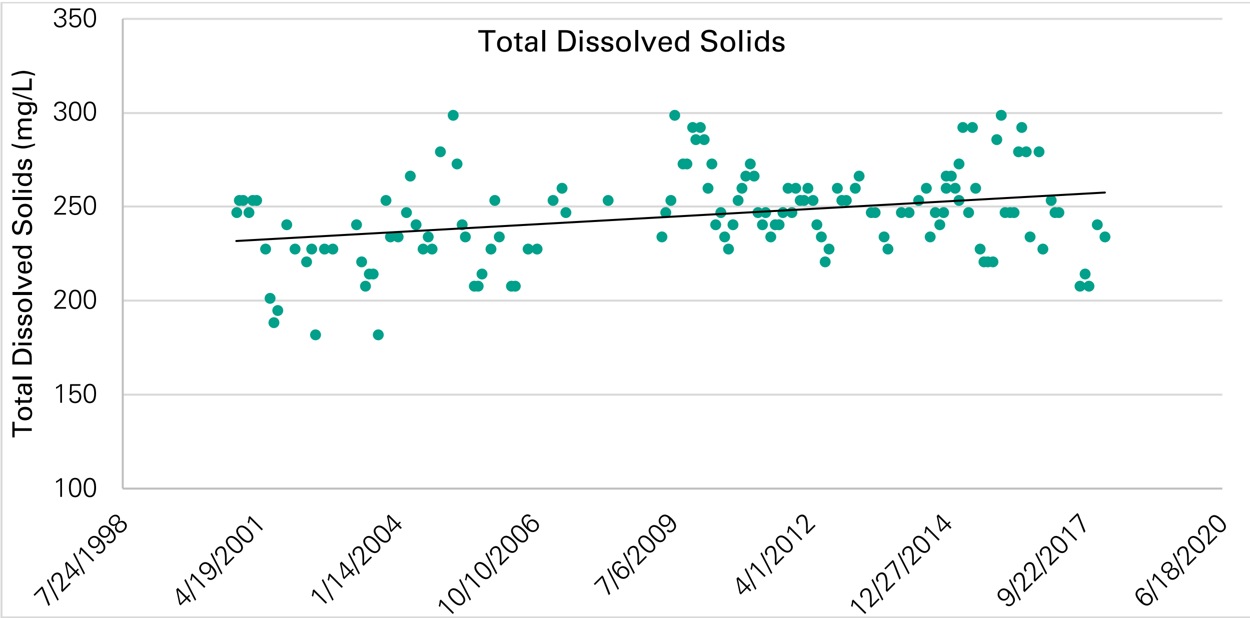

Figure 29: Total dissolved solids at Site 80187

Dissolved Oxygen

Citizen scientists took 137 DO samples at this site between 10/27/2000 and 2/15/2018. The mean DO concentration was 7.3 mg/L. DO concentrations ranged from a low of 2.0 mg/L in June of 2009 to a high of 11.1 mg/L in December of 2005. There was a significant decrease in DO over time observed at this site (P-Value = < 0.0001). The relatively high R^2 value of 0.1735 indicates that this relationship explains about 17.4% of the variation in the data.

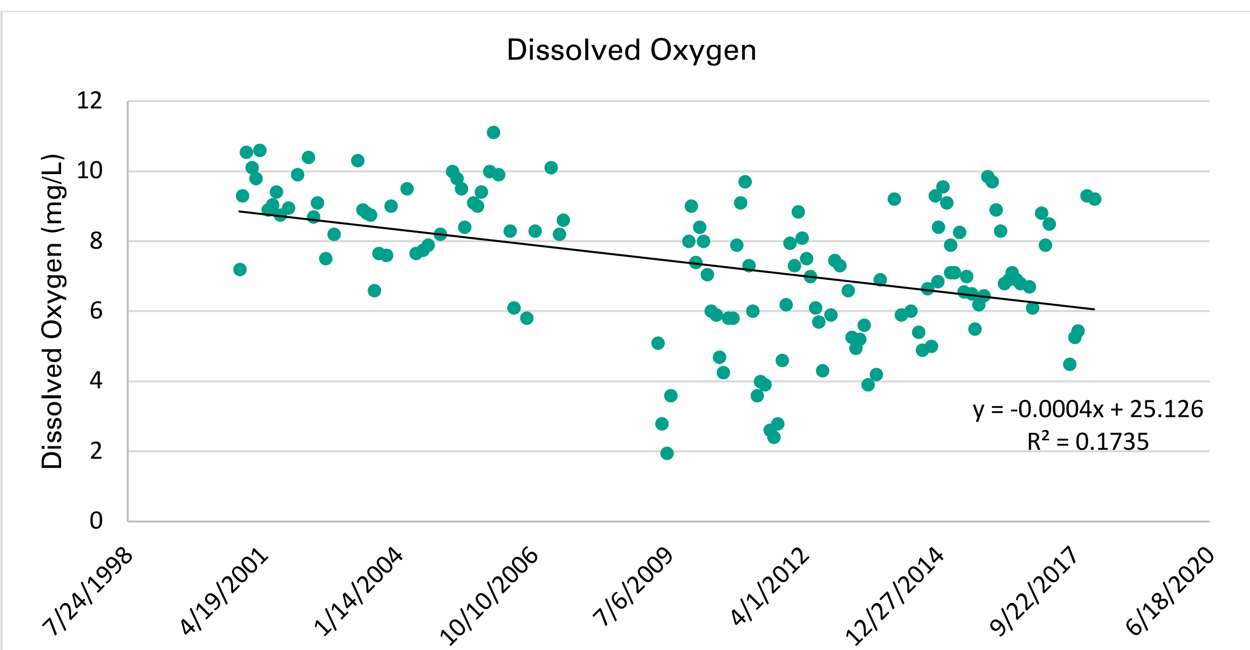

Figure 30: Dissolved oxygen at Site 80187

pH

There were 141 pH measurements taken at this site between 10/27/2000 and 2/15/2018. The mean pH was 8.0 and pH ranged from a low of 7.0 taken in March of 2014 to a high of 8.5 taken on multiple occasions. There was a significant decrease in pH over time observed at this site (P-Value = Less than 0.0001). The R^2 value of 0.0061 indicates this relationship only explains 0.61% of the variation in the data.

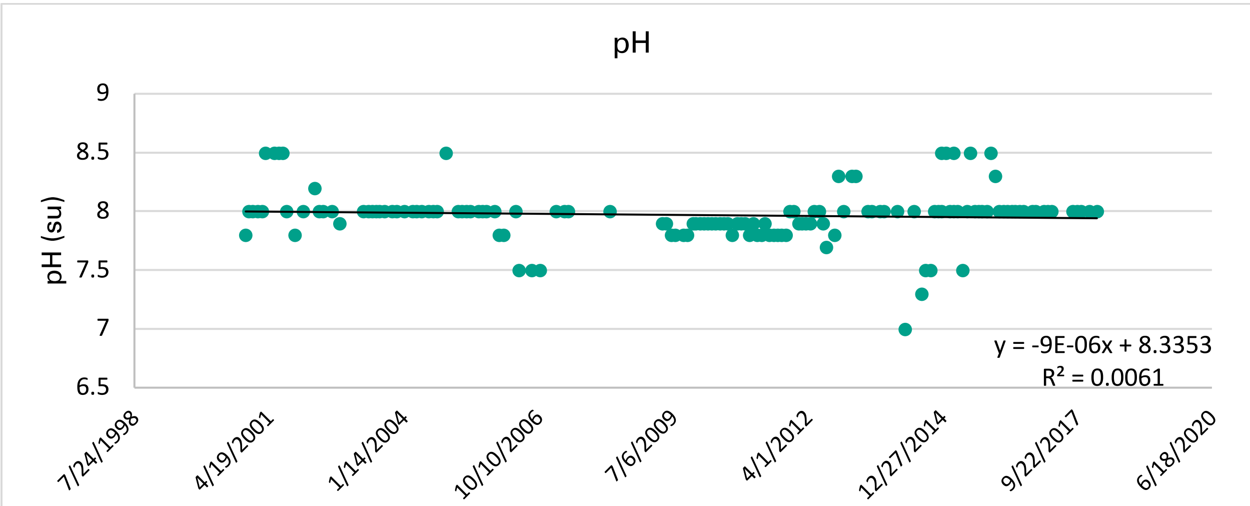

Figure 31: pH at Site 80187

E. coli

There were 11 *E. coli* measurements taken at this site between 10/27/2000 and 2/15/2018. The observed geomean was 6 CFU/100mL and ranged from 1 CFU/100mL taken on multiple occasions to a high of 90 CFU/100mL taken in December of 2014. There was no significant trend in *E. coli* over time detected (P-Value = 0.886). The R^2 value of 0.0059 indicates that this relationship only explains 0.59% of the variation in the data.

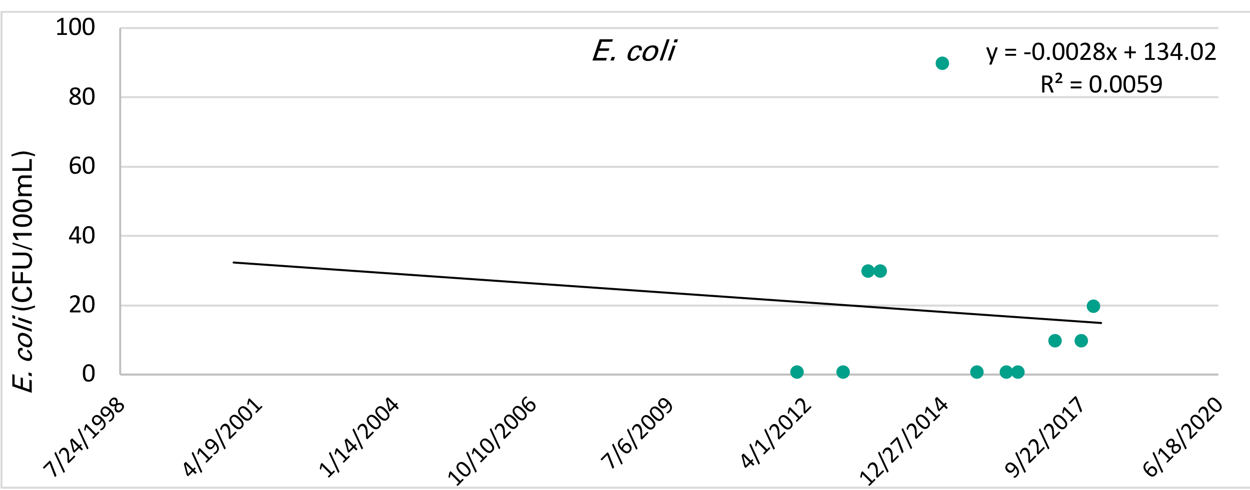

Figure 32: *E. coli* at Site 80187

Nitrate-Nitrogen

There were two nitrate-nitrogen measurements taken at this site between 10/27/2000 and 2/15/2018 which both produced results of 1 mg/L.

Orthophosphate

There were three orthophosphate measurements taken at this site between 10/27/2000 and 2/15/2018, all producing results of 0 mg/L.

Secchi Disk and Total Depth

Secchi disk data was collected a total of 83 times between 10/27/2000 and 2/15/2018. The mean total depth was 0.48 m. In all cases but one, the Secchi disk depth was recorded as greater than the total depth, indicating that the water was clear all the way to the bottom of the creek at this location. The mean Secchi disk depth was 0.49 m and visibility ranged from 0.00 m to 0.96 m.

Field Observations

A total of 144 field observations were taken at this site. On average, algae cover was recorded as absent or rare (0-25%) at this site, and on 14 instances the algae cover was recorded to be common (25-50%). On one instance, the algae cover was abundant (51-75%). The water typically had no distinguishable color and on nine instances had a light green color. Water clarity was recorded as clear in almost all cases, but two observations were described as cloudy. The water had no describable odor except for on two instances when a rotten egg odor was present and on one instance when musky smell was present.

Site 80904 – Upper Cibolo Creek Upstream of Boerne Lake

Site Description

This site is located near the Lake Side Dr. crossing of Upper Cibolo Creek. It is upstream from where the creek is impounded to form a small reservoir called Boerne Lake. There is one house upstream of the location, and most of the land in the area is undeveloped with cultivated cropland on either side. There are sparse junipers and live oaks along the banks of the creek.

Sampling Information

This site was sampled 43 times between 11/15/2012 and 2/15/2018. The time of sampling for this site ranged from 07:10 to 18:05.

Table 8: Descriptive parameters for Site 80904

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	41	260 ± 32	182	332
Water Temperature (°C)	42	19.1 ± 6.1	8.0	30.5

Parameter (cont.)	Number of Samples (cont.)	Mean ± Standard Deviation (cont.)	Min (cont.)	Max (cont.)
Dissolved Oxygen (mg/L)	42	7.3 ± 1.5	3.6	10.3
pH (su)	41	8.2 ± 0.3	7.3	8.5
E. coli CFU/100mL)	11	33 ± 60	1	170
Nitrate-Nitrogen (mg/L)	1	1 ± 0	1	1
Orthophosphate (mg/L)	1	0 ± 0	0	0

Site was sampled 43 times between 11/15/2012 and 2/15/2018.

Air and Water Temperature

Air and water temperatures were taken 42 times at this site between 11/15/2012 and 2/15/2018. The mean water temperature was 19.1°C and ranged from a low temperature of 8.0°C in February of 2012 to a high 30.5°C in August of 2014. The air temperature ranged from a low of 9.0°C in December of 2017, to a high of 30.5°C in October of 2017.

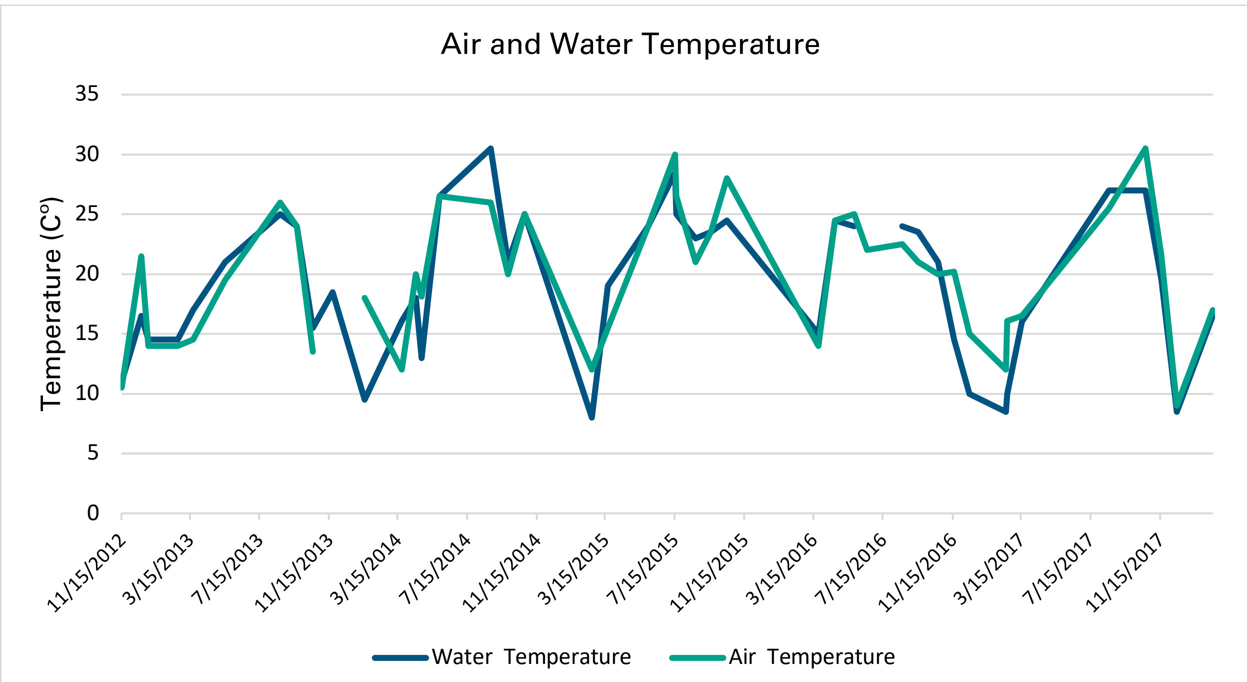

Figure 33: Air and water temperature at Site 80904

Total Dissolved Solids

Citizen scientists collected 41 TDS samples at this site between 11/15/2012 and 2/15/2018. The mean TDS concentration was 260 mg/L. The minimum TDS concentration was 182 mg/L and was taken in October of 2017. The maximum TDS concentration was 331.5 mg/L and was taken in May of 2015. There was a significant decrease in TDS over time observed at this site (P-Value = 0.164). The R^2 value of 0.049 indicates that this relationship only explains 4.9% of the variation in the data.

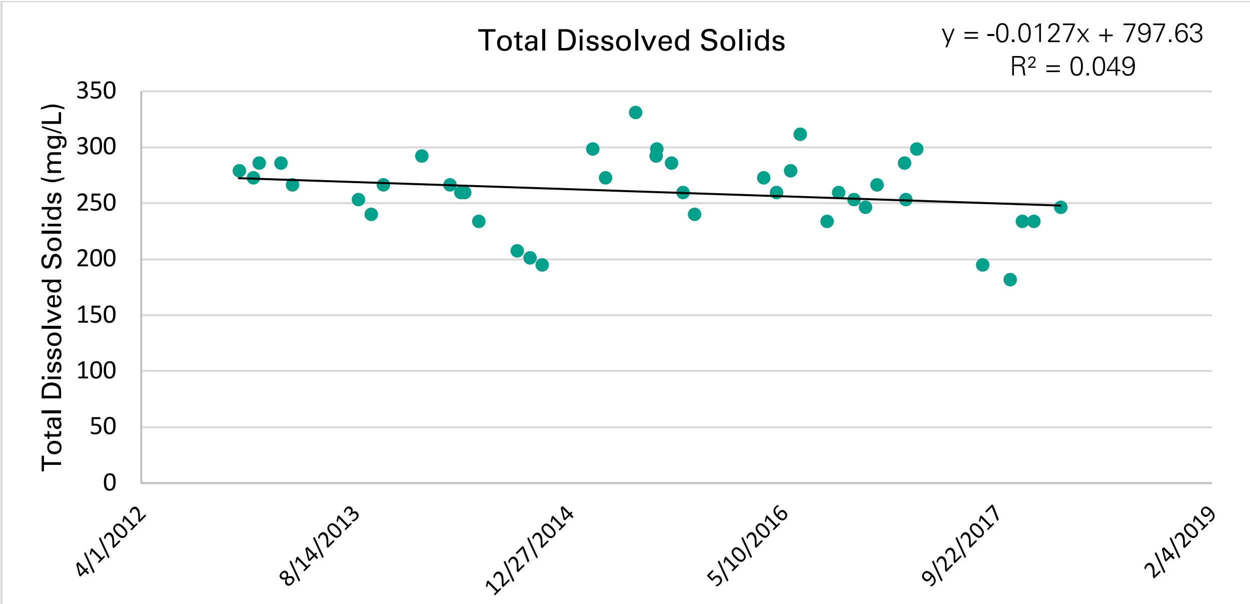

Figure 34: Total dissolved solids at Site 80904

Dissolved Oxygen

Citizen scientists collected 42 DO samples at this site between 11/15/2012 and 2/15/2018. The mean DO concentration was 7.3 mg/L. The minimum DO concentration was 3.6 mg/L and was taken in August of 2013. The maximum DO concentration was 10.3 mg/L and was taken in December of 2017. There was a significant increase in DO over time observed at this site (P-Value = 0.118). The R^2 value of 0.06 indicates that this relationship only explains 6.0% of the variation in the data.

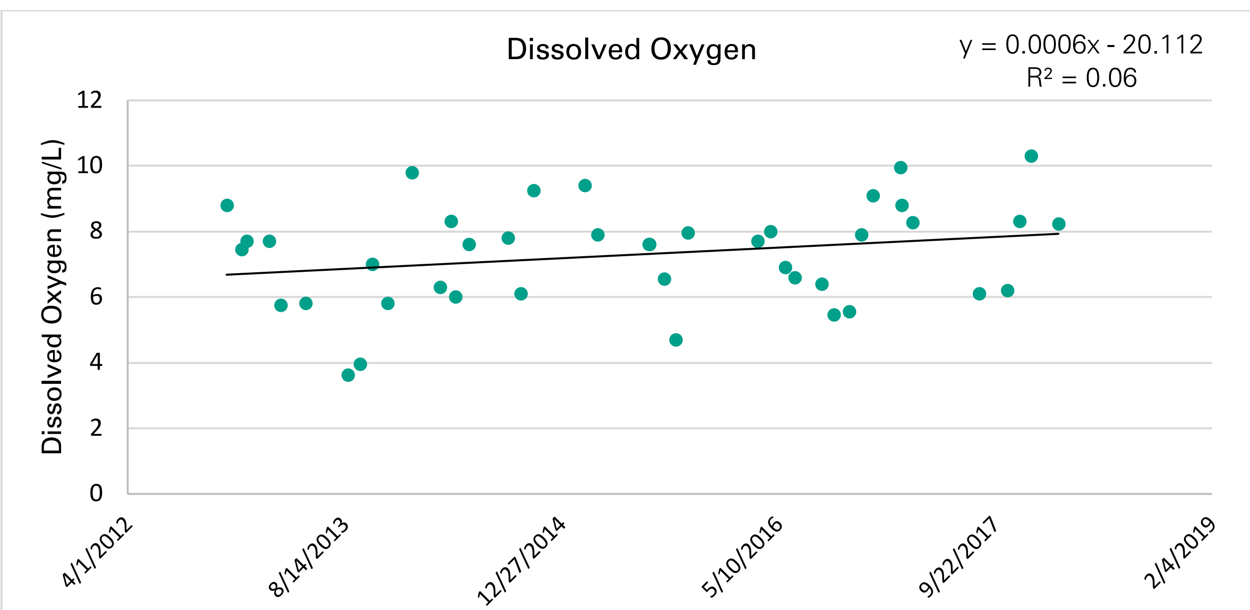

Figure 35: Dissolved oxygen at Site 80904

pH

A total of 41 pH measurements were taken at this site between 11/15/2012 and 2/15/2018. The mean pH was 8.2 and ranged from a low of 7.3 in April of 2014 to a high of 8.5 observed on multiple instances. There was a significant increase in pH over time observed at this site (P-Value = 0.0866). The R^2 value of 0.0734 indicates that this relationship only explains 7.3% of the variation in the data.

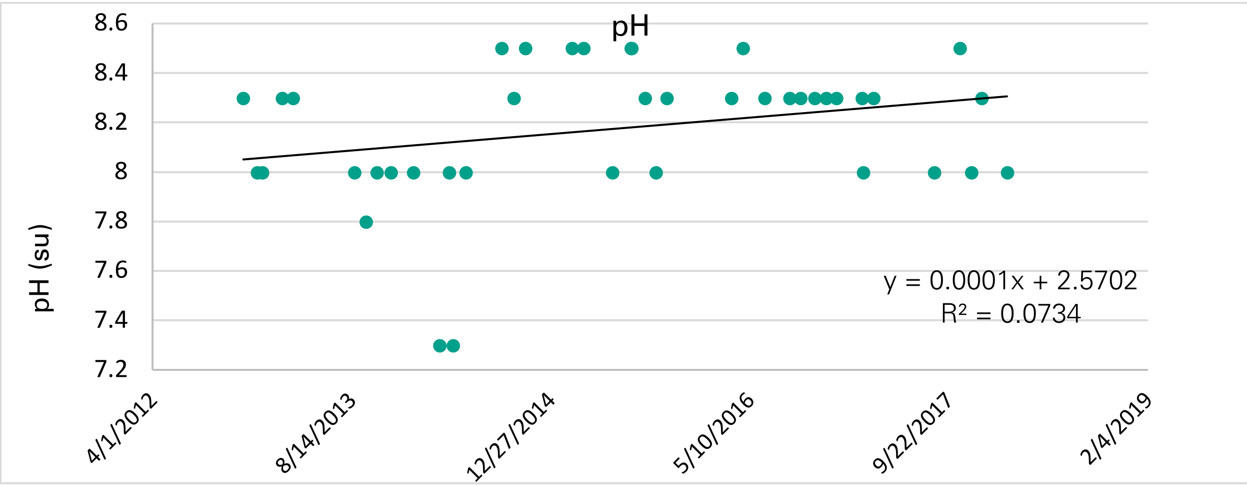

Figure 36: pH at Site 80904

E. coli

There were 11 *E. coli* measurements taken at this site between 11/15/2012 and 2/15/2018. The observed geomean was 33 CFU/100mL and ranged from a low of 1 CFU/100mL taken on multiple occasions to a high of 170 CFU/100mL taken in August of 2015. There was no significant trend in *E. coli* over time detected (P-Value = 0.751). The R^2 value of 0.0118 indicates that this relationship only explains 1.2% of the variation in the data.

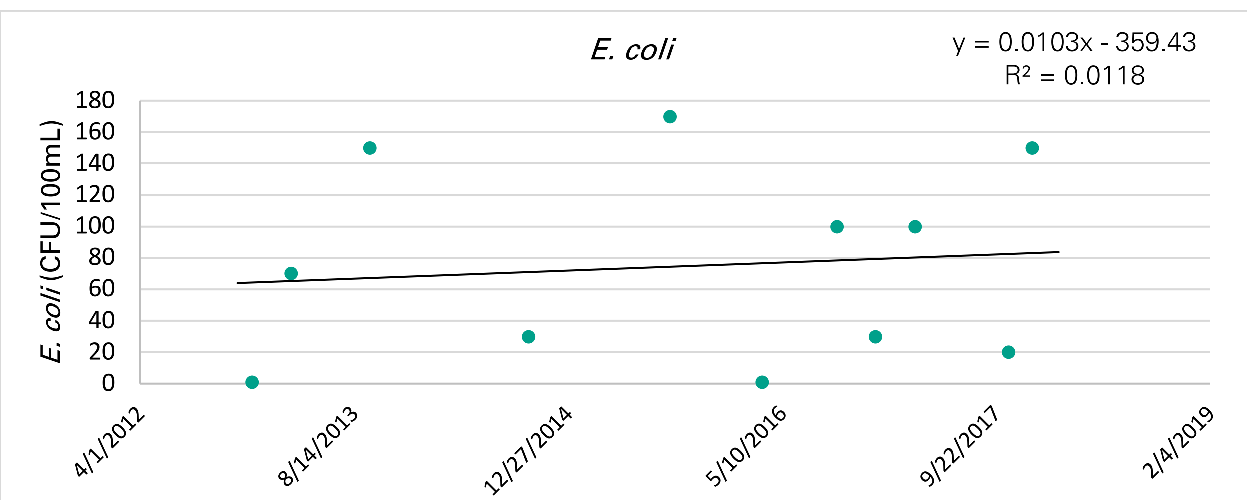

Figure 37: E. coli at Site 80904

Nitrate-Nitrogen

There was one nitrate-nitrogen measurement taken at this site between 11/15/2012 and 2/15/2018 which produced a result of 1 mg/L.

Orthophosphate

There was one orthophosphate measurement taken at this site between 11/15/2012 and 2/15/2018 which produced a result of 0 mg/L.

Secchi Disk and Total Depth

Secchi disk data was collected a total of 42 times between 11/15/2012 and 2/15/2018. The mean total depth was 0.68 m. In all cases but one, the Secchi disk depth was recorded as greater than the total depth, indicating that the water was clear all the way to the bottom of the creek at this location. The mean Secchi disk depth was 0.65 m and visibility ranged from 0.15 m to 1.37 m.

Field Observations

A total of 42 field observations were taken at this site between 11/15/2012 and 2/15/2018. On average, algae cover was recorded as absent or rare (0-25%) at this site, and on one instance the algae cover was recorded as common (25-50%). The water typically had no distinguishable color but on 16 instances had a light green color and on two instances indicated a tan color. The water clarity was typically recorded as clear, but eight observations were described as cloudy and one as turbid. The water had no describable odor except for on one instance when an acrid or pungent odor was present.

Site 20823 – Upper Cibolo Creek @ River Road Park

Site Description

This site is located in a city park that is in the downtown area of Boerne. There is a low water dam that widens and deepens the creek in this area. River Road runs along this stretch of the creek. There are several shops, restaurants, and houses on the opposite side of the road from the creek. The park grass is mowed and there are a few cypress trees at this location.

Sampling Information

This site was sampled 75 times between 3/15/2012 and 4/19/2018. Sampling times ranged between 8:30 and 14:50.

Table 9: Descriptive parameters for Site 20823

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	70	301 ± 79	137	735
Water Temperature (°C)	73	20.5 ± 5.9	6.9	30.1

Parameter (cont.)	Number of Samples (cont.)	Mean ± Standard Deviation (cont.)	Min (cont.)	Max (cont.)
Dissolved Oxygen (mg/L)	75	6.3 ± 2.0	2.3	9.9
pH (su)	71	7.6 ± 0.4	7.0	8.6
E. coli (CFU/100 mL)	20	460 ± 978	50	3530
Nitrate-Nitrogen (mg/L)	65	0.75 ± 0.43	0	2.0
Orthophosphate (mg/L)	65	0.20 ± 0.51	0	3.6
Turbidity (JTU)	65	6.21 ± 7.66	0.00	50.00

Site was sampled 30 times between 3/15/2012 and 4/19/2018.

Air and Water Temperature

Air and water temperatures were taken 73 and 72 times, respectively, during this time period. The mean water temperature was 20.5°C and ranged from low of 6.9°C in January of 2018 to a high of 30.1°C in July of 2016. The mean air temperature was 18.4°C and ranged from a low of 2°C in December of 2015 and January of 2018 to a high of 29°C taken in August of 2014.

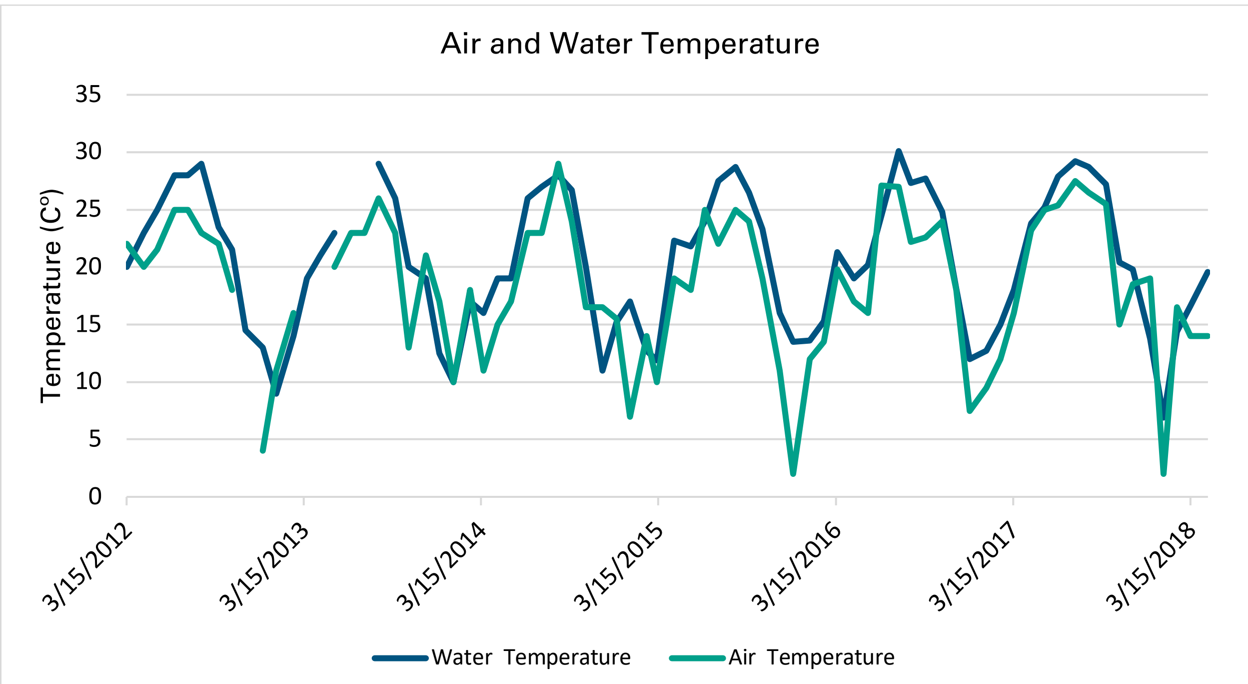

Figure 38: Air and water temperature at Site 20823

Total Dissolved Solids

Citizen scientists collected 70 TDS samples between 3/15/2012 and 4/19/2018. The mean TDS concentration was 301 mg/L and ranged from a minimum of 137 mg/L in May of 2014 to a maximum of 735 mg/L in October of 2015. There was no significant trend in TDS observed at this site over the sampling period (P-Value = 0.581). The R^2 value was 0.0045 indicating that this relationship explained about 0.45% of the variation in the data.

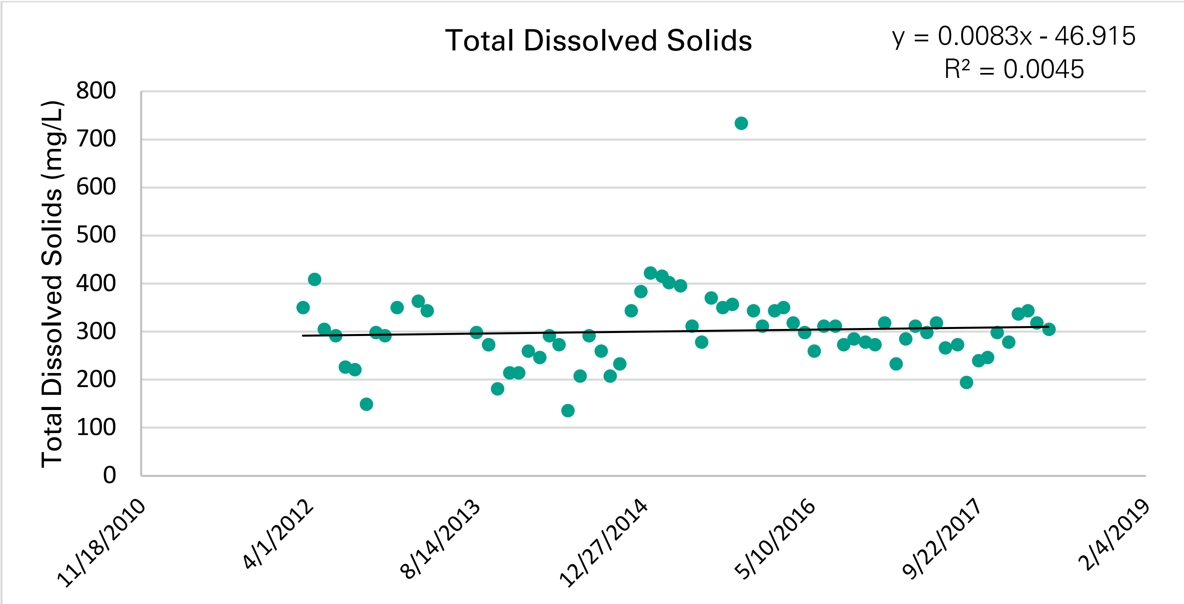

Figure 39: Total dissolved solids at Site 20823

Dissolved Oxygen

Citizen scientists collected 75 DO samples at this site between 3/15/2012 and 4/19/2018. The mean DO concentration was 6.3 mg/L. The minimum DO concentration was 2.3 mg/L and was taken in August of 2013. The maximum DO concentration was 9.9 mg/L and was taken in January of 2018. There was a significant increase in DO concentrations over time observed at this site (P-Value = 0.178). The R^2 value was 0.0247 indicating that this relationship explained about 2.5% of the variation in the data.

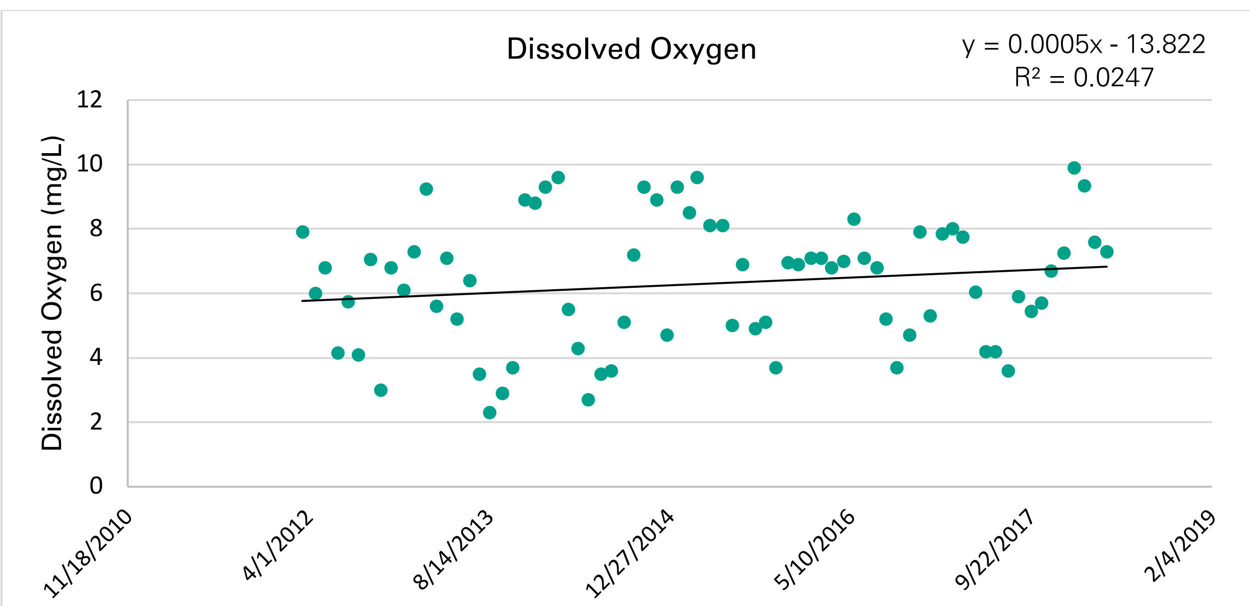

Figure 40: Dissolved oxygen at Site 20823

pH

Citizen scientists took 71 pH measurements at this site. The mean pH was 7.6 and ranged from a low of 7.0 in multiple instances to a high of 8.6 in April of 2014. There was a significant decrease in pH concentrations over time observed at this site (P-Value = <0.0001). The R^2 value was 0.2789 indicating that this relationship explained about 28% of the variation in the data.

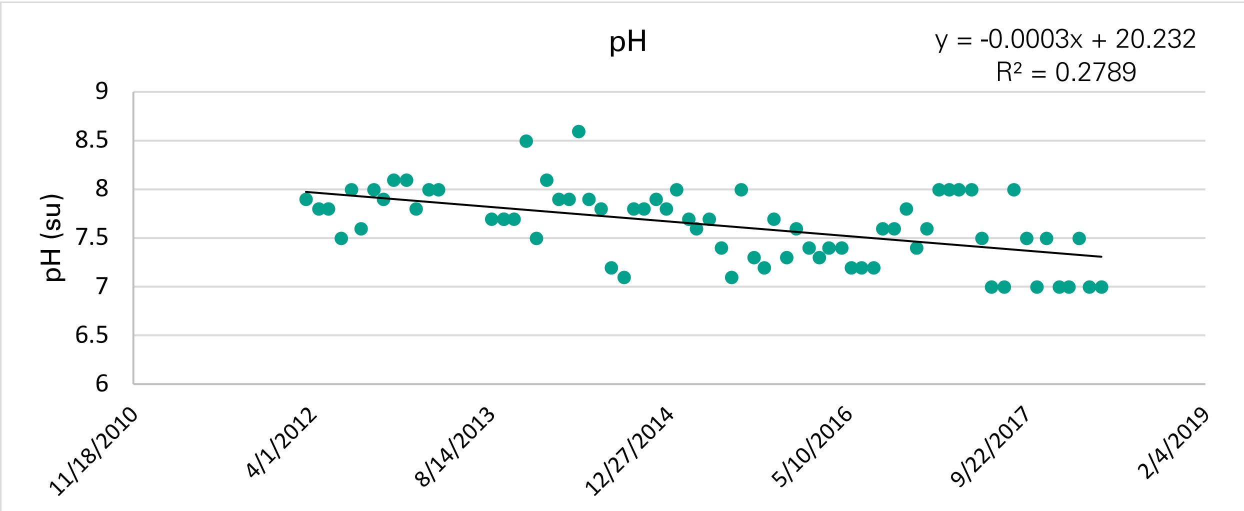

Figure 41: pH at Site 20823

E. coli

There were 65 *E. coli* measurements taken at this site between 3/15/2012 and 4/19/2018. The observed geomean was 460 CFU/100mL and ranged from a low of 50 CFU/100mL taken in March of 2015 to a high of 3530 CFU/100mL taken in June of 2015. There was a significant decrease in *E. coli* over time observed at this site (P-Value = 0.0531). The R^2 value of 0.1923 indicates that this relationship only explains 19.23% of the variation in the data.

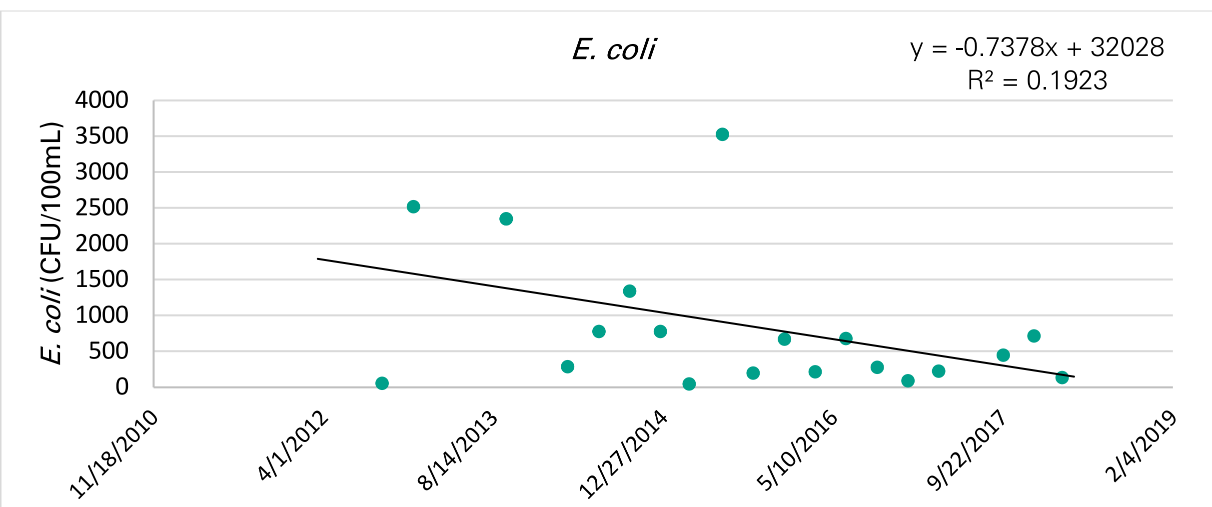

Figure 42: *E. coli* at Site 20823

Nitrate-Nitrogen

There were 65 nitrate-nitrogen measurements taken at this site between 3/15/2012 and 4/19/2018, producing a mean of 0.75 mg/L. Values ranged from 0 mg/L on multiple instances and in one sample was observed as high as 2 mg/L in May of 2013. There was a significant decrease in nitrate-nitrogen over time observed at this site (P-Value = <0.0001). The R^2 value of 0.3108 indicates that this relationship only explains 31.08% of the variation in the data.

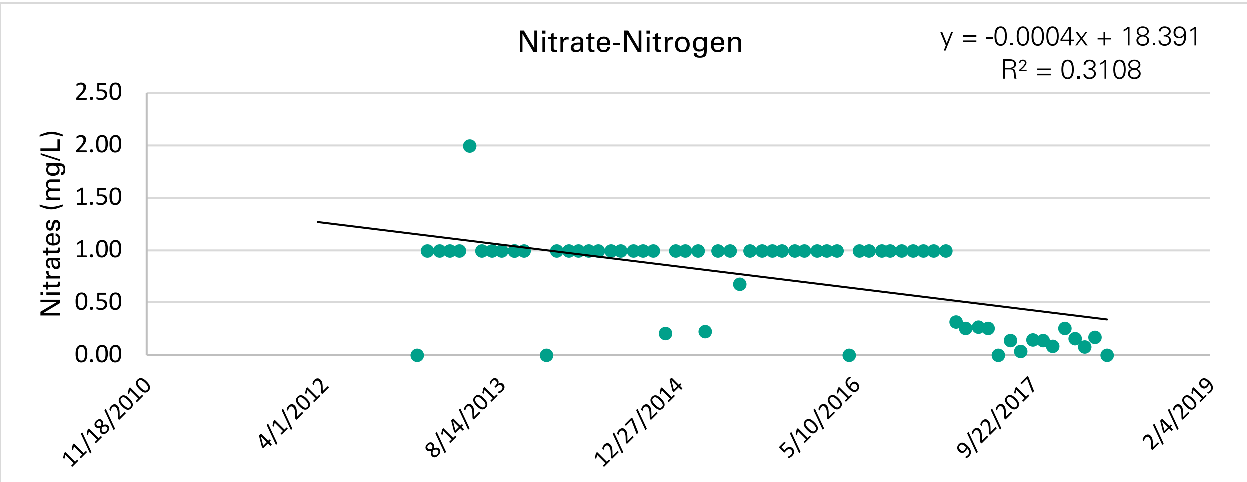

Figure 43: Nitrate-Nitrogen at Site 20823

Orthophosphate

There were 65 orthophosphate measurements taken at this site between 3/15/2012 and 4/19/2018, producing a mean of 0.20 mg/L. Values ranged from 0 mg/L on multiple instances and in one sample was observed as high as 3.6 mg/L in June of 2015. There was no significant trend in orthophosphate over time detected (P-Value = 0.502). The R^2 value of 0.0072 indicates that this relationship only explains 0.72% of the variation in the data.

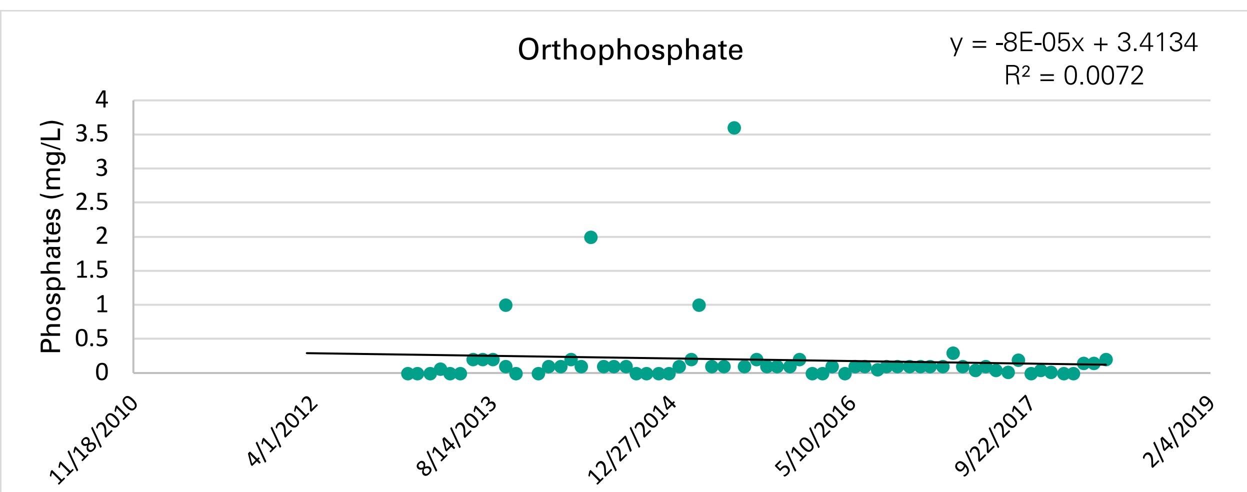

Figure 44: Orthophosphate at Site 20823

Secchi Disk and Total Depth

Secchi disk data was collected a total of 60 times between 3/15/2012 and 4/19/2018. The mean total depth at this site was 0.82 m. Secchi disk depth was typically less than total depth, indicating that the water clarity was not visible all the way to the bottom of the creek. The mean Secchi disk depth was 0.79 m and visibility ranged from 0.18 m to 1.40 m.

Field Observations

A total of 75 field observations were taken at this site between 3/15/2012 and 4/19/2018. Algae cover was typically described as rare (< 25%), but on several occasions the algae cover was abundant (51 – 75%). The water color was clear to light green, on three occasions was tan, and on one occasion was green/brown. Water clarity was clear a majority of the time but was described as cloudy for several monitoring events. Two instances exist where water odor was indicated as fishy and musky, respectively.

Site 80966 – Currey Creek @ Boerne WWTP Effluent Outfall

Site Description

This site is at the confluence of Currey Creek and Upper Cibolo Creek. It is located at a wastewater treatment plant effluent outfall into Currey Creek near River Road.

Sampling Information

This site has been sampled 61 times between 5/16/2013 and 4/19/2018. Sampling typically takes place in the morning after 09:00 and in two instances occurred in the afternoon as late as 14:00.

Table 10: Descriptive parameters for Site 80966

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	61	613 ± 89	85	735
Water Temperature (°C)	61	21.5 ± 4.4	11.5	27.9
Dissolved Oxygen (mg/L)	61	6.3 ± 0.7	5.3	8.2
pH (su)	61	7.3 ± 0.3	7.0	7.9
E. coli (CFU/100 ML)	18	27 ± 237	1	1060
Nitrate-Nitrogen (mg/L)	61	15.0 ± 2.0	1.0	15.0
Orthophosphate (mg/L)	61	11.0 ± 4.0	0.0	28.0
Turbidity (JTU)	60	4.25 ± 7.95	0	60

Site was sampled 16 times between 5/16/2013 and 4/19/2018.

Air and Water Temperature

Air and water temperatures were taken 61 times at this site. The mean water temperature was 21.5°C, varying from a low of 11.5°C in December of 2017 to a high of 27.9°C in July of 2016. The air temperature varied from a low of 1°C in December of 2015 to a high of 27.5°C in July of 2016.

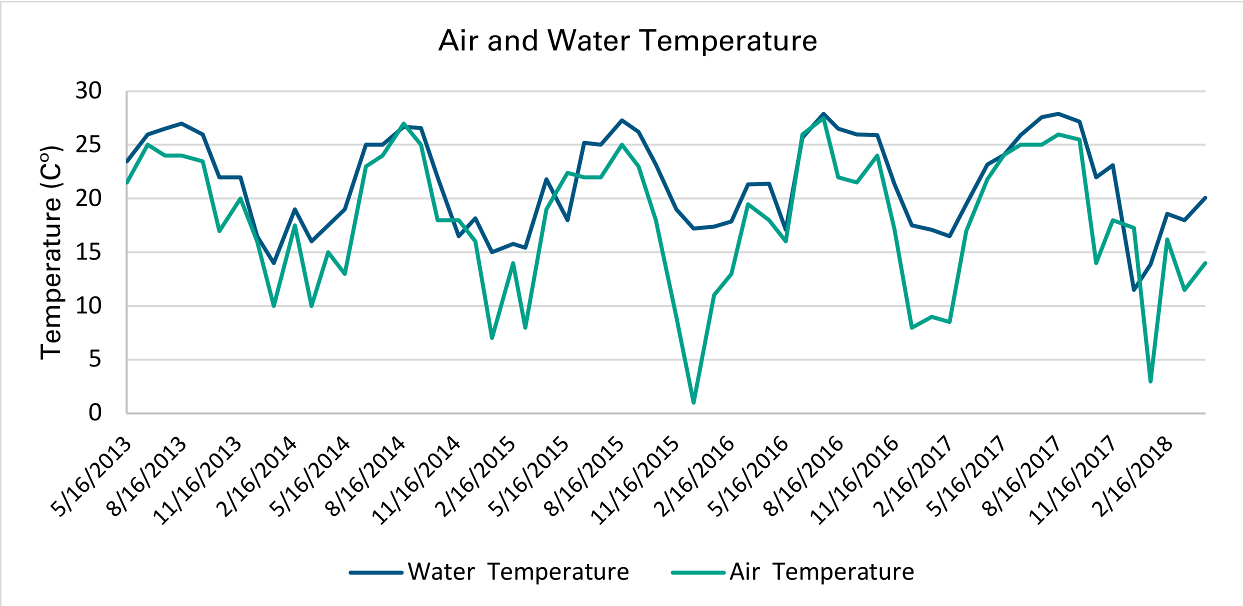

Figure 45: Air and water temperature at Site 80966

Total Dissolved Solids

Citizen scientists collected 61 TDS samples at this site between 5/16/2013 and 4/19/2018. The mean TDS concentration was 613 mg/L at this site. The minimum TDS concentration was 84.5 mg/L and was taken in May of 2016. The maximum TDS concentration was 734.5 mg/L taken in September of 2015. There was a significant increase in TDS over time observed at this site (P-Value = 0.159). The R^2 value of 0.0333 indicates that this relationship only explains 3.3% of the variation in the data.

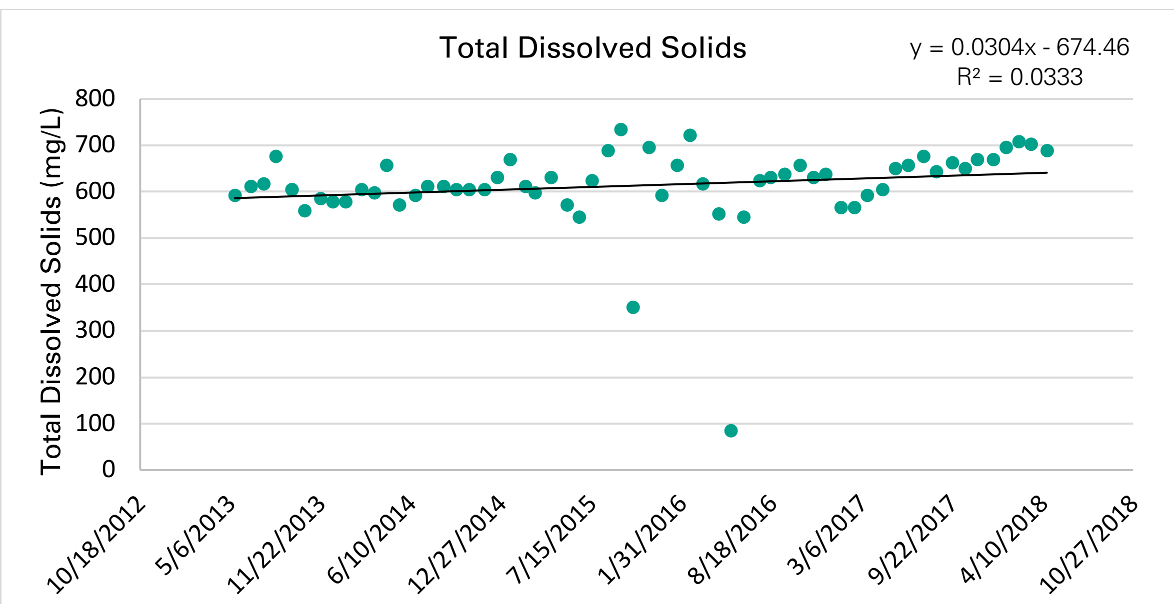

Figure 46: Total dissolved solids at Site 80966

Dissolved Oxygen

Citizen scientists collected 61 DO samples at this site between 5/16/2013 and 4/19/2018. The mean DO concentration was 6.3 mg/L. The minimum DO concentration was 5.3 mg/L and was recorded in June of 2016. The maximum DO concentration was 8.2 mg/L and was recorded in January of 2014. There was no significant trend in DO over time detected (P-Value = 0.747). The R^2 value of 0.0018 indicates that this relationship only explains 0.18% of the variation in the data.

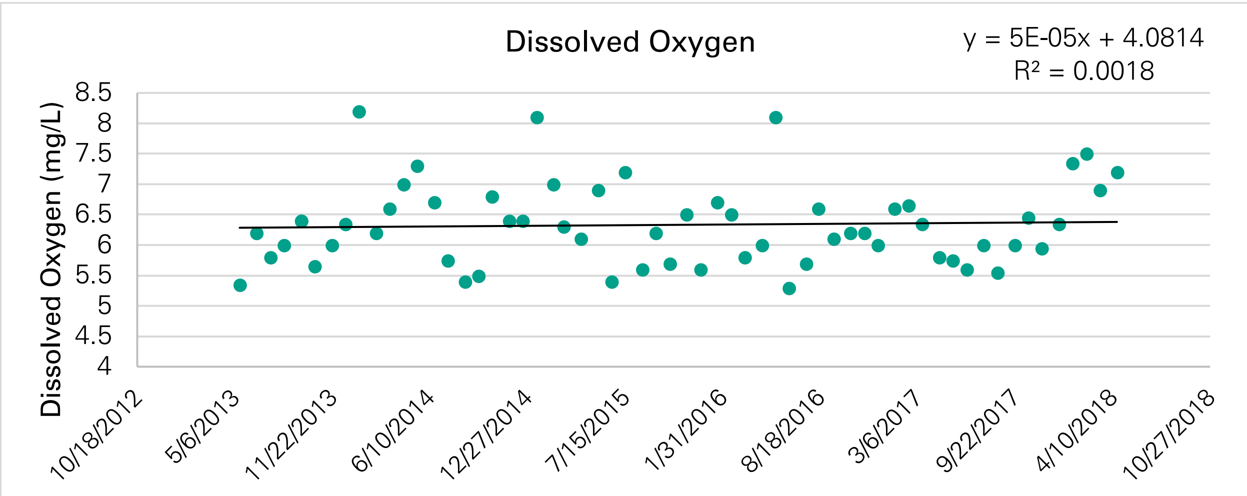

Figure 47: Dissolved oxygen at Site 80966

pH

Citizen scientists took 61 pH measurements at this site. The mean pH was 7.3 and it ranged from a low of 7.0 in February of 2014, to a high of 7.9 in August of 2013. There was a significant decrease in pH over time observed at this site (P-Value = 0.00181064215756588). The R^2 value of 0.1532 indicates that this relationship only explains 15.3% of the variation in the data.

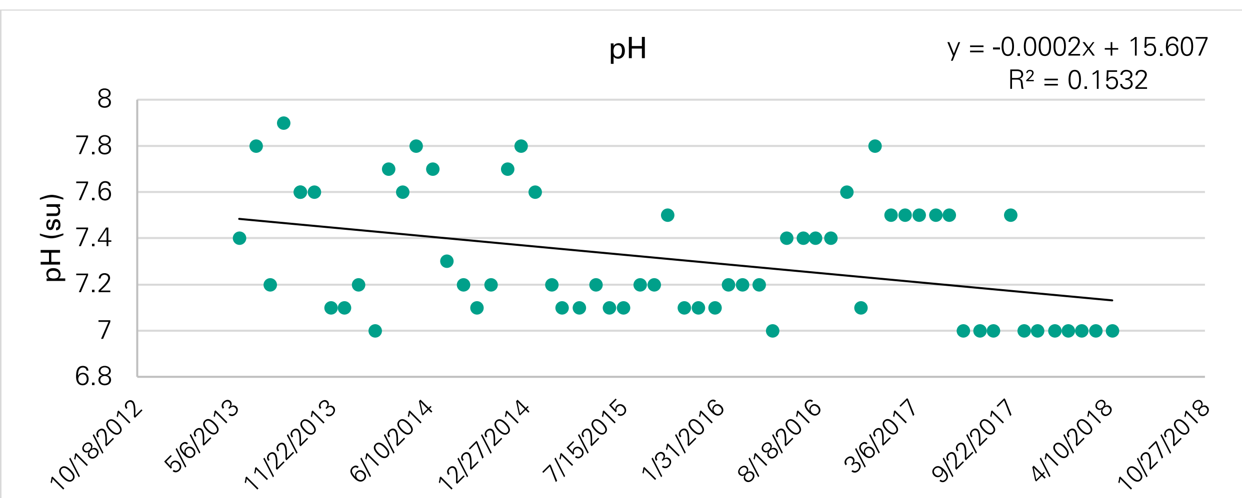

Figure 48: pH at Site 80966

E. coli

There were 18 *E. coli* measurements taken at this site between 5/16/2013 and 4/19/2018. The observed geomean was 27 CFU/100mL and ranged from a low of 1 CFU/100mL to a high of 1060 CFU/100mL taken in June of 2015. There was no significant trend in *E. coli* over time detected (P-Value = 0.935). The R^2 value of 0.0004 indicates that this relationship only explains 0.04% of the variation in the data.

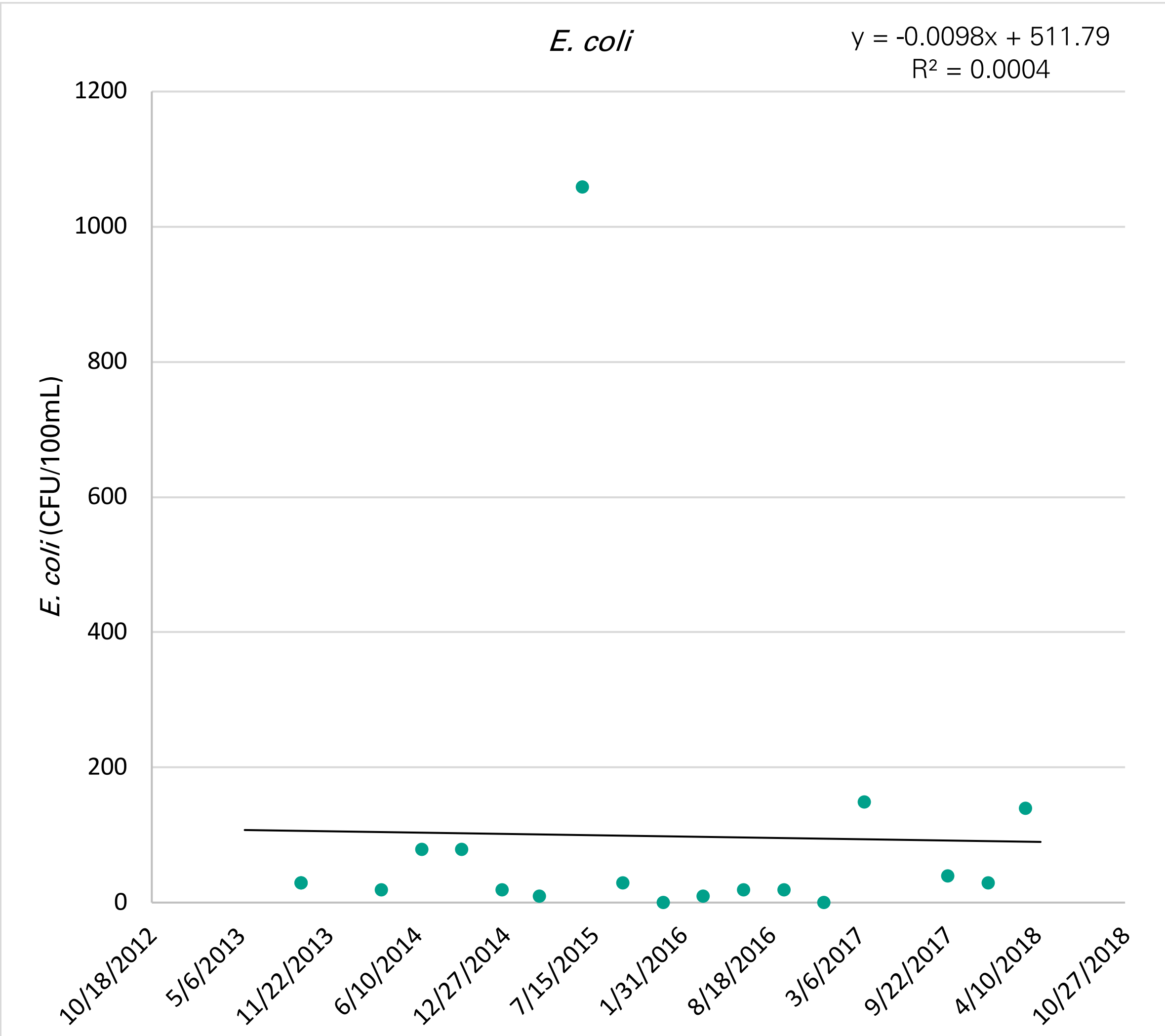

Figure 49: *E. coli* at Site 80966

Nitrate-Nitrogen

Citizen scientists collected 61 nitrate-nitrogen samples at this site. Every nitrate-nitrogen sample at this site was recorded as 15 mg/L except for on one instance of 1 mg/L recorded in May of 2016. There was no significant trend in nitrate-nitrogen over time observed at this site (P-Value = 0.695). The R^2 value of 0.0026 indicates that this relationship only explains 0.26% of the variation in the data.

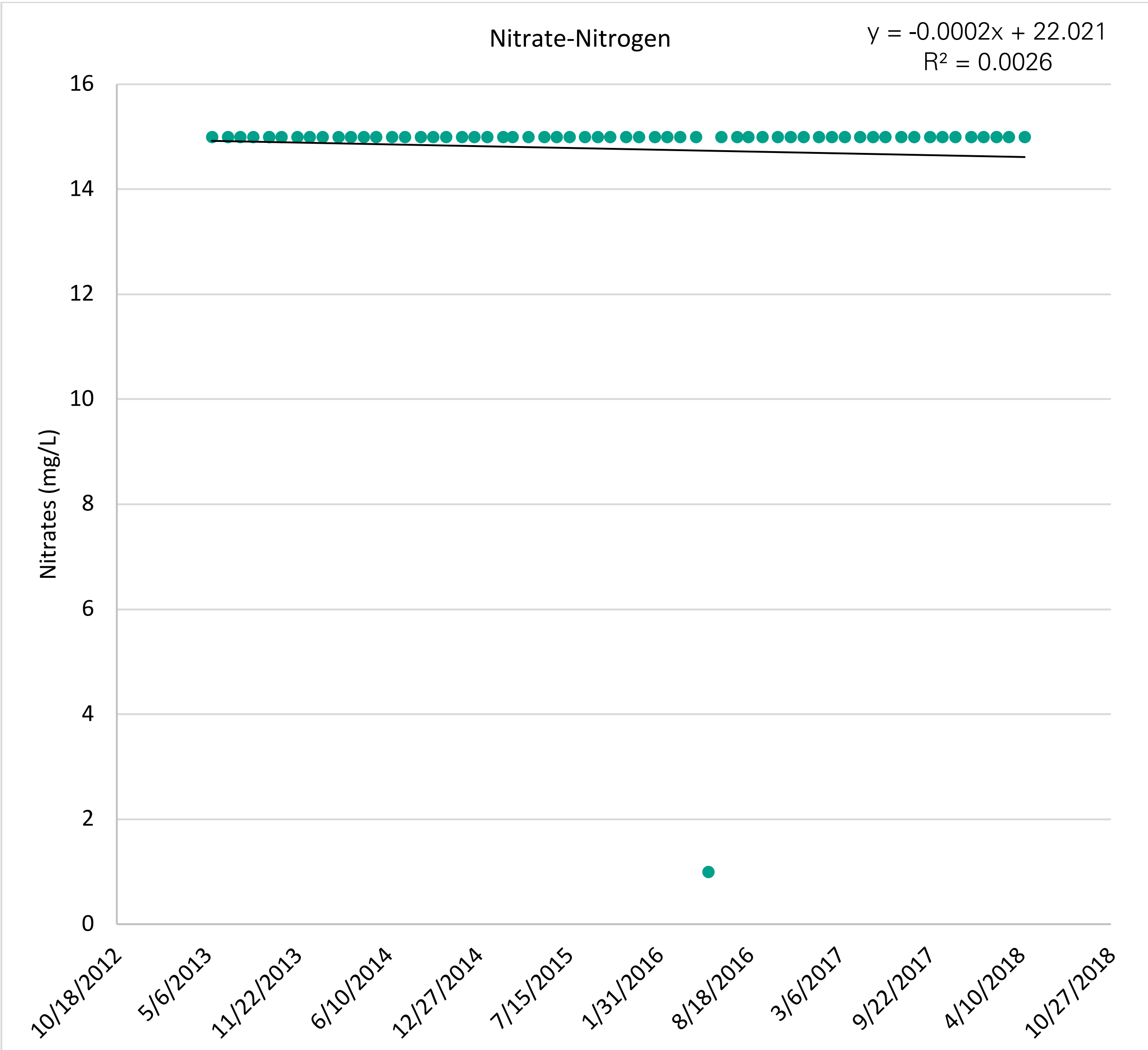

Figure 50: Nitrate-Nitrogen at Site 80966

Orthophosphate

Citizen scientists collected 61 orthophosphate samples at this site. The mean orthophosphate concentration was 11.0 mg/L. The minimum orthophosphate concentration, observed in two instances, was 0 mg/L. The maximum orthophosphate concentration was 28.0 mg/L and was recorded in December of 2015. There was no significant trend in orthophosphate over time observed at this site (P-Value = 0.726). The R^2 value of 0.0021 indicates that this relationship only explains 0.21% of the variation in the data.

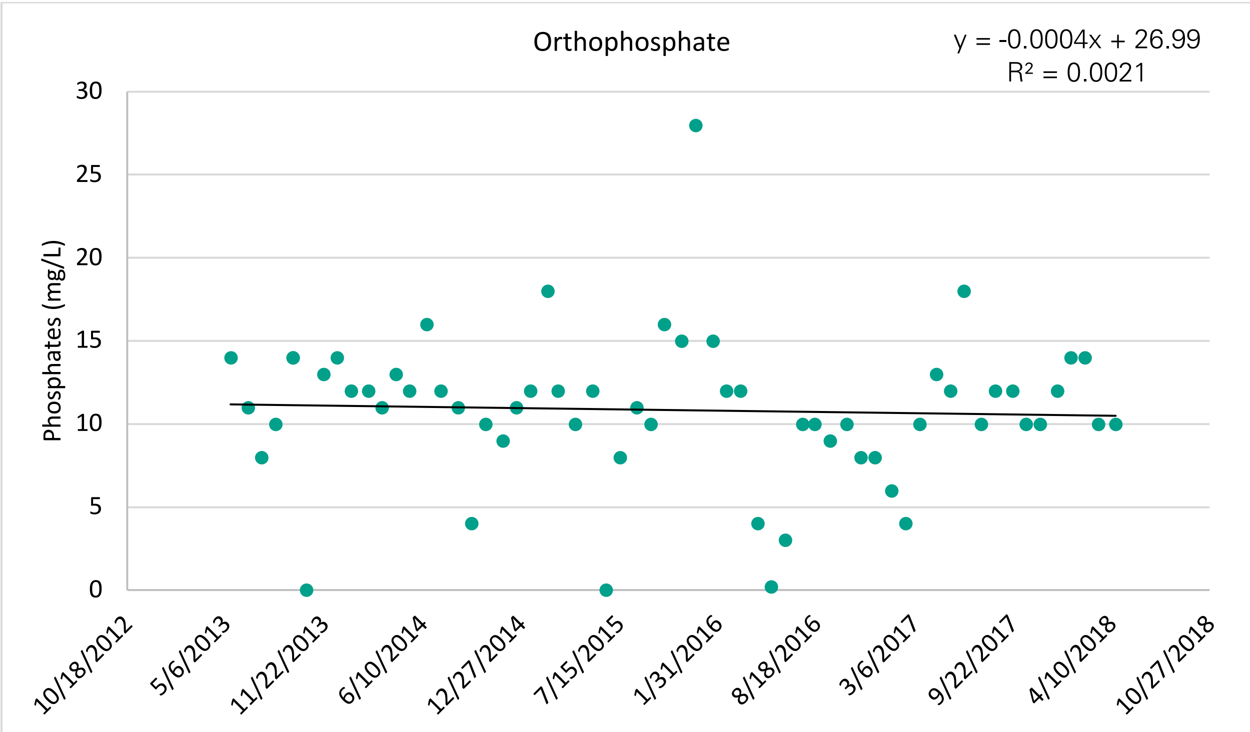

Figure 51: Orthophosphate at Site 80966

Secchi Disk and Total Depth

Secchi disk depth data was taken a total of 45 times at this site between 5/16/2013 and 4/19/2018 and total depth was taken 59 times. Secchi disk depth was greater than total depth for all monitoring events indicating that the bottom of the creek was visible at this site. The mean total depth was 0.25m.

Field Observations

Flow was described as normal for most events and recorded as low for 23 events. One flood event was noted. The algae cover was usually absent to rare (< 25%) but was noted to be common (26-50%) five times and abundant (51-75%) twice. The water color was typically described as clear to light green but was described as tan or green/brown four times. Water clarity was clear for all events except four that were recorded as cloudy. Water odor was typically not present, but 25 samples documented a musky scent.

Site 80186 – Cibolo Nature Center Marsh

Site Description

This site is located in a restored spring-fed marsh in the Cibolo Nature Center in Boerne, Texas. There is a small pool of water surrounded by grasses, sedges, and cypress trees. The sampling site is off of a boardwalk across the marsh.

Sampling Information

This site has been sampled 121 times between 1/24/1999 and 4/19/2018. Monitoring at this location took place between 08:30 and 16:30.

Table 11: Descriptive parameters for Site 80186

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	115	443 ± 76	254	618
Water Temperature (°C)	118	19.7 ± 6.1	4.5	34.5
Dissolved Oxygen (mg/L)	114	6.5 ± 2.6	1.0	13.7
pH (su)	114	7.6 ± 0.2	6.9	8.1
E. coli (CFU/100 ML)	18	85 ± 414	1	1810
Nitrate-Nitrogen (mg/L)	3	0.55 ± 0.28	0.23	0.92
Orthophosphate (mg/L)	2	0.10 ± 0.10	0.0	0.20
Turbidity (JTU)	2	0 ± 0	0	0

Site was sampled 81 times between 1/24/1999 and 4/19/2018.

Air and Water Temperature

There were 118 air and water temperatures taken at this site. The mean water temperature was 19.7°C. Water temperature varied from a low of 4.5°C in January of 2018, and a high of 34.5°C in August of 1999. The air temperature ranged from a low of 0°C in January of 2018 to a high of 37°C in August of 2005.

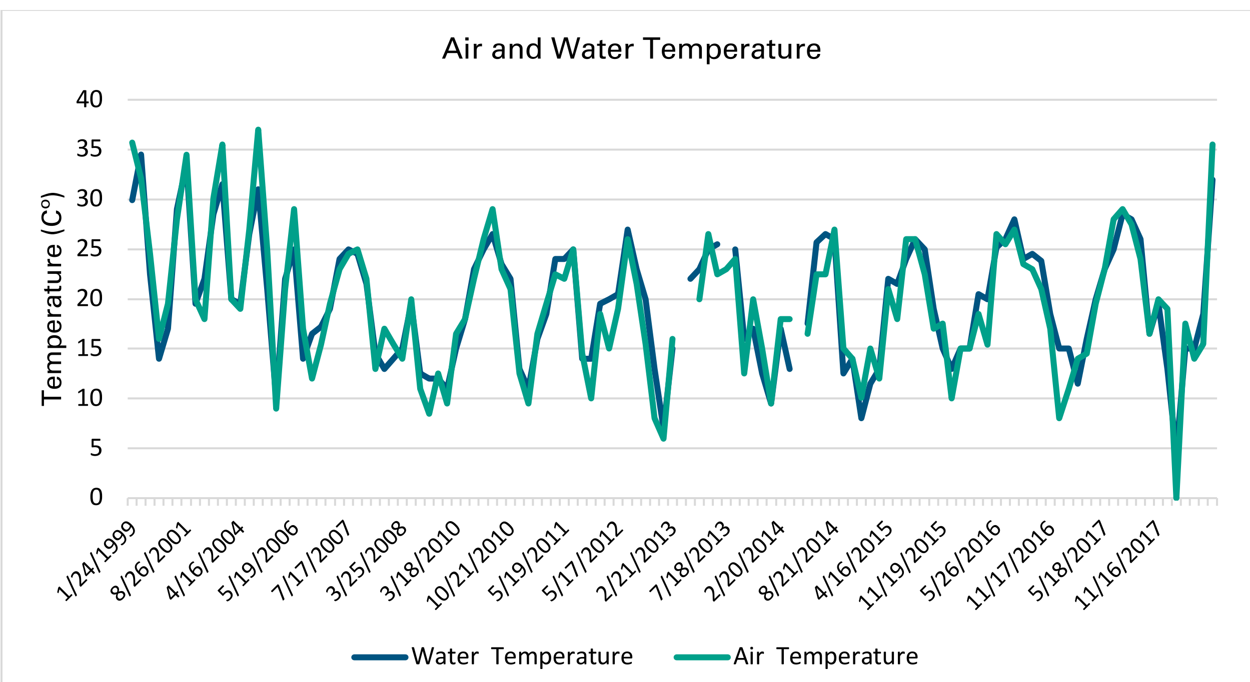

Figure 52: Air and water temperature at Site 80186

Total Dissolved Solids

Citizen scientists took 115 TDS samples at this site. The mean TDS concentration was 443 mg/L. The minimum TDS concentration of 254 mg/L was recorded in August of 1999. The maximum TDS concentration was recorded in June of 2011 and was 618 mg/L. There was a significant increasing trend in TDS concentration over time observed at this site (P-Value = 0.006). The R^2 value was 0.0648 indicating that this relationship explained about 6.5% of the variation in the data.

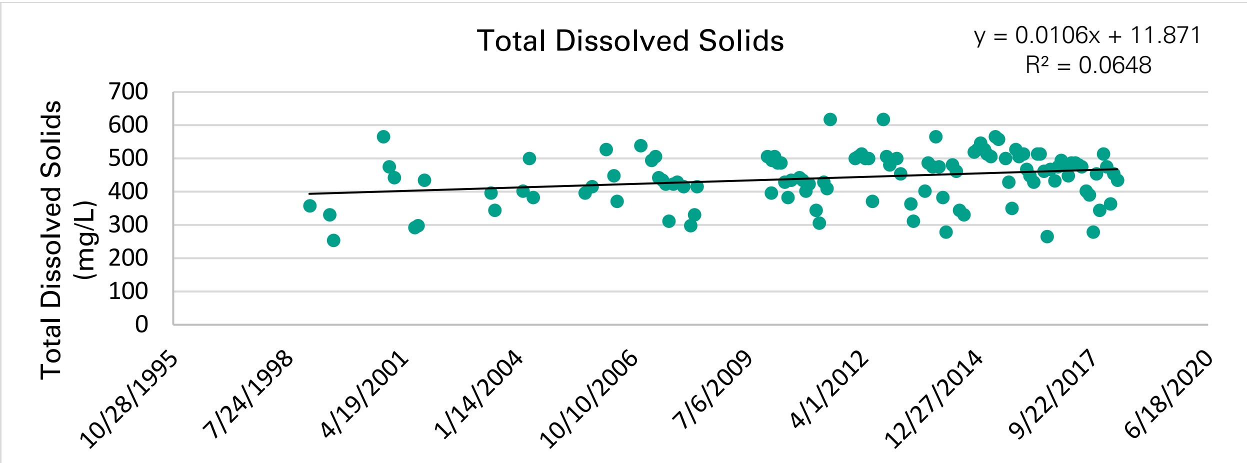

Figure 53: Total dissolved solids at Site 80186

Dissolved Oxygen

Citizen scientists collected 114 DO samples at this site between 1/24/1999 and 4/19/2018. The mean DO concentration was 6.5 mg/L. The DO concentration varied from a low of 1.0 mg/L in May of 2011, to a high of 13.7mg/L in June of 2003. There was a significant decreasing trend in DO concentrations over time observed at this site (P-Value = 0.003). The R^2 value was 0.0765 indicating that this relationship explained about 7.6% of the variation in the data.

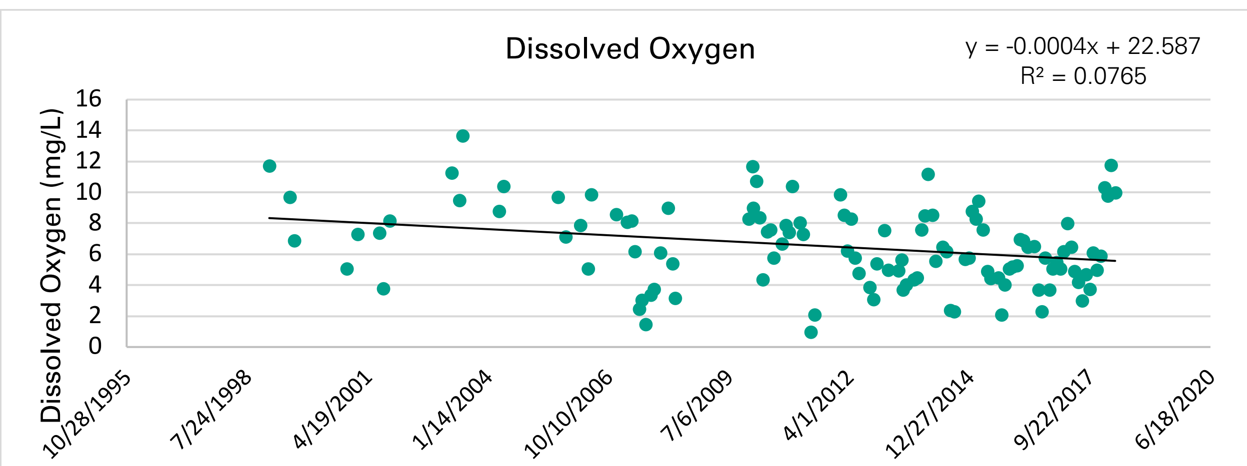

Figure 54: Dissolved oxygen at Site 80186

pH

A total of 114 pH measurements were taken at this site. The mean pH was 7.6 and it ranged from a high of 8.1 in October of 2005, to a low of 6.9 in June of 2014. There was a significant decrease in pH over time observed at this site (P-Value = 0.0006). The R^2 value was 0.0992 indicating that this relationship explained 10% of the variation in the data.

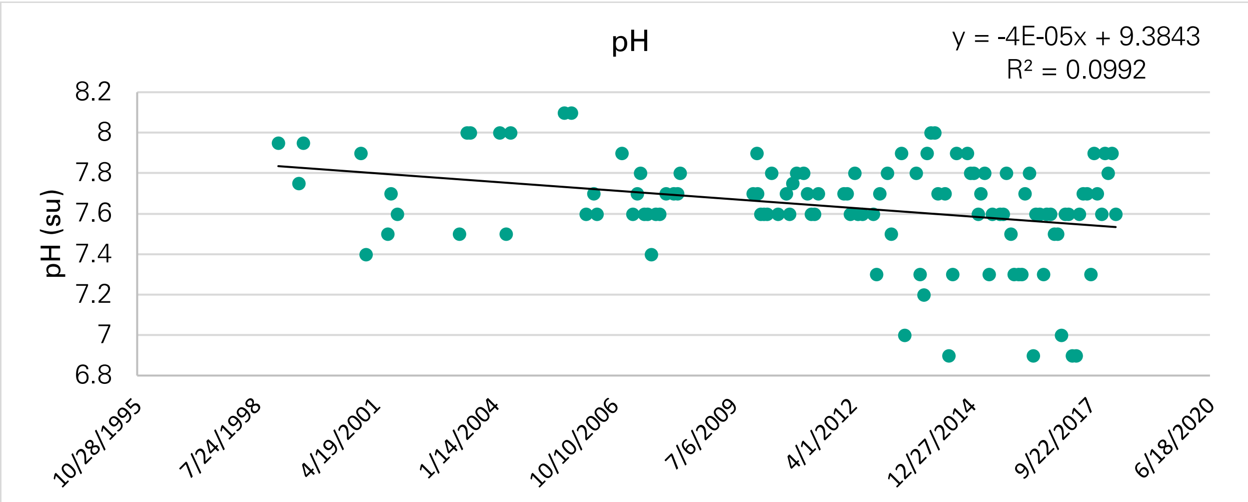

Figure 55: pH at Site 80186

E. coli

There were 18 *E. coli* measurements taken at this site between 1/24/1999 and 4/19/2018. The observed geomean was 85 CFU/100mL and ranged from a low of 1 CFU/100mL to a high of 1810 CFU/100mL taken in September of 2017. There was no significant trend in *E. coli* over time observed at this site (P-Value = 0.487). The R^2 value of 0.0307 indicates this relationship only explains 3.07% of the variation in the data.

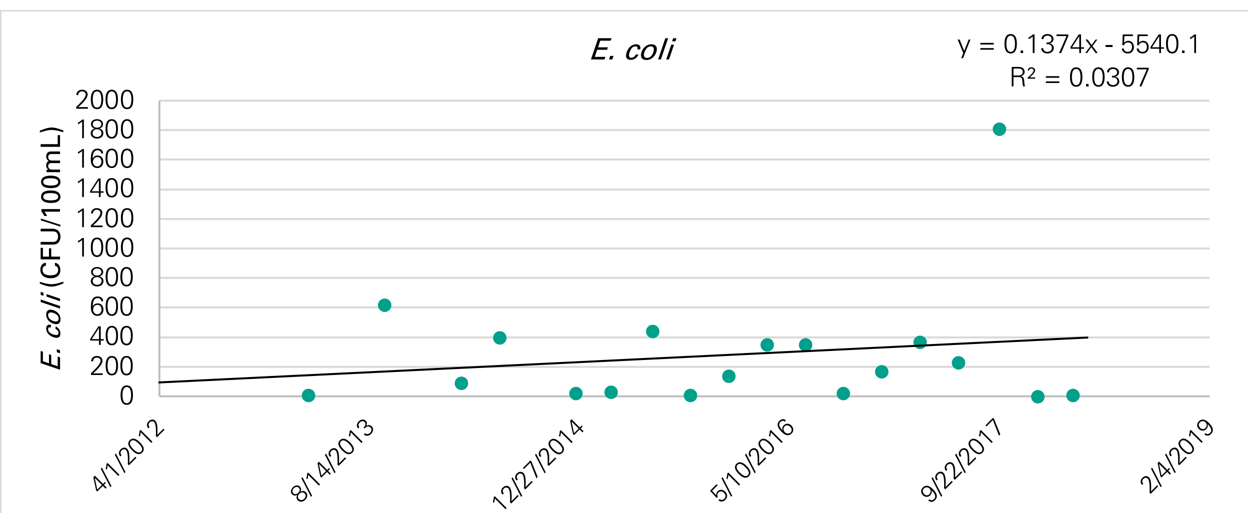

Figure 56: *E. coli* at Site 80186

Nitrate-Nitrogen

There were three nitrate-nitrogen measurements taken at this site between 1/24/1999 and 4/19/2018, producing a mean of 0.55 mg/L. Values ranged from 0.23 mg/L in August of 2014 to 0.92 mg/L in January of 2017. There were not enough nitrate-nitrogen measurements to determine a significant trend analysis.

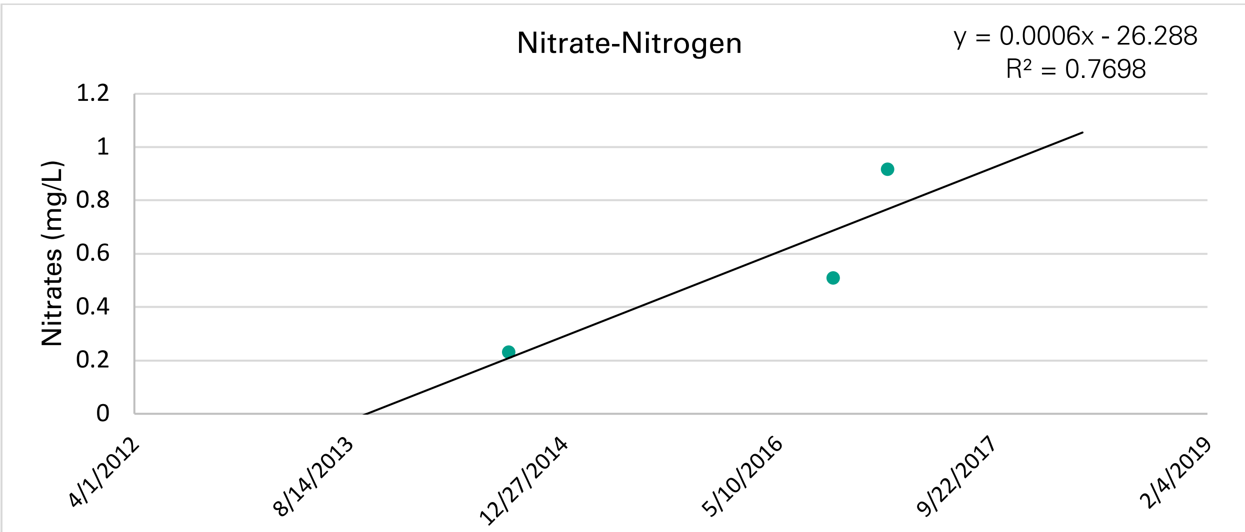

Figure 57: Nitrate-Nitrogen at Site 80186

Orthophosphate

Citizen scientists collected two orthophosphate samples at this site, one of which was recorded to be 0 mg/L in January of 2017 and the other recorded to be 0.20 mg/L in September of 2016. There were not enough orthophosphate measurements to determine a significant trend analysis.

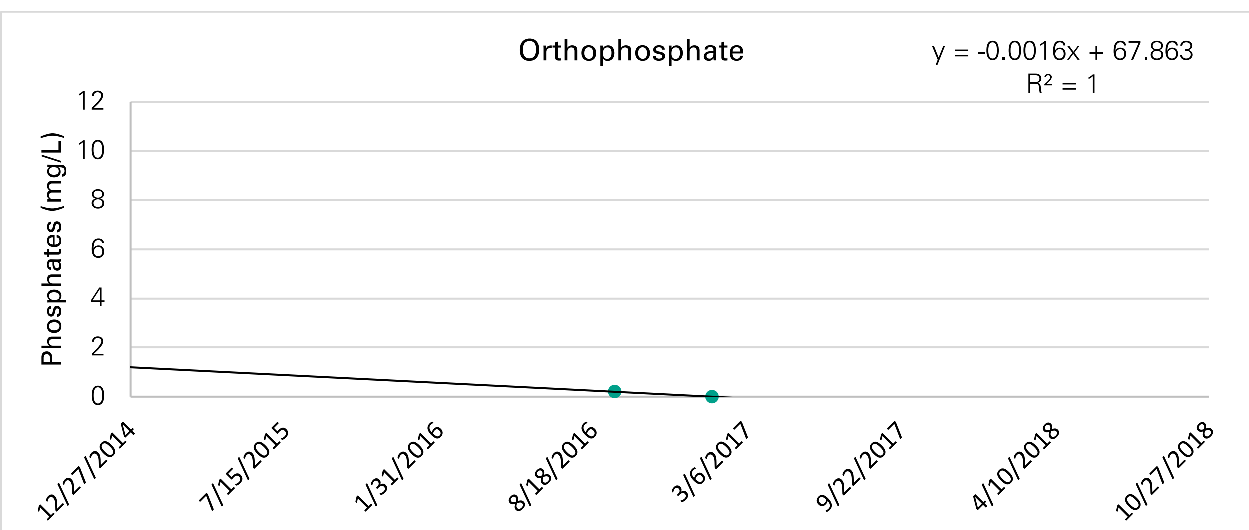

Figure 58: Orthophosphate at Site 80186

Secchi Disk and Total Depth

Secchi disk and total depth measurements were taken 93 and 116 times, respectively. The Secchi disk depth was recorded as equal to the total depth in all cases, indicating that the water clarity was such that the bottom of the wetland was visible at the sampling site.

Field Observations

Water flow varied greatly at this site from normal to conditions where the pond was almost completely dried up. The algae cover also varied greatly. There were 28 monitoring events where there were no algae present, but the amount of algae cover ranged from 0 to greater than 75% coverage at the site. The water typically had no describable color and the clarity was recorded as clear a majority of the time. The water usually had no odor, but on several occasions, it was described as fishy or musky.

Site 15126 – Cibolo @ Menger Creek

Site Description

This site is located at the confluence of Upper Cibolo Creek with Menger Creek. This site is on undeveloped land in the Cibolo Nature Center in Boerne, Texas. The banks of the creek are lined with cypress trees. There is a wastewater treatment plant effluent outfall in Menger Creek just before the confluence Upper Cibolo Creek.

Sampling Information

This site was monitored 199 times between 9/24/1999 and 4/19/2018. Sampling times typically occur in the morning between 8:30 and 10:00 and during the afternoon between 15:00 and 17:00.

Table 12: Descriptive parameters for Site 15126

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	191	443 ± 111	169	728
Water Temperature (°C)	199	19.8 ± 5.4	6.0	32.0
Dissolved Oxygen (mg/L)	187	6.7 ± 1.7	3.3	12.0
pH (su)	192	7.8 ± 0.8	7.0	8.8
E. coli (CFU/100mL)	19	115 ± 767	20	3540
Nitrate-Nitrogen (mg/L)	60	7.4 ± 4.9	0.0	15.0
Orthophosphate (mg/L)	19	2.7 ± 2.6	0.0	12.0
Turbidity (JTU)	59	1.82 ± 9.19	0.0	70.00

Site was sampled 157 times between 9/24/1999 and 4/19/2018.

Air and Water Temperature

Air and water temperatures were taken 199 and 192 times at this site, respectively. The mean water temperature was 19.8°C. Water temperature varied from a low of 6.0°C in January of

2018, to a high of 32.0°C in August of 2001. The air temperature varied from a low of 3.0°C in January 2008, to a high of 33.0°C in August of 2004.

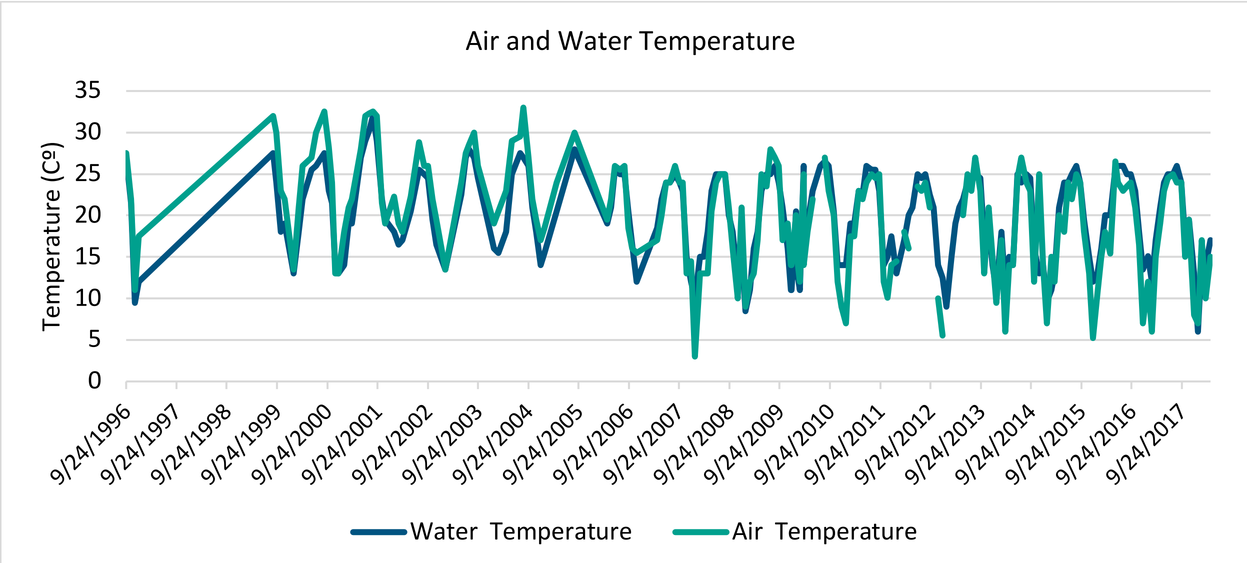

Figure 59: Air and water temperature at Site 15126

Total Dissolved Solids

Citizen scientists took a total of 191 TDS samples at this site 9/24/1999 and 4/19/2018. The mean TDS concentration was 443 mg/L. The concentration of TDS varied from a low of 169 mg/L in October in 2004, to a high of 728 mg/L in January 2014. There was a significant increase in TDS concentration over time at this location (P-Value = <0.0001). The R2 value of 0.1177 indicates that this relationship explains about 11.8% of the variability in the data.

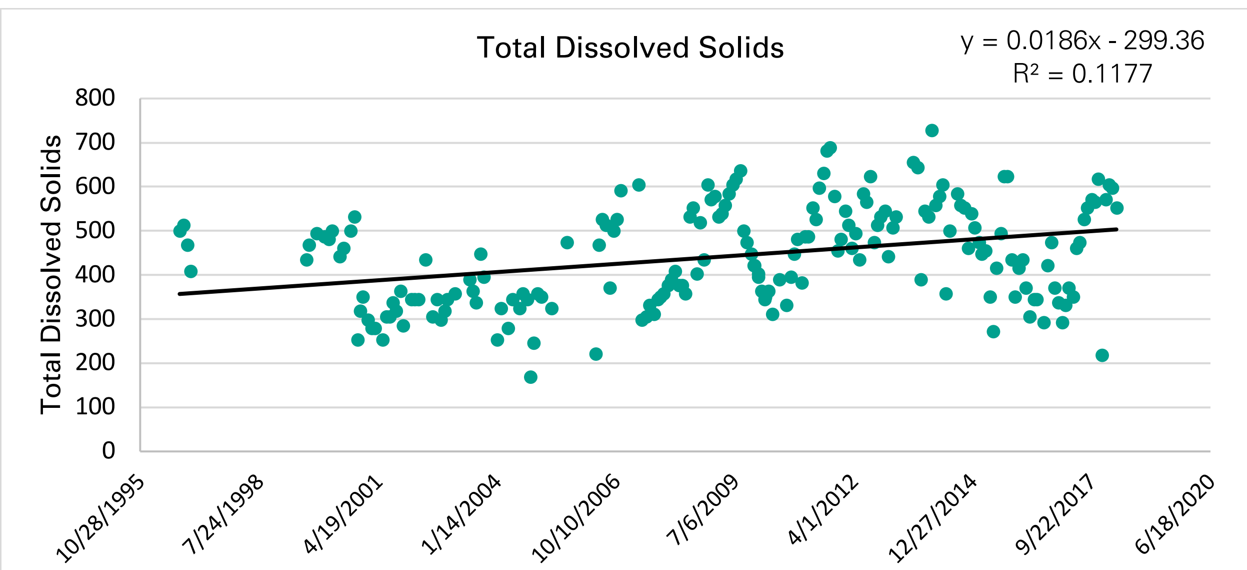

Figure 60: Total dissolved solids at Site 15126

Dissolved Oxygen

Citizen scientists took 187 DO samples at this site. The mean DO concentration was 6.7 mg/L. The minimum DO concentration was 3.3 mg/L and was taken in April of 2013. The maximum DO concentration was 12.0 mg/L and was taken in February of 2002. There was a significant decrease in DO concentrations over time observed at this site (P-Value = < 0.0001). The R^2 value of 0.3281 indicates that this relationship explains about 32.8% of the variability in the data.

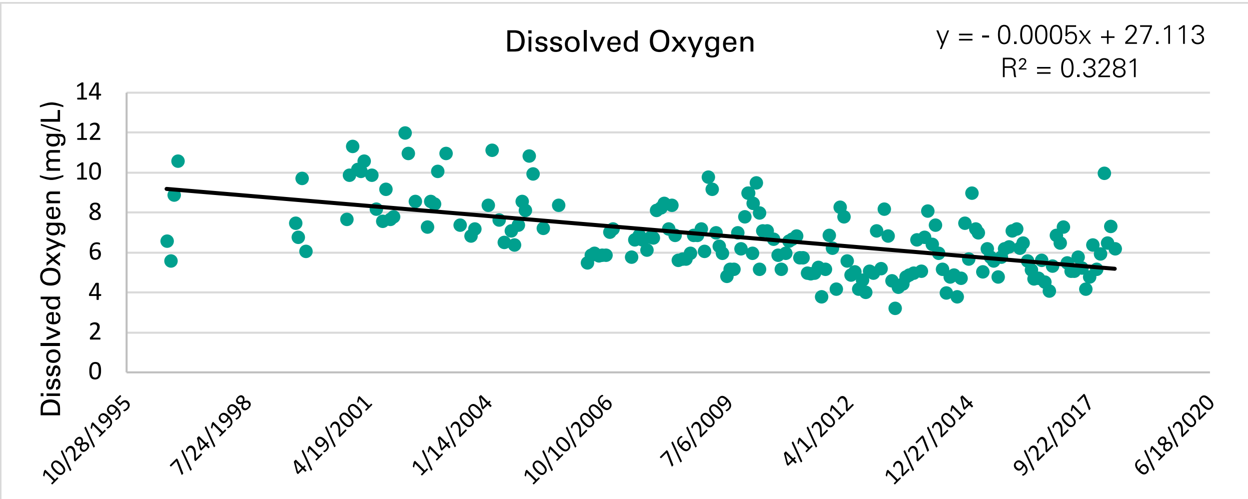

Figure 61: Dissolved oxygen at Site 15126

pH

Citizen scientists took 190 pH measurements at this site. The mean pH was 7.9. The pH ranged from a low of 7.0 in April and August of 2013 to a high of 8.8 in April of 2016. There was a significant decrease in pH over time observed at this site (P-Value = 0.0106). The R^2 value of 0.0342 indicated a small correlation between pH and time.

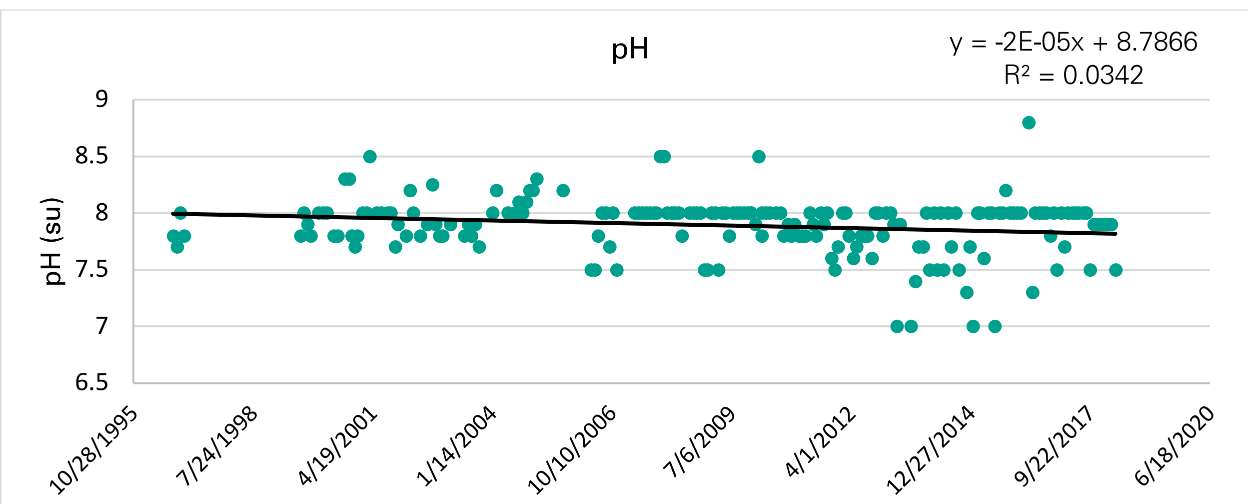

Figure 62: pH at Site 15126

E. coli

Citizen scientists collected 19 *E. coli* samples at this site between 9/24/1999 and 4/19/2018. The geomean for *E. coli* was 115 CFU/100 mL. The minimum *E. coli* count was 20 CFU/100 mL and was recorded in December of 2017. The maximum *E. coli* count was 3540 CFU/100 mL and was collected in June of 2015. There was no significant trend in *E. coli* over time observed at this site (P-Value = 0.789). The R^2 value of 0.0043 indicated a small correlation between CFU/100 mL and time.

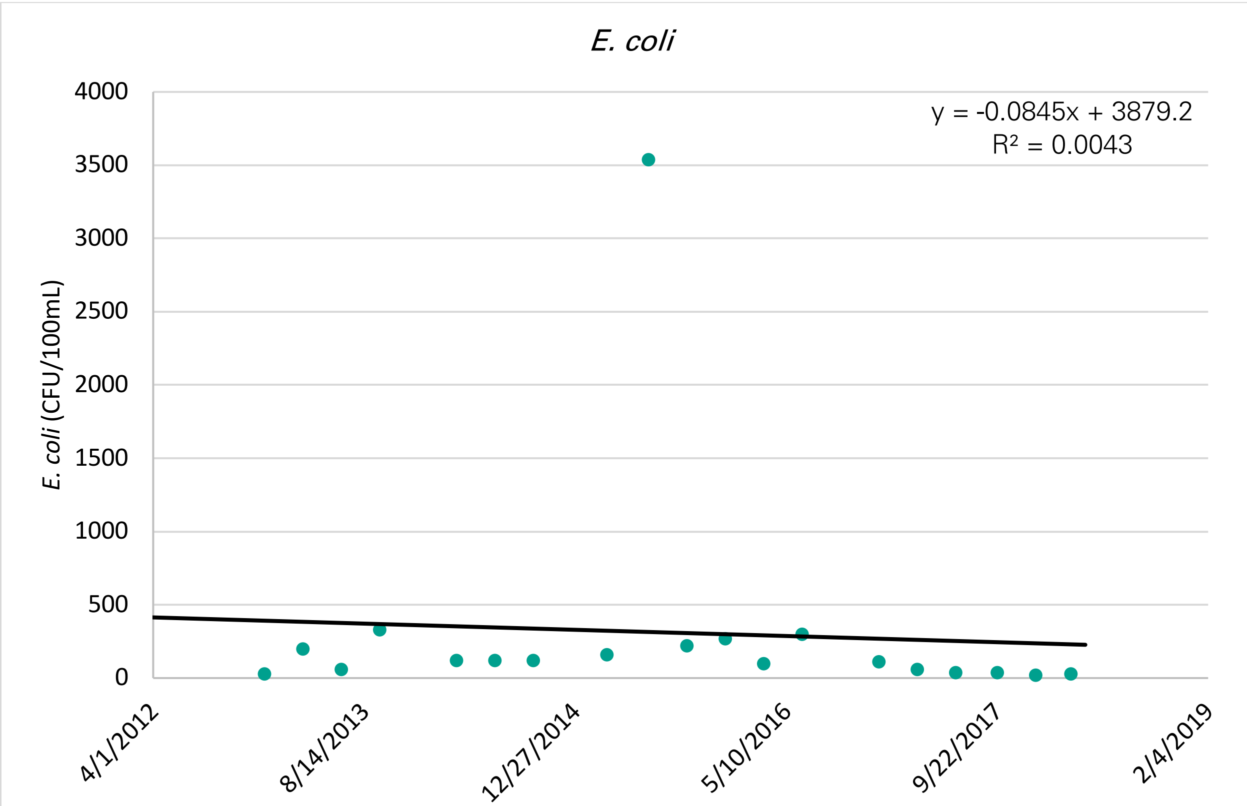

Figure 63: *E. coli* at Site 15126

Nitrate-Nitrogen

Citizen scientists collected 60 nitrate-nitrogen samples at this site between 9/24/1999 and 4/19/2018. The mean nitrate-nitrogen concentration was 7.4 mg/L. Nitrate-nitrogen ranged in concentration from 0 mg/L in November of 2012 to a high of 15.0 mg/L taken on multiple occasions. There was no significant trend in nitrate-nitrogen over time observed at this site (P-Value = 0.607). The R^2 value of 0.0046 indicated a small correlation between nitrate-nitrogen and time.

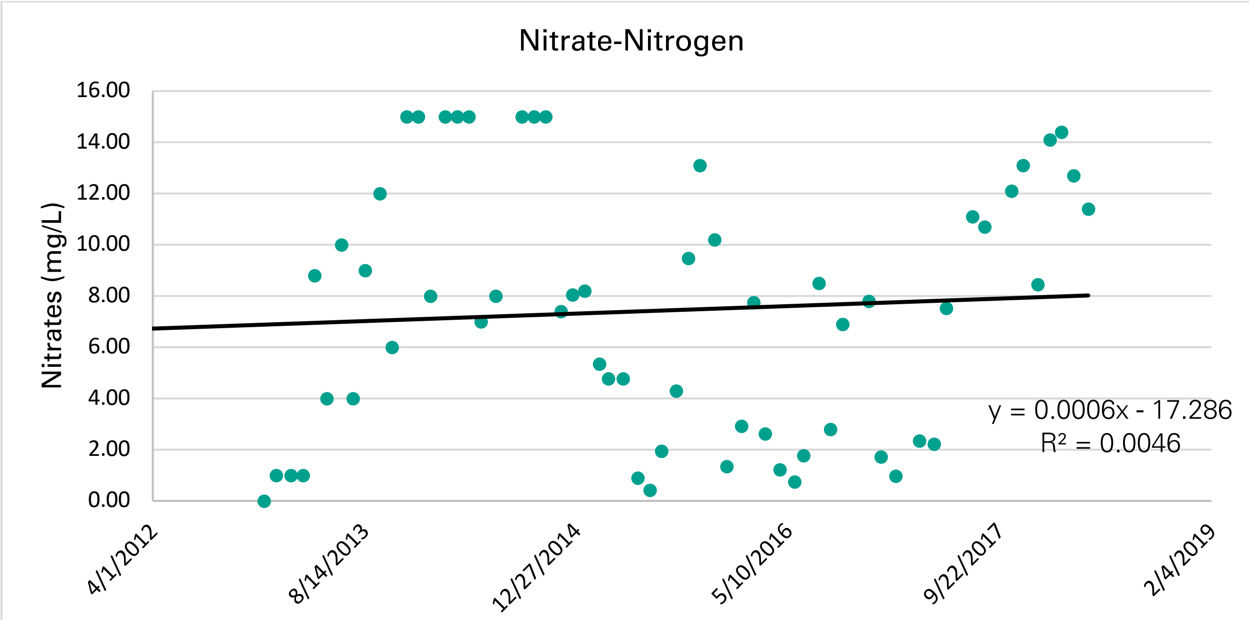

Figure 64: Nitrate-Nitrogen at Site 15126

Orthophosphate

Citizen scientists collected 60 orthophosphate samples at this site between 9/24/1999 and 4/19/2018. The mean orthophosphate concentration was 2.6 mg/L. Orthophosphate concentrations ranged from 0.0 mg/L to 12.0 mg/L recorded in November of 2016. There was no significant trend in orthophosphate over time observed at this site (P-Value = 0.749). The R^2 value of 0.0018 indicated a small correlation between orthophosphate and time.

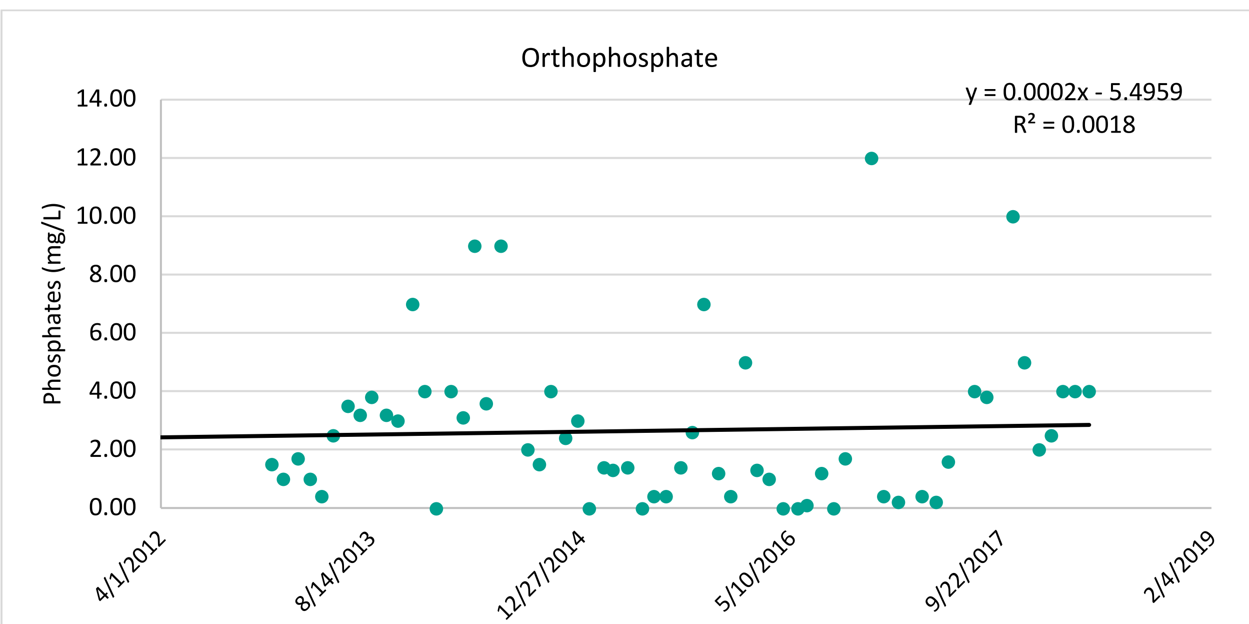

Figure 65: Orthophosphate at Site 15126

Secchi Disk and Total Depth

Secchi disk and total depth data was acquired at this site between 9/24/1999 and 4/19/2018a total of 162 and 197 times, respectively. The average total depth was calculated to be 0.36 m. In most cases, the Secchi disk depth was equal to the total depth, indicating that the bottom of the creek was visible through the water at this site.

Field Observations

The flow at this site was generally recorded as normal. Algae cover was variable ranging from no algae present to greater than 75% of the area covered in algae. Water color typically had no describable color, with a few occasions of water being described as tan, red, or brown. Water clarity was typically clear. The water usually had no discernible odor but when it did, was described as fishy or musky. One instance described a sewage smell to be present in July of 2006.

UPPER CIBOLO CREEK WATERSHED SUMMARY

TST citizen scientists monitored several water quality parameters from six different sites in the Upper Cibolo Creek Watershed from 1996 to 2018, including TDS, DO, pH levels, and *E. coli*. Data from the seven monitoring sites was analyzed to find trends over the monitoring periods. There were a few sampling events at Sites 80966, 80186, and 15126 with elevated *E. coli* levels reported above the standard for a single sample. The geometric mean at Site 20823 was 460 ± 978 CFU/100 mL, above the 126CFU/100mL standard. The highest *E. coli* quantities are within the area closely surrounded by the city center. The downstream area of Frederick Creek may be a problem area; and the variability of values at each site indicates the high likelihood of nonpoint source pollution. Besides seasonal variations, there were also statistically significant relationships between a decrease in DO levels and time at Sites 80186 and 15126. There were statistically significant relationships between an increase in DO levels and time at Sites 80904 and 20823. The Cibolo Creek Nature Center and citizen scientist monitoring group will continue to monitor the water quality of the Upper Cibolo Creek Watershed. Future work will consist of nutrient monitoring and rapid benthic macroinvertebrate bioassessments at sites where there are concerns. Cibolo Nature Center will continue to support existing TST citizen scientists with core supplies for local citizen scientists to collect and test samples for water quality. Additionally, the Cibolo Nature Center will continue to create new TST monitoring sites and activate existing sites.

GET INVOLVED WITH TEXAS STREAM TEAM!

Once trained, citizen scientists can directly participate in monitoring by communicating their data to various stakeholders. Some options include: participating in the Clean Rivers Program (CRP) Steering Committee Process, providing information during “public comment” periods, attending city council and advisory panel meetings, developing relations with local TCEQ and river authority water specialists, and, if necessary, filing complaints with environmental agencies, contacting elected representatives and media, or starting organized local efforts to address areas of concern.

The Texas Clean Rivers Act established a way for the citizens of Texas to participate in building the foundation for effective statewide watershed planning activities. Each CRP partner agency has established a steering committee to set priorities within its basin. These committees bring together the diverse stakeholder interests in each basin and watershed. Steering committee participants include representatives from the public, government, industry, business, agriculture, and environmental groups. The steering committee is designed to allow local concerns to be addressed and regional solutions to be formulated. For more information about participating in these steering committee meetings, please contact the appropriate CRP partner agency for your river basin at: http://www.tceq.state.tx.us/compliance/monitoring/crp/partners.html. Currently, TST is working with various public and private organizations to facilitate data and information sharing. One component of this process includes interacting with watershed stakeholders at CRP steering committee meetings. A major function of these meetings is to discuss water quality issues and to obtain input from the general public. While participation in this process may not bring about instantaneous results, it is a great place to begin making institutional connections and to learn how to become involved in the assessment and protection system that Texas agencies use to keep water resources healthy and sustainable.

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APPENDIX A- LIST OF MAPS, TABLES, AND FIGURES

Tables

Figures