Cibolo Creek Watershed Data Report

August 2014

THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

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

Table of Contents

Introduction

Texas Stream Team is a volunteer-based citizen 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.

Texas Stream Team citizen scientist data are not used by the state to assess whether water bodies are meeting the designated surface water quality standards. Texas Stream Team citizen scientists use different methods than the professional water quality monitoring community. These methods are utilized by Texas Stream Team due to higher equipment costs, training requirements, and stringent laboratory procedures that are required of the professional community. As a result, Texas Stream Team data do not have the same accuracy or precision as professional data, and is not directly comparable. However, the data collected by Texas Stream Team provides valuable records, often collected in portions of a water body that professionals are not able to monitor at all, or monitor as frequently. 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 Volunteer Water Quality Monitoring Manual
- Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring Procedures

The information that Texas Stream Team citizen scientists collect is covered under a TCEQ approved Quality Assurance Project Plan (QAPP) to ensure that a standard set of methods are used. All data used in watershed data reports are screened by the Texas Stream Team 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 Texas Stream Team 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 partner reports, such as Basin Summary Reports and Highlight Reports
- TCEQ Total Maximum Daily Load reports
- TCEQ and Texas State Soil and Water Conservation Board Nonpoint Source Program funded reports, including Watershed Protection Plans

Questions regarding this watershed data report should be directed to the Texas Stream Team at (512) 245-1346.

Watershed Location and Physical Description

Location and Climate

Cibolo Creek springs up in Kendall County, about ten miles northwest of Boerne (Texas State Historical Association (TSHA)). It flows for 100 miles through Kendall, Bexar, Comal, Guadalupe, Wilson, and Karnes Counties, forming the Bexar County line between Guadalupe and Comal Counties (Texas Parks & Wildlife Department (TPWD) "An Analysis of Texas Waterways"; TSHA). The creek deposits into the San Antonio River in Karnes County, five miles northwest of Karnes City (TSHA). The creek flows through several different ecological areas. Its path through Kendall and Comal Counties is in the Edwards Plateau ecoregion (TPWD "Region 7 – Edwards Plateau"). In Bexar, Wilson, and Karnes Counties it flows through the South Brushland ecoregion (TPWD "Region 8 – South Texas Brushlands"). The section in Guadalupe County is located in the Blackland Prairie Ecoregion (TPWD "Region 3 – Oaks and Prairies"). The creek has average ambient temperatures of around 22.78°C with sporadic rains averaging between 15 and 33 inches of annual precipitation (TPWD "Ecoregion 7 – Edwards Plateau").

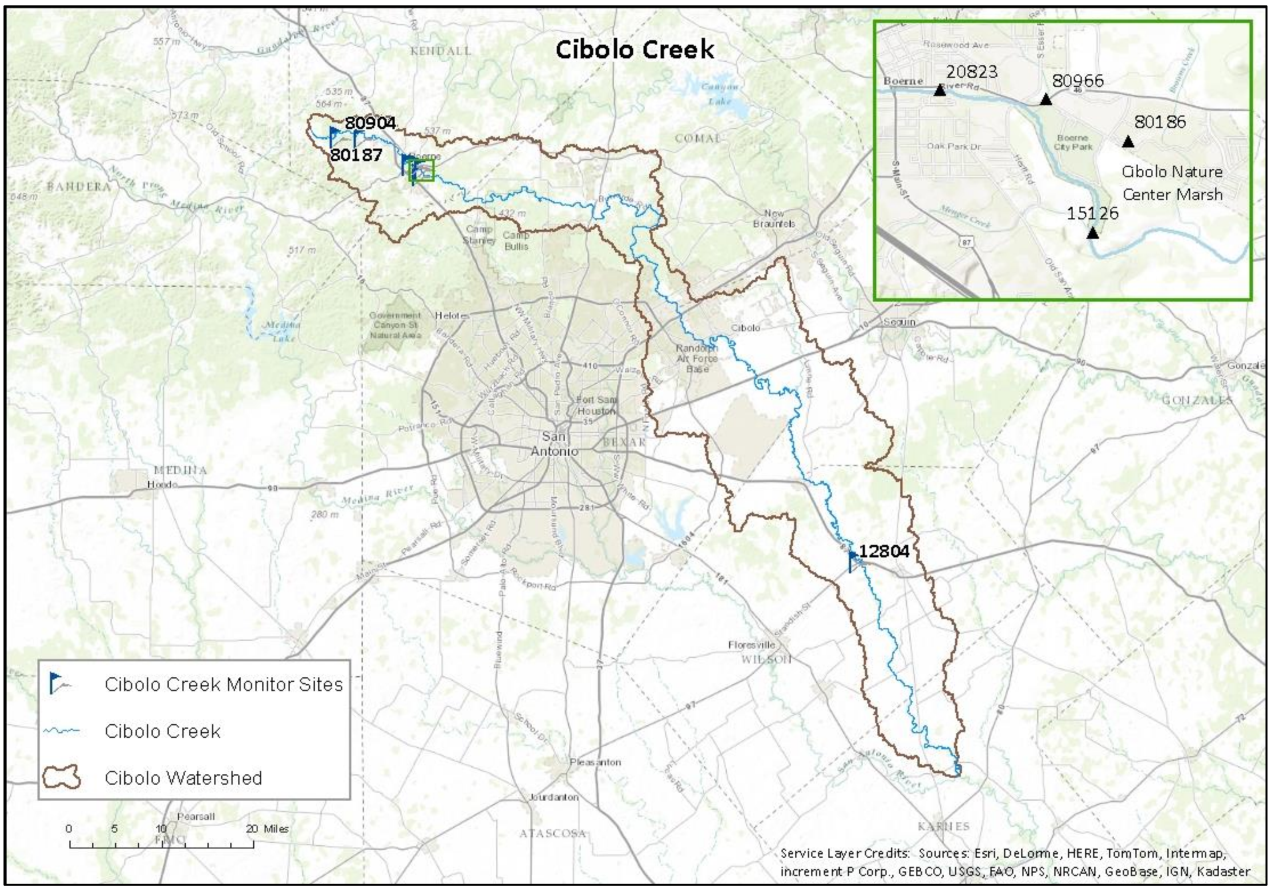

Figure 1: Map of the Cibolo Creek Watershed with Texas Stream Team Monitor Sites

Physical Description and Land Use

Cibolo Creek recharges the Trinity and Edwards Aquifer, which are the primary water sources of San Antonio and the surrounding Hill Country (Cibolo Nature Center (CNC)). As mentioned, Cibolo creek runs through several distinct ecological regions and has different types of vegetation associated with each of those regions. In the northern part of the stream in the Edwards Plateau, Ash juniper, oak and mesquite trees are dominant (TPWD "Ecoregion 7 – Edwards Plateau"). The portion in Guadalupe County has more pecan, cedar and oak trees with little and big blue stem grasses (TPWD "Ecoregion 4 – The Blackland Praries"). The southern portion in the South Brushlands has more shrubs and thorny low-growing woody vegetation (TPWD "Ecoregion 6 – South Texas Brush Country"). The creek is also home to catfish, sunfish, and white bass (CNC). Honey Comb Rock and Cascade Cavern are two unique geologic features located along Cibolo creek near Boerne (TPWD "An Analysis of Texas Waterways"). Lower Cibolo Creek is approved from primary water contact including swimming, fishing, and kayaking (Texas Commission on Environmental Quality (TCEQ) "Lower Cibolo Creek").The region around 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).

History

Cibolo Creek has had many different names in its history. Before European settlement and naming it was called "Xoloton" by Coahuiltecan Indians and "Bata Coniquiyoqui" by Tonkawa Indians (TSHA). Several Spanish settlers also had several 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).

Watershed Protection Plan

In September of 2013, the Upper Cibolo Creek Watershed Protection Plan was approved by the Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality (TCEQ) (City of Boerne). Upper Cibolo Creek has had a history of elevated bacteria levels and low dissolved oxygen levels and was listed on the Texas Water Quality Inventory and 303(d) List of impaired water bodies in 1999 (City of Boerne). The watershed protection plan targets point and non-point sources of bacteria and other pollutants through monitoring and best management practices to improve water quality and restore its approval for contact recreation activities (TCEQ "Upper Cibolo Creek Watershed Protection Plan").

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 Dissolved Oxygen (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.

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 micro Siemens per cubic centimeter ($\mu S/cm^3$). A body of water is more conductive if it has more dissolved solids 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 Total Dissolved Solids (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 results 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 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 a 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 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 nitrates, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with the 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 above under the "Dissolved Oxygen" section. Nitrates dissolve more readily than phosphates, 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 Texas Stream Team 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 Texas Stream Team's approved Quality Assurance Project Plan (QAPP).

Table 1: Sample Storage, Preservation, and Handling Requirements

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

*Preservation performed within 15 minutes of collection.

Processes to Prevent Contamination

Procedures documented in Texas Stream Team 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 (QC) 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 Texas Stream Team.

Sampling is still encouraged with expired reagents and bacteria media; however, the corresponding values will be flagged in the database. Detailed observational data are 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 monitors collect field data and report the measurement results on Texas Stream Team approved physical or electronic datasheet. The physical data sheet is submitted to the Texas Stream Team and local partner, if applicable. The electronic datasheet is accessible in the online DataViewer and, upon submission and verification, is uploaded directly to the Texas Stream Team Database.

Quality Assurance & Quality Control

All data are reviewed to ensure that they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to specified monitoring procedures and project specifications. 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 Texas Stream Team 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 are verified and evaluated against project specifications and are 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 Texas Stream Team 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 Texas Stream Team Program Manager. If repeated errors occur, the monitor and/or the group leader will be notified via e-mail or telephone.

Data Analysis Methods

Data are 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 are 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 & 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 2010 Texas Surface Water Quality Standards report was used to calculate the exceedances for the Cibolo Creek Watershed, as seen below in Table 2.

Table 2: Summary of Surface Water Quality Standards for Cibolo Creek Watershed

Parameter	Texas Surface Water Quality Standard 2014
Water Temperature (°C)	32.2
Total Dissolved Solids (mg/L)	600
Dissolved Oxygen (mg/L)	5.0
pH (su)	6.5-9.0
E.coli (CFU/100 mL)	126 (geomean during sampling period)

Methods of Analysis

All data collected from Cibolo Creek and its tributaries were exported from the Texas Stream Team database and were then grouped by site. Data was reviewed and, for the sake of data analysis, only one sampling event per month, per site was selected for the entire study duration. If more than one sampling event occurred per month, 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. 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.

Cibolo Creek Watershed Data Analysis

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. For 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.

Cibolo Creek Watershed Trends over Time

Sampling Trends over Time

Sampling along Cibolo Creek began in September of 1996 and continues to this day. A total of 407 individual monitoring events from 7 sites were analyzed. There was no monitoring occurring in 1997 and 1998, and monitoring in this watershed increased in 2012 with the addition of new sites. Monthly monitoring occurred on a consistent basis throughout the years. The time of sampling ranged from 08:00 to 19:00 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.

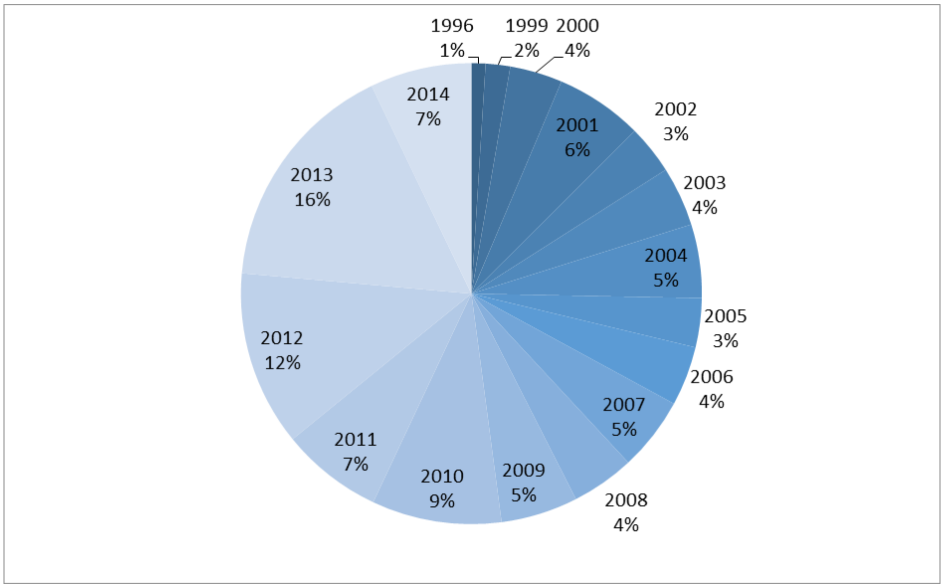

Figure 2: Breakdown of monitoring events by year.

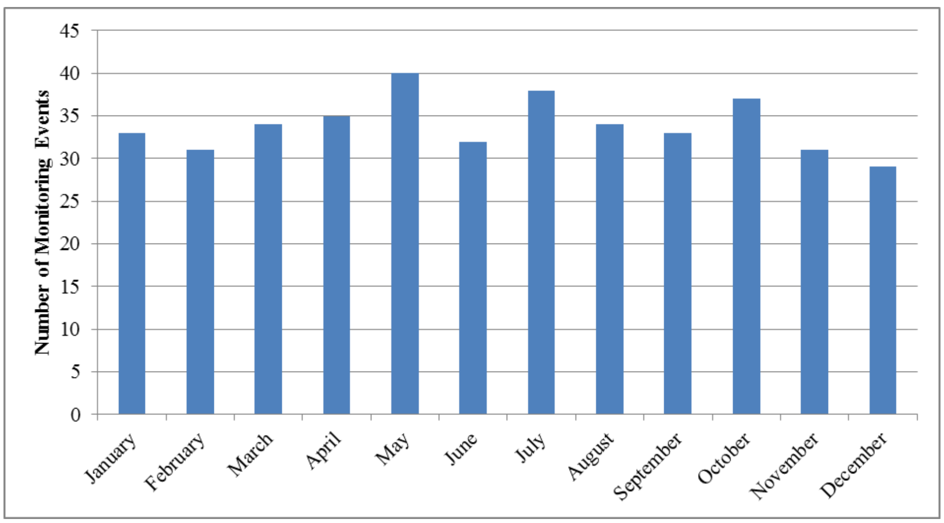

Figure 3: Breakdown of monitoring events by month in the Cibolo Creek Watershed

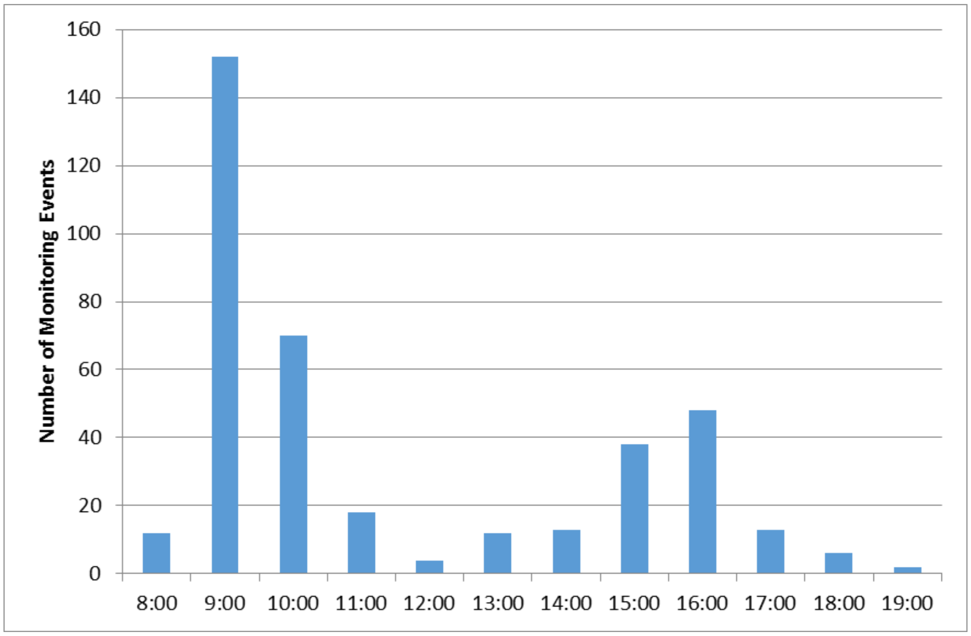

Figure 4: Breakdown of time of monitoring in the Cibolo Creek Watershed

Table 3: Descriptive parameters for all sites in the Cibolo Creek Watershed

Cibolo Creek Watershed September 1996 – July 2014				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	381	378 ± 131	137	728
Water Temperature (°C)	401	20.0 ± 6.0	0.0	35.0
Dissolved Oxygen (mg/L)	378	6.9 ± 2.2	1.0	13.7
pH	379	7.9 ± 0.3	6.9	8.6
E. coli	29	75	0	2520
Nitrates	55	7.4 ± 6.4	0.0	15.0
Phosphates	55	4.6 ± 5.3	0.0	16.0

There were a total of 407 sampling events between 9/24/1996 and 07/17/2014. 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 401 air and water temperatures were collected in the Cibolo Creek Watershed between 1996 and 2014. Water temperature exceeded the TCEQ optimal temperature of 32.2°C only twice during this time. Air temperature varied between 0 and 37°C.

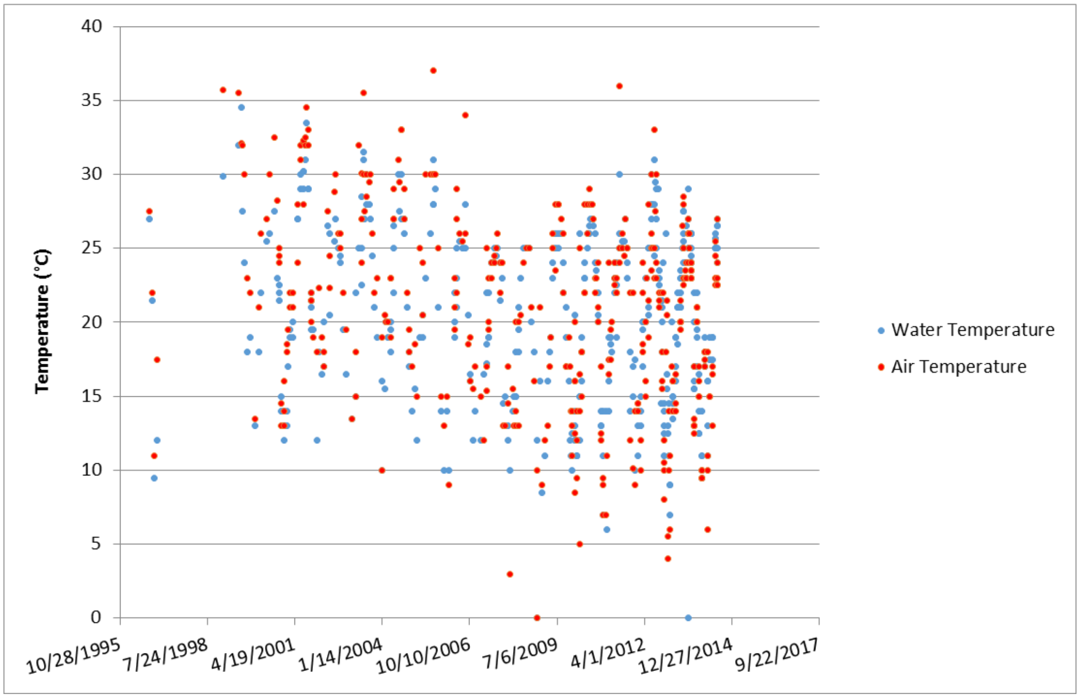

Figure 5: Air and water temperature over time at all sites within the Cibolo Creek Watershed

Total Dissolved Solids

Citizen scientists collected 381 TDS samples within the watershed. The TDS measurement was completed for 93.6% of all monitoring events. The average TDS measurement for all sites was 378 mg/L. There was a significant increase in TDS concentrations over time detected in this watershed ($p = 0.000$). However, the low R^2 value of 0.06 indicates that this relationship only accounts for about 6% of the variation in the data.

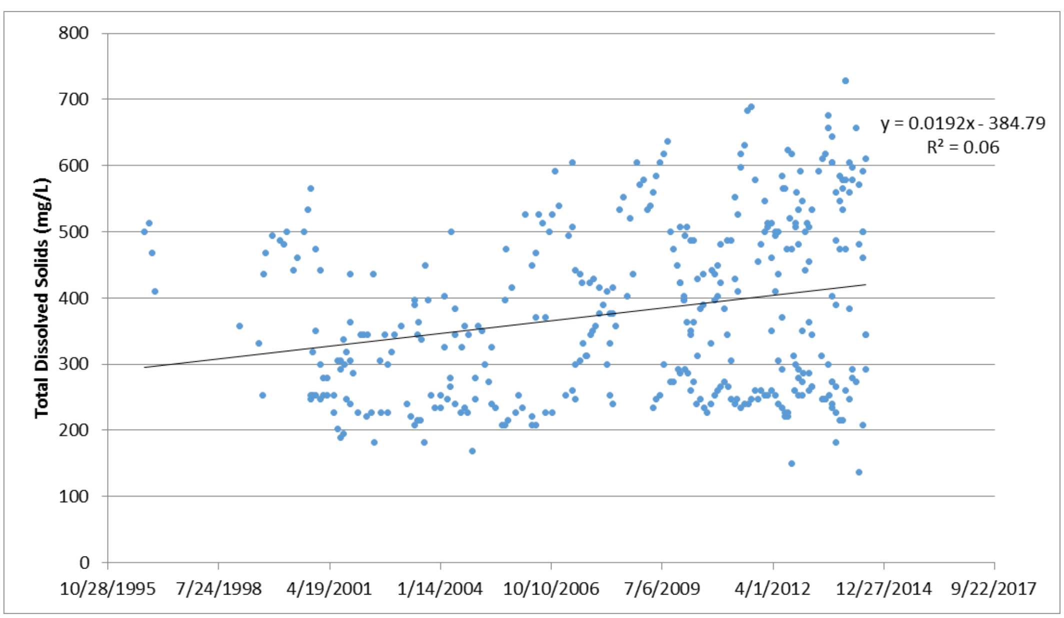

Figure 6: Total Dissolved Solids over time at all sites within the Cibolo Creek Watershed

Dissolved Oxygen

Citizen scientists collected a total of 378 DO samples in the Cibolo Creek Watershed. The mean DO was 6.9 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. 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 4.

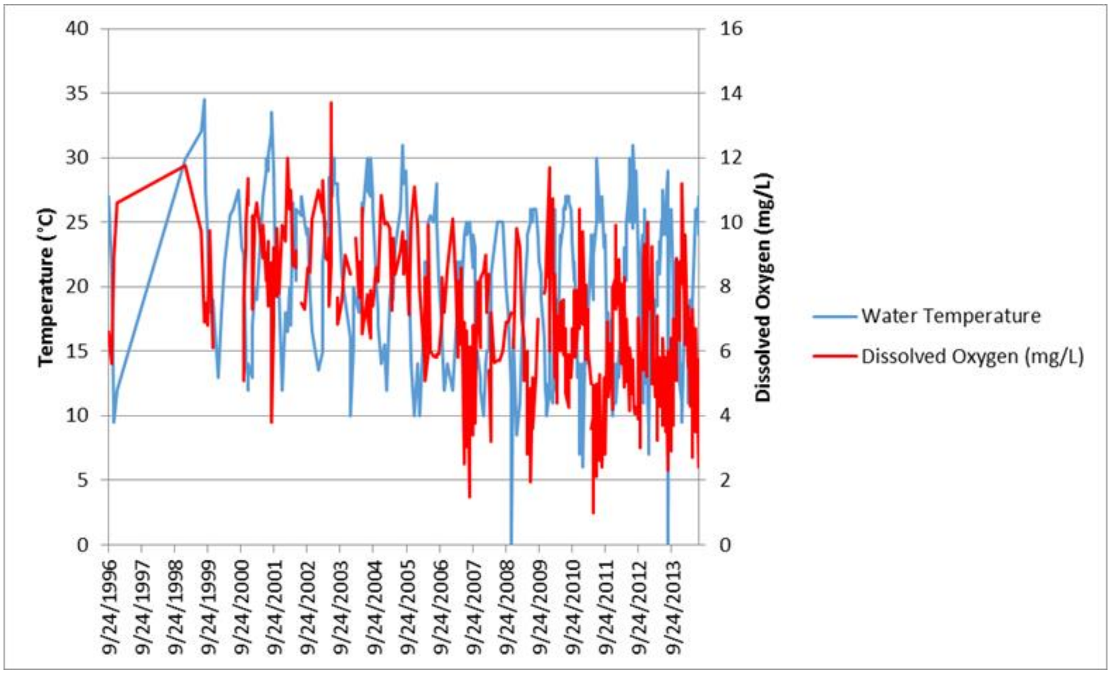

Figure 7: Dissolved oxygen and water temperature over time at all sites in the Cibolo Creek Watershed

Table 4: Average Dissolved Oxygen values by Sampling Time within the Cibolo Creek Watershed

Time	Average DO (mg/L)	Standard Deviation
08:00 – 09:00	6.7	1.9
09:00 – 10:00	6.1	1.9
10:00 – 11:00	6.3	1.9
11:00 – 12:00	6.9	1.5
12:00 – 13:00	7.7	1.2
13:00 – 14:00	8.9	1.7
14:00 – 1500	8.0	1.8
15:00 – 16:00	9.1	1.8
16:00 – 17:00	8.5	1.6
17:00 – 18:00	7.5	1.4

pH

The pH was measured for 93.1% of all sampling events in the watershed. The mean pH was 7.9 and it ranged from 6.9 to 8.6 for all sites. There was a significant decrease in pH over time observed in the watershed ($p = 0.000$). The low R^2 value of 0.092 indicates that this relationship explains only about 9.2% of the variation in the data.

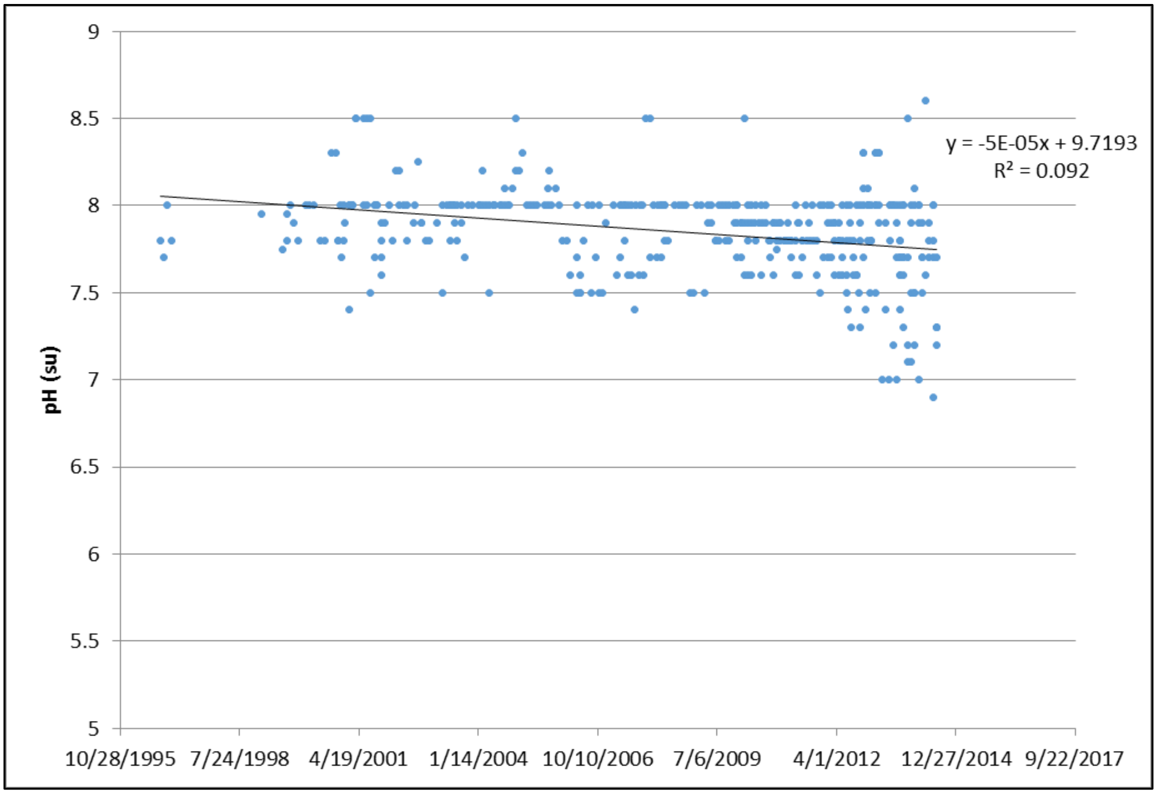

Figure 8: pH over time at all sites within the Cibolo Creek Watershed

E. coli Bacteria

E. coli samples were taken at 3 of the 7 sites in the Cibolo Creek Watershed. A total of 29 E. coli samples were taken. The geomean for E. coli was 75 CFU/100 mL. The E. coli counts ranged from 0 CFU/100 mL to a high of 2520 CFU/100 mL in December of 2012. There was no significant trend in E. coli over time detected.

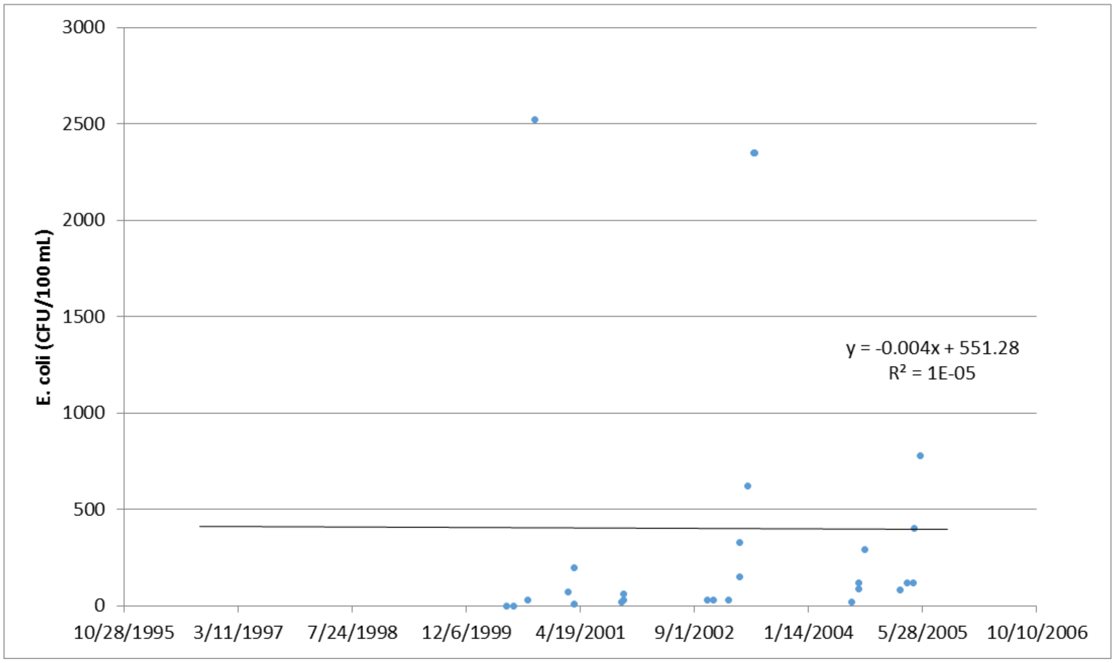

Figure 9: E. coli over time at all sites within the Cibolo Creek Watershed

Orthophosphate

Phosphate samples were taken at 3 of the 7 sites. A total of 55 phosphate samples were taken. The mean concentration for phosphates in the watershed was 4.6 mg/L. Phosphate concentrations ranged from 0 mg/L to a high of 16.0 mg/L in June of 2014. There was a significant increase in phosphate concentrations over time observed in the watershed ($p = 0.013$). The R^2 value of 0.1119 indicates that this relationship explains about 11.1% of the variation in the data.

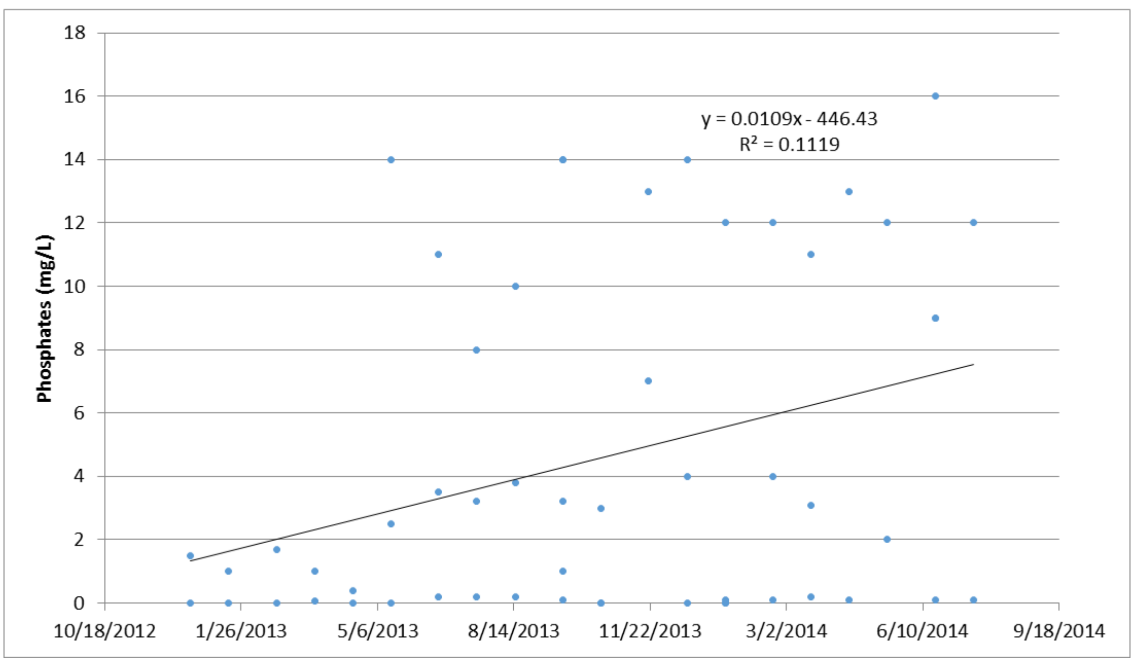

Figure 10: Phosphates over time at all sites within the Cibolo Creek Watershed

Nitrate-Nitrogen

Nitrate concentrations were taken sampled at 3 of the 7 sites in the watershed. A total of 55 nitrate samples were taken. The mean nitrate concentration in the watershed was 7.4 mg/L and nitrates ranged from 0.0 mg/L to a high of 15.0mg/L. There was a significant increase in nitrates over time observed in this watershed (p=0.012). The R^2 value of 0.1138 indicates that this relationship explains about 11.4% of the variation in the data.

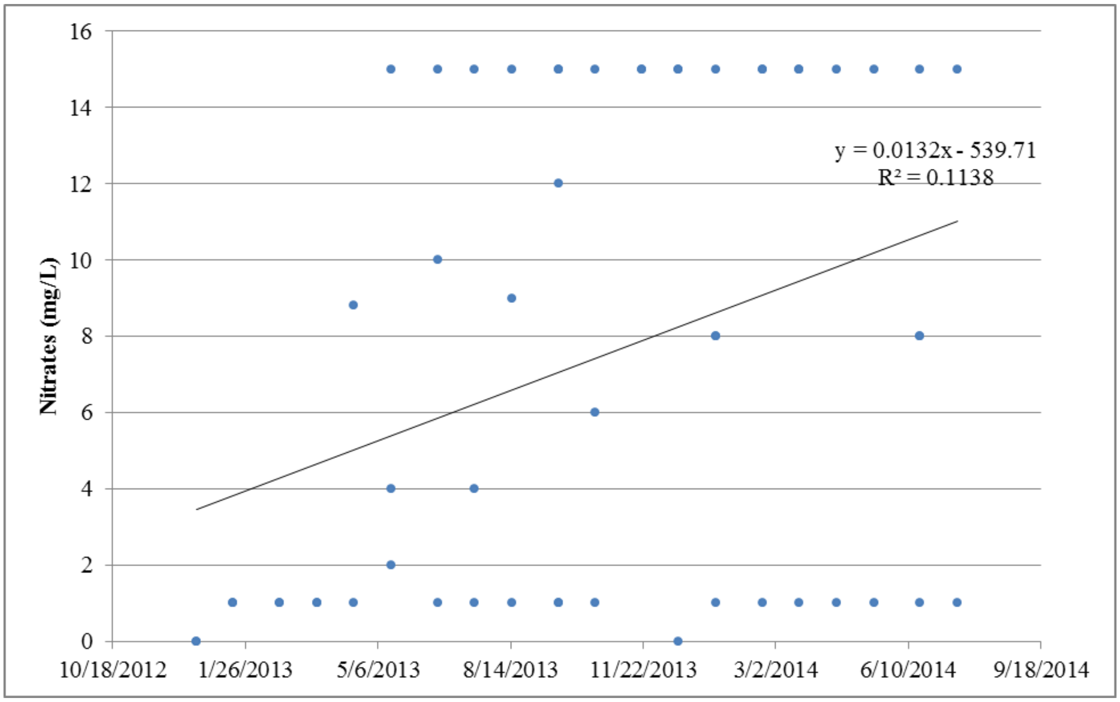

Figure 11: Nitrates over time at all sites within the Cibolo Creek Watershed

Cibolo Creek Upstream to Downstream Trends

Total Dissolved Solids

There was a significant increase in TDS concentrations as one moves downstream in the watershed (p = 0.000). The R^2 value of 0.0867 indicates that this relationship explains about 8.7% of the variability in the data.

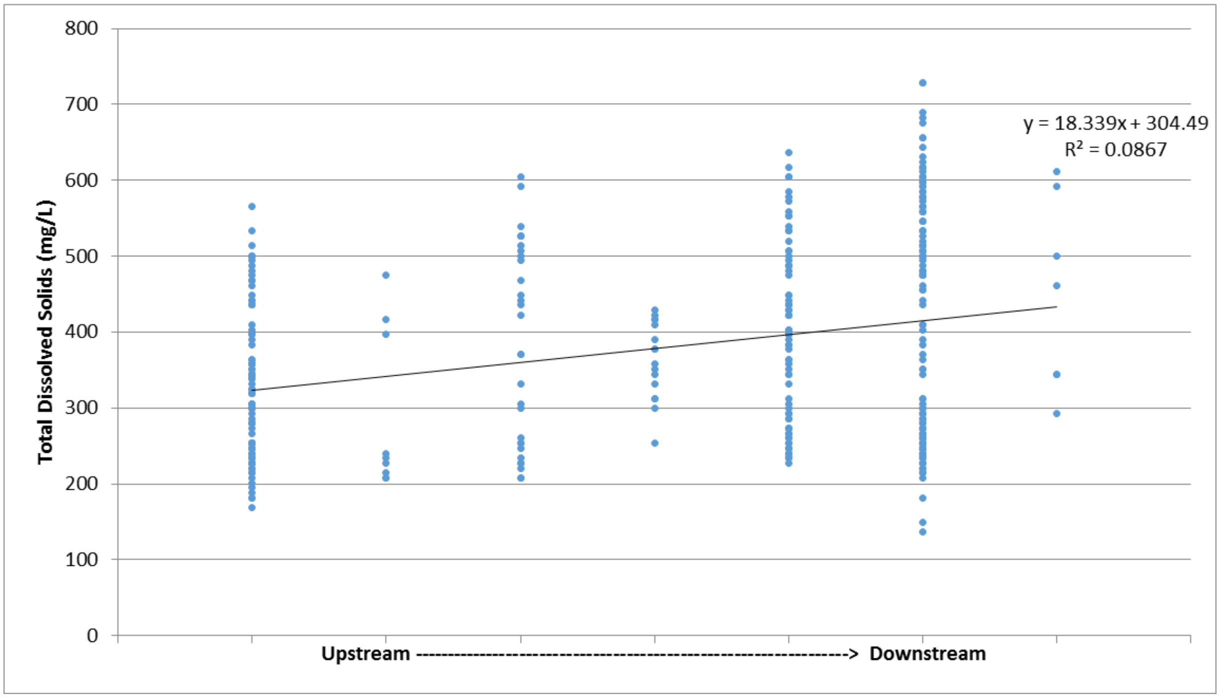

Figure 12: Upstream vs. downstream trends in Total Dissolved Solids in the Cibolo Creek Watershed

Dissolved Oxygen

There was no significant relationship in DO concentrations as one moves downstream in the watershed.

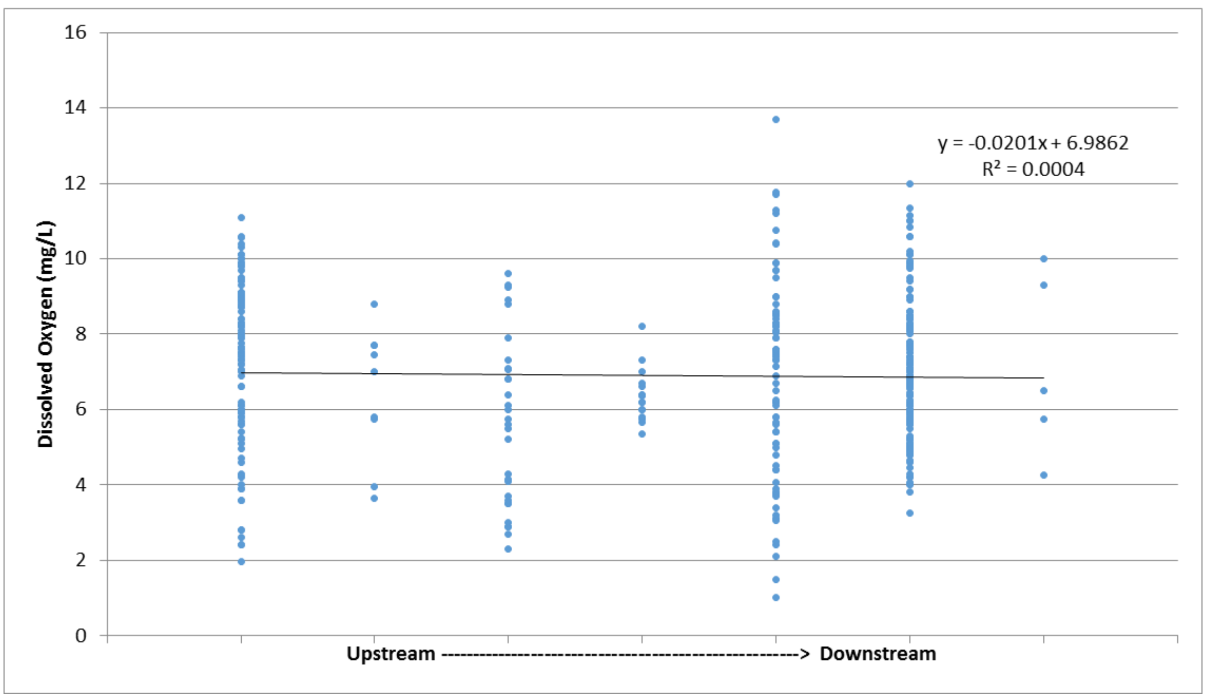

Figure 13: Upstream vs. downstream trends in Dissolved Oxygen in the Cibolo Creek Watershed

pH

There was a significant decrease in pH observed as one moves downstream in the watershed ($p = 0.000$). The R^2 value of 0.1024 indicates that this relationship explains about 10.2% of the data.

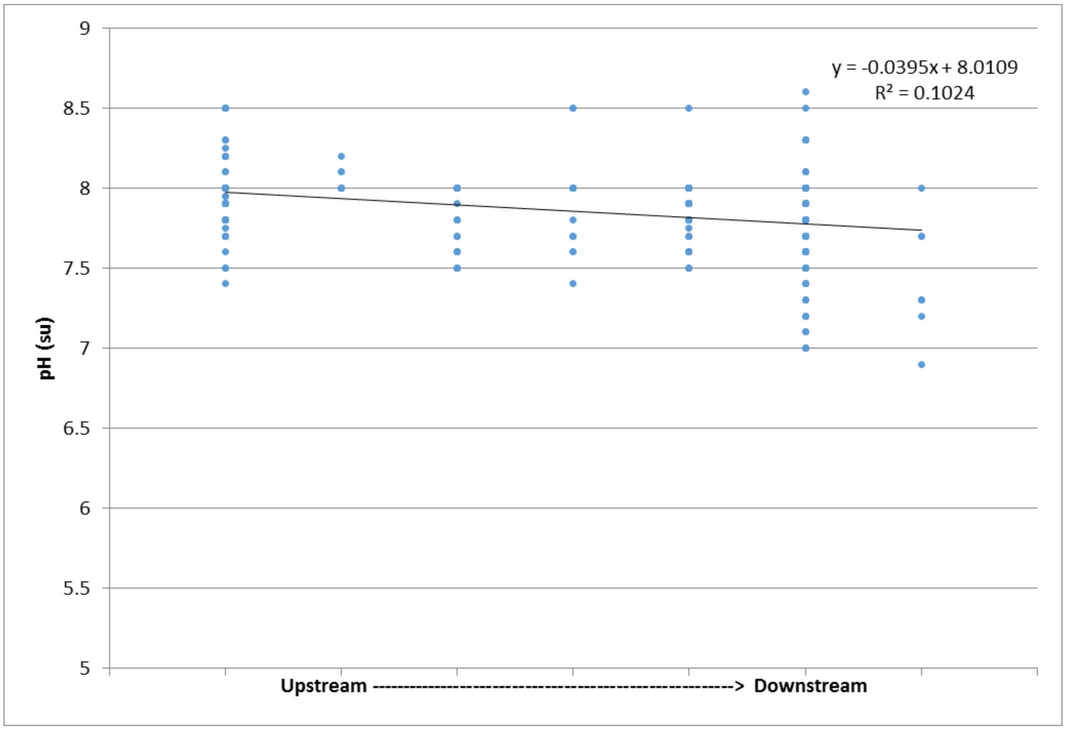

Figure 14: Upstream vs. downstream trends in pH in the Cibolo Creek Watershed

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 recorded in the watershed. These 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 602 ± 29 mg/L. Site 80187 had the lowest average TDS, with a result of 243 ± 23 mg/L.

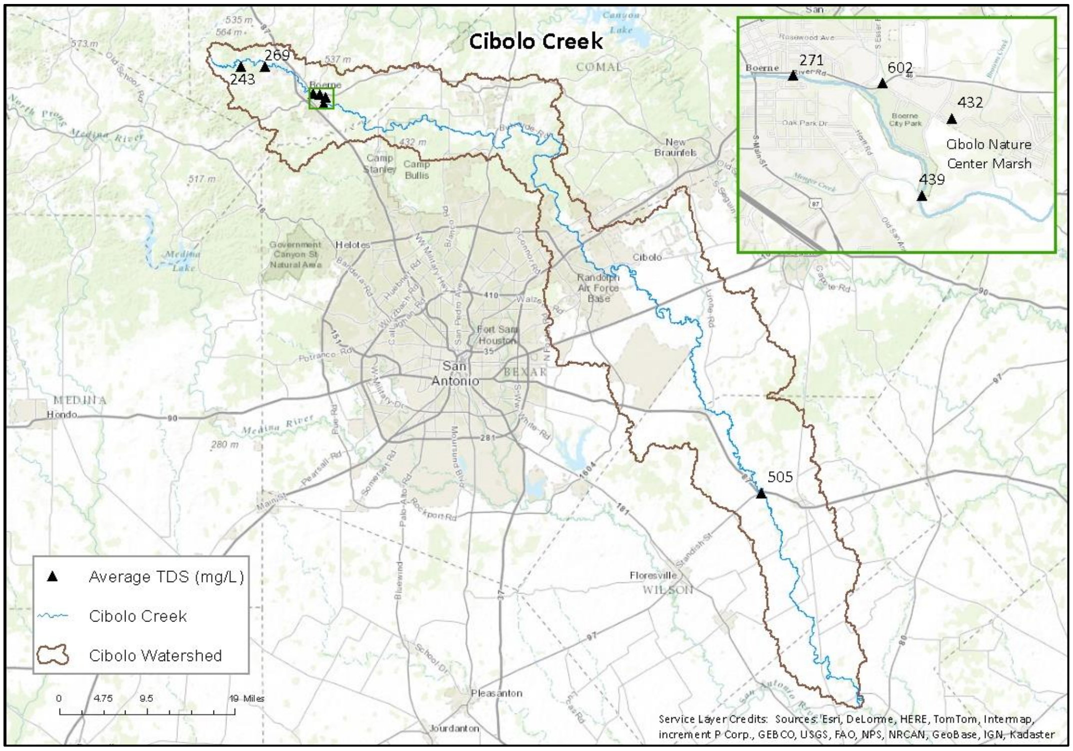

Figure 15: Map of the average total dissolved solids for sites in the Cibolo Creek Watershed

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 than 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 dissolved oxygen 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 5.7 ± 2.2 mg/L. Site 80187 had the highest average DO reading, with a result of 7.3 ± 2.2 mg/L.

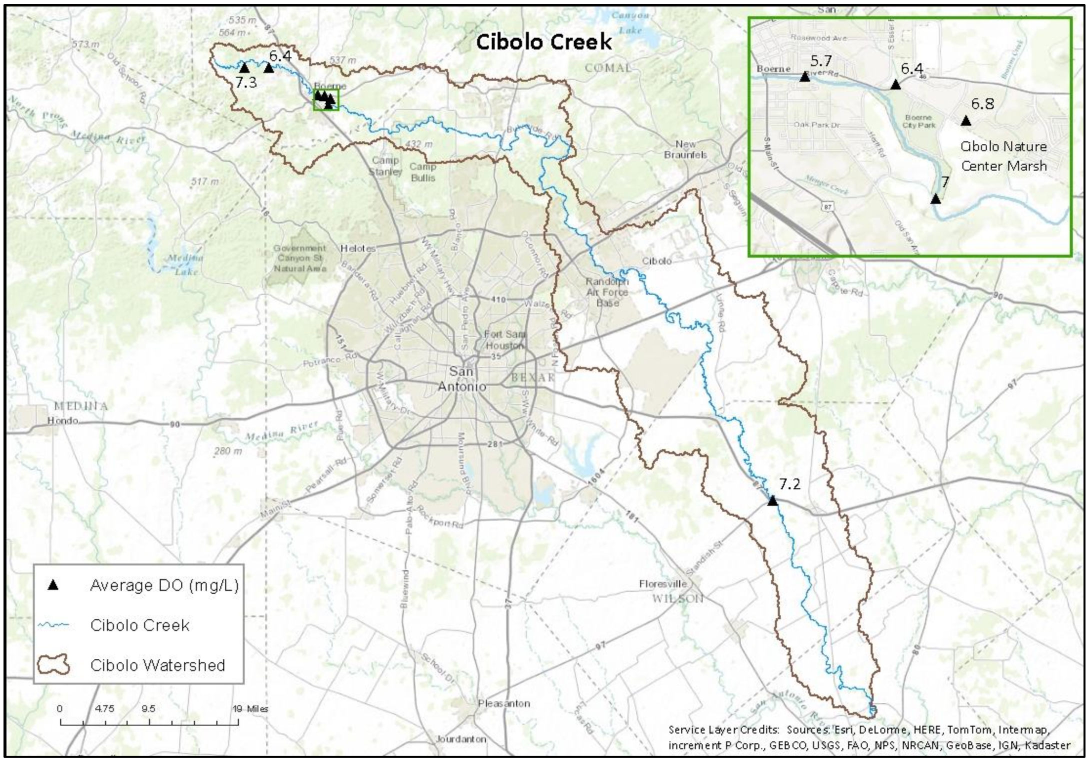

Figure 16: Map of the average dissolved oxygen concentration for sites in the Cibolo Creek Watershed

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 8.1 ± 0.2. Site 12804 had the lowest average pH level, with a result of 7.4 ±0.1.

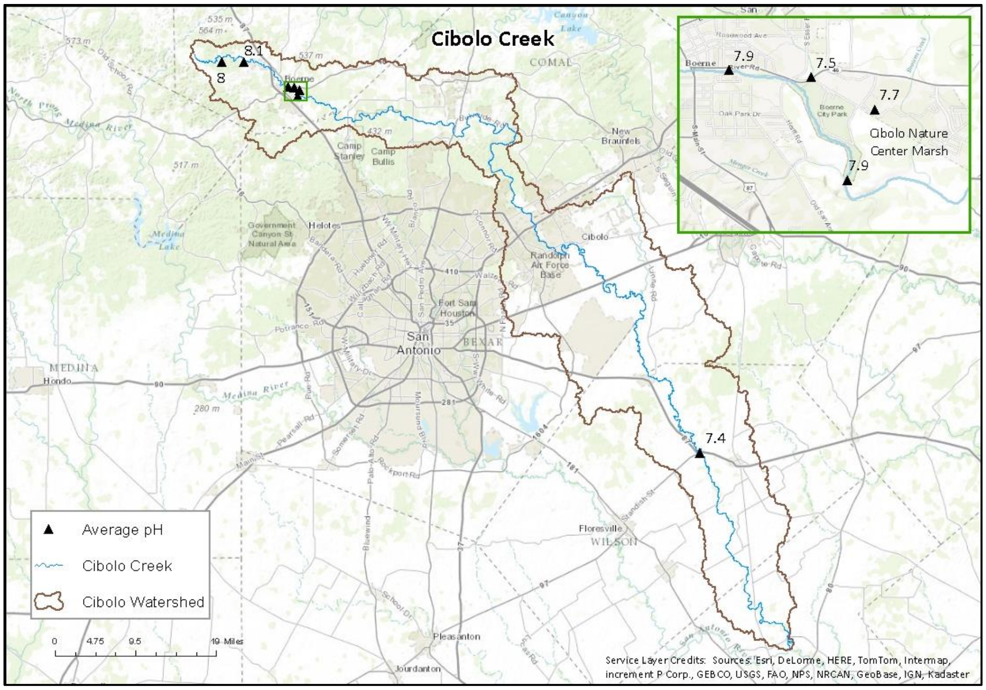

Figure 17: Map of the average pH for sites in the Cibolo Creek Watershed

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 which takes into account the high variability of parameters such as E. coli which can vary from zero to tens of thousands of CFU/100 mL. Site 20823 had the highest average geomean, with a result of 603 CFU/100mL. Site 15126 had the lowest average geomean, with at result of 111 CFU/100mL.

Nitrates and phosphates were measured for 3 of the 7 sites. Site 20823 had the minimum nitrate and phosphate concentrations with 0.95 mg/L and 0.22 mg/L respectively. Site 80966 had the highest nitrate and phosphates with concentrations of 15.0 mg/L and 11.6 mg/L respectively.

Please see Table 5 for a summary of average results at all sites. It is important to note that not all sites were tested for *E. coli.* Additionally, it is also 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. Texas Stream Team citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards.

Table 5: Average Values for all Cibolo Creek Watershed Sites

Site Number	TDS (mg/L)	DO (mg/L)	pH	E.coli (CFU/100 mL)	Nitrates (mg/L)	Phosphates (mg/L)
80187	243 ± 23 (min)	7.3 ± 2.2 (max)	8.0 ± 0.2	N/A	N/A	N/A
80904	268 ± 15	6.4 ± 1.7	8.1 ± 0.2 (max)	N/A	N/A	N/A
20823	271 ± 63	5.7 ± 2.2 (min)	7.9 ± 0.3	603 (max)	0.95 (min)	0.22 (min)
80966	602 ± 29 (max)	6.4 ± 0.7	7.5 ± 0.3	N/A	15.0 ± 0.0 (max)	11.6 ± 3.5 (max)
80186	432 ± 78	6.8 ± 2.7	7.7 ± 0.2	122	N/A	N/A
15126	439 ± 114	7.0 ± 1.8	7.9 ± 0.2	111 (min)	7.8 ± 5.0	3.2 ± 2.6
12804	505 ± 87	7.2 ± 2.2	7.4 ± 0.1 (min)	N/A	N/A	N/A

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

Site Description

This site is located in the upper reaches of Cibolo Creek. There is a road called Upper Cibolo Creek Road that runs along the creek. This site is at the fifth crossing of that 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 106 times between 10/27/2000 and 10/17/2013. The time of sampling for this site ranged from 09:00 to 18:00.

Table 6: Descriptive parameters for Site 80187

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	103	243 ± 23	182	299
Water Temperature (°C)	105	20.6 ± 6.3	6.0	31.0
Dissolved Oxygen (mg/L)	99	7.3 ± 2.2	2.0	11.1
pH	103	8.0 ± 0.2	7.5	8.5

Site was sampled 106 times between 10/27/2000 and 10/17/2013.

Air and water temperature

Air and water temperatures were taken 105 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 20.6°C and the water temperature ranged from a low of 6°C recorded in January of 2011, to a high of 31°C in July of 2012.

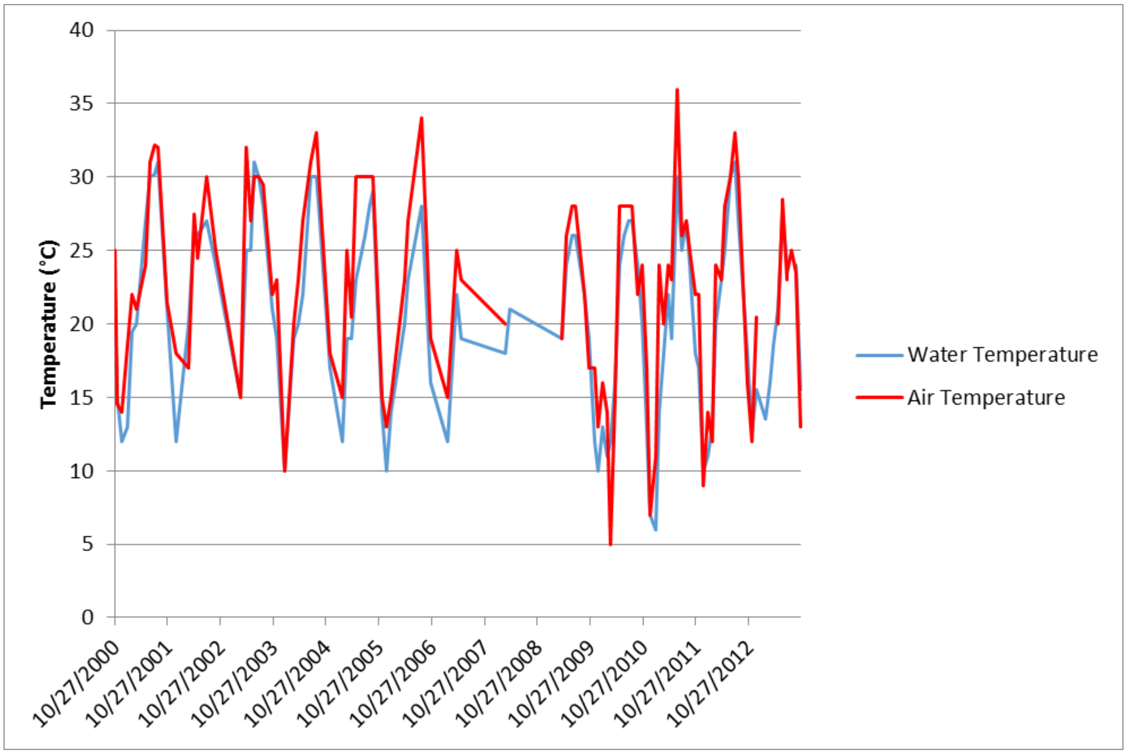

Figure 18: Air and Water Temperature at site 80187

Total Dissolved Solids

Citizen scientists sampled TDS at this site 103 times during the time period. The mean TDS concentration was 243 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. There was a significant increase in TDS concentrations over time observed at this site ($p = 0.000$). The R^2 value of 0.1535 indicated that this relationship explains about 15.4% of the variation in the data.

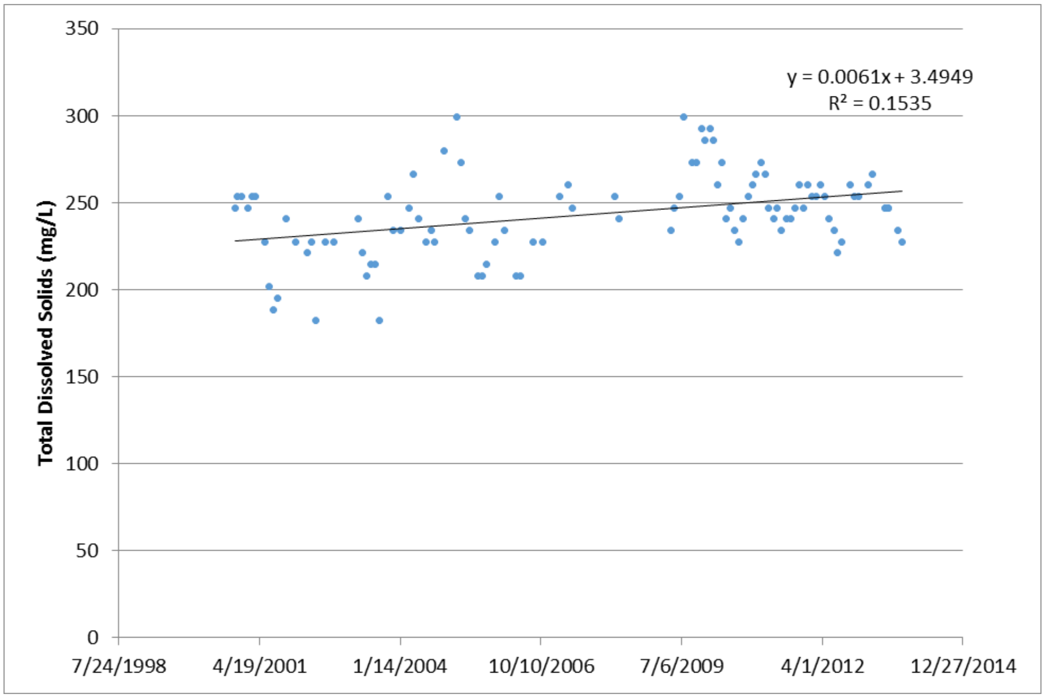

Figure 19: Total Dissolved Solids at site 80187

Dissolved Oxygen

Citizen scientists took 99 DO samples at this site. The mean DO concentration was 7.3 mg/L. Dissolved oxygen 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 dissolved oxygen over time observed at this site ($p = 0.000$). The relatively high R^2 value of 0.4268 indicates that this relationship explains about 42.6% of the variation in the data.

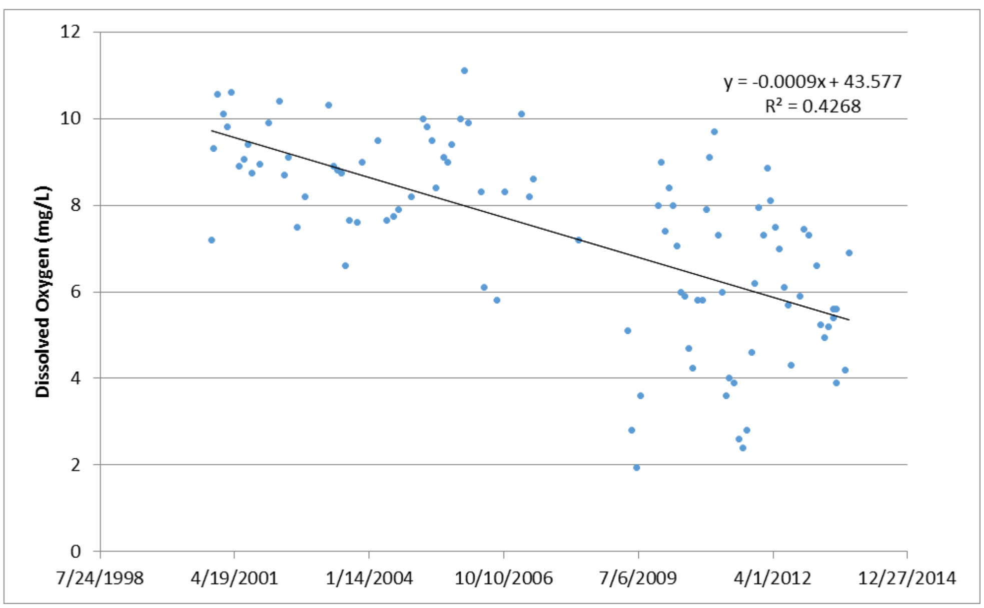

Figure 20: Dissolved Oxygen at site 80187

pH

There were 103 pH measurements taken at this site during this time period. The mean pH was 8.0 and pH ranged from a low of 7.5 taken on multiple occasions, to a high of 8.5 taken on multiple occasions. There was a significant decrease in pH over time observed at this site ($p = 0.002$). The R^2 value of 0.089 indicates that this relationship only explains 8.9% of the variation in the data.

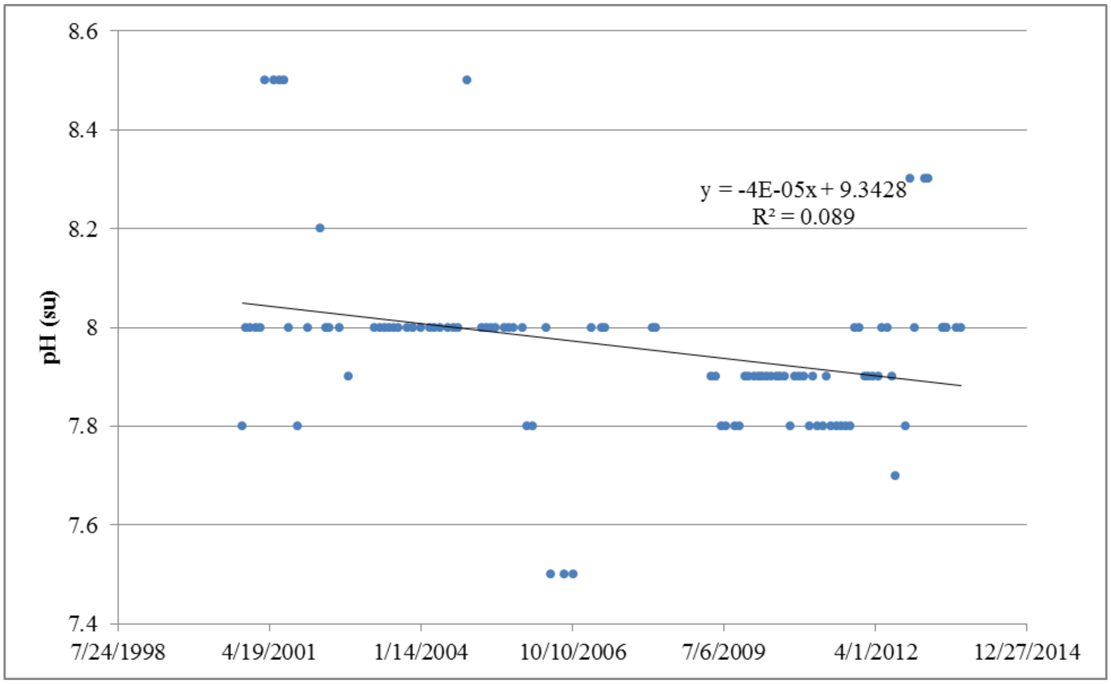

Figure 21: pH at site 80187

Secchi disk and total depth

The mean total depth was 0.44 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.

Field Observations

Algae cover was recorded as absent or rare (0-25%) at this site. The water had no distinguishable color. Water clarity was recorded as clear in all cases but one where it was described as cloudy. The water had no describable odor.

Site 80904– Cibolo Creek Upstream of Boerne Lake

Site Description

This site is located near the Lake Side Dr. Crossing of 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. There are sparse junipers and live oaks along the banks of the creek, and cultivated cropland on either side of the creek.

Sampling Information

This site is no longer active. It was sampled 9 times between 11/15/2012 and 10/17/2013. The sampling was done in the morning between 09:00 and 11:00.

Table 7: Descriptive parameters for Site 80904

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	8	269 ± 15	241	286
Water Temperature (°C)	9	17.7 ± 4.4	11.0	25.0
Dissolved Oxygen (mg/L)	9	6.4 ± 1.7	3.6	8.8
pH	8	8.1 ± 0.2	7.8	8.3

Site was sampled 9 times between 11/15/2012 and 10/17/2013.

Air and water temperature

Air and water temperatures were taken 9 times at this site. The mean water temperature was 17.7°C and ranged from a low temperature of 11°C in November, 2012, to a high 25°C in August, 2013. The air temperature ranged from a low of 10.5°C in November of 2012, to a high of 26°C in August, 2013.

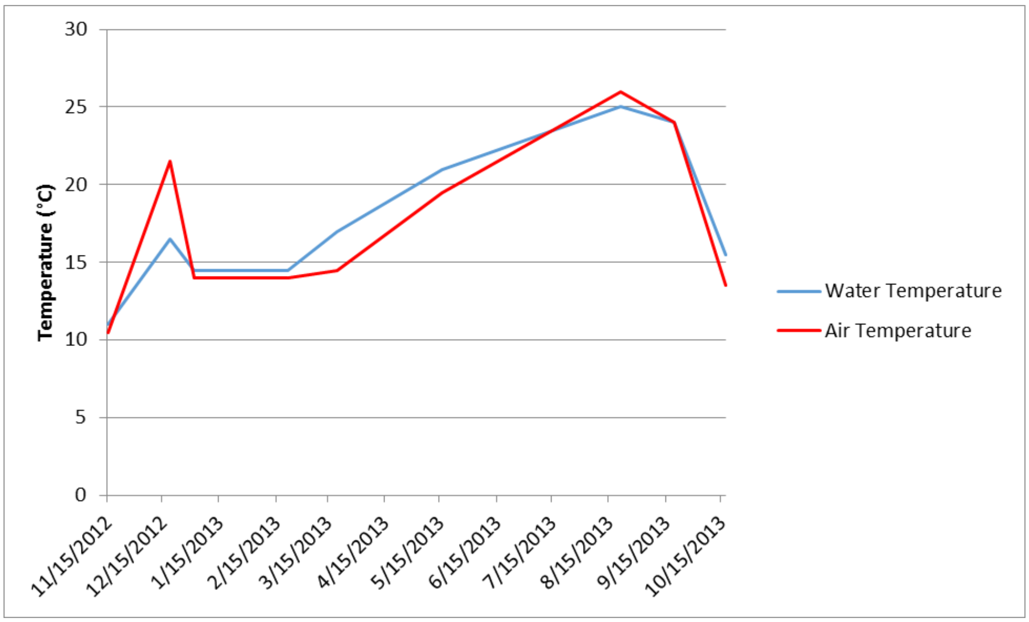

Figure 22: Air and water temperature at site 80904

Total Dissolved Solids

Citizen scientists collected 8 TDS samples at this site during this time period. The mean TDS concentration was 269 mg/L. The minimum TDS concentration was 241 mg/L and was taken in September of 2013. The maximum TDS concentration was 286 mg/L and was taken in February of 2013.

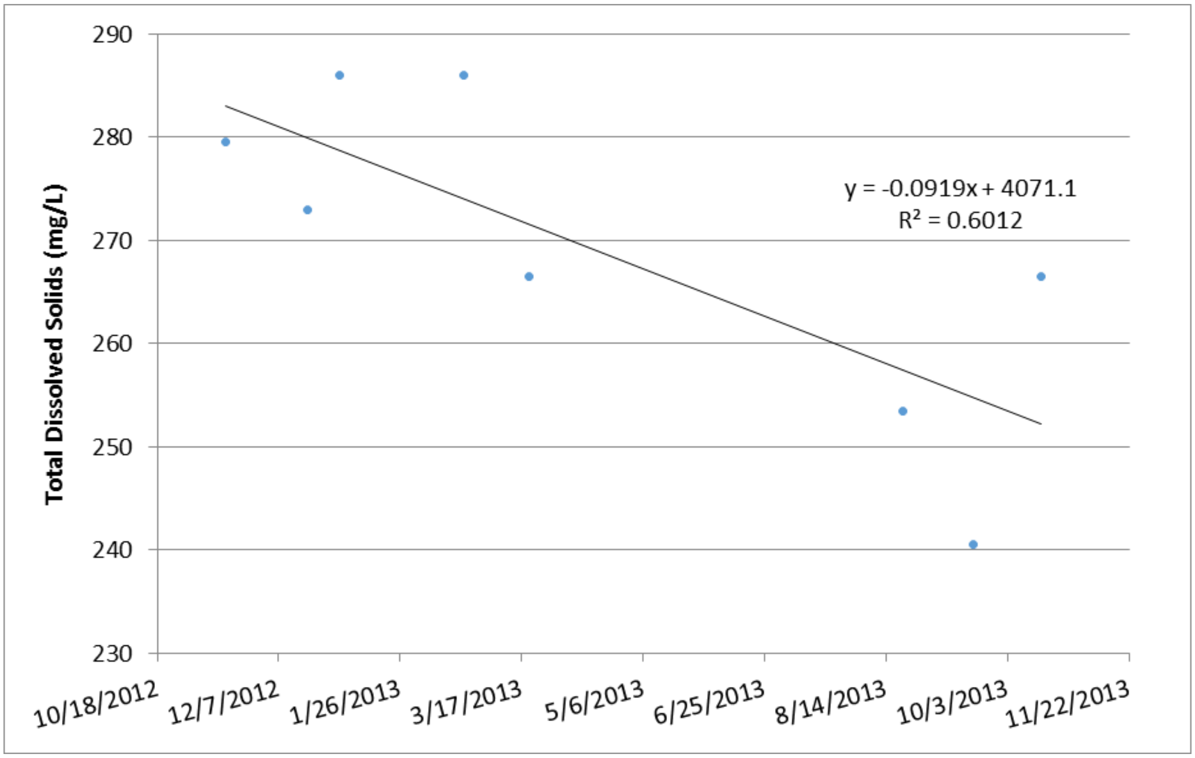

Figure 23: Total Dissolved Solids at site 80904

Dissolved Oxygen

Citizen scientists collected 9 DO samples at this site during this time period. The mean DO concentration was 6.4 mg/L. The minimum DO concentration was 3.6 mg/L and was taken in August, 2013. The maximum DO concentration was 8.8 mg/L and was taken in November of 2012.

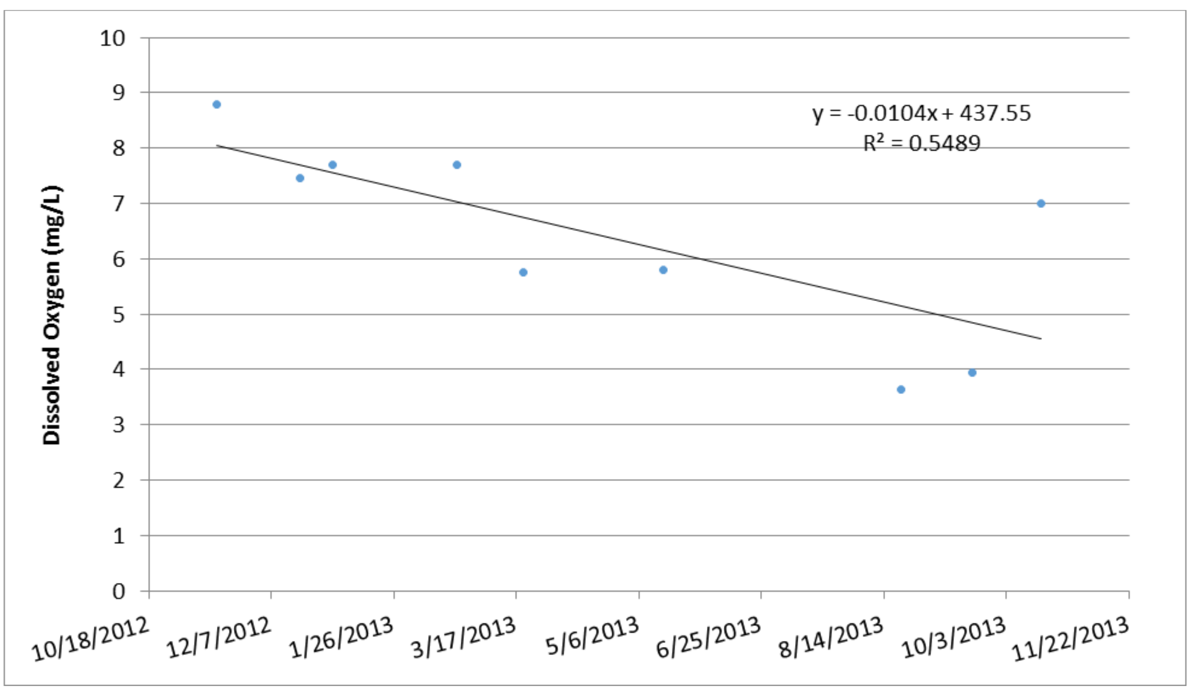

Figure 24: Dissolved Oxygen at site 80904

pH

A total of 8 pH measurements were taken at this site during this time period. The mean pH was 8.1 and it ranged from a high of 8.3 to a low of 7.8 in September of 2013.

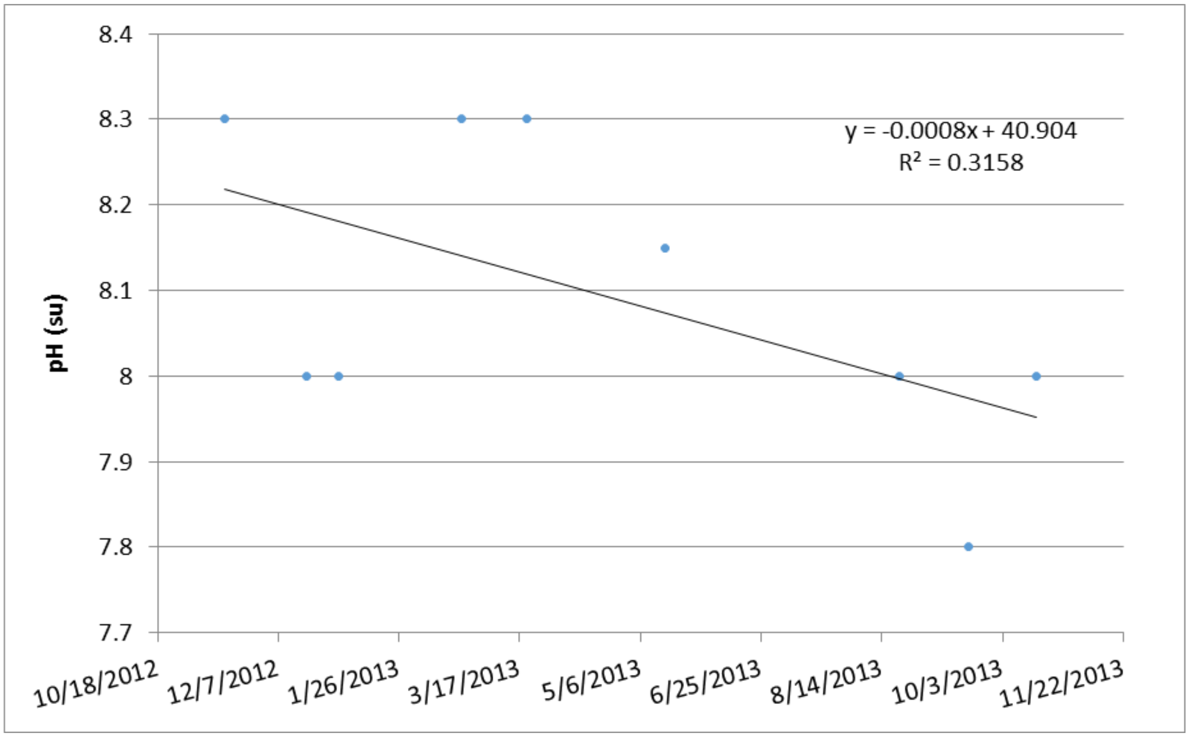

Figure 25: pH at site 80904

Secchi disk and total depth

The mean total depth at this site was 0.67 m. The Secchi disk depth was recorded as greater than the total depth in all cases indicating that the water way to the bottom of the creek.

Field Observations

Algae cover was described as absent or rare (0-25%) for all monitoring events. The water color was clear to light green. Water color was clear for all monitoring events except one where it was described as cloudy. The water had no distinguishable odor.

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 Rd 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 is currently active and was sampled 30 times between3/15/2012 and 7/17/2014. The site was sampled in the morning between 09:00 and 11:00.

Table 8: Descriptive parameters for Site 20823

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	25	271 ± 65	137	410
Water Temperature (°C)	28	20.6 ± 5.7	9.0	29.0
Dissolved Oxygen (mg/L)	30	5.7 ± 2.2	2.3	9.6
pH	26	7.9 ± 0.3	7.2	8.6
E. coli (CFU/100 mL)	5	604	60	2520
Nitrates	20	0.95 ± 0.4	0	2.0
Phosphates	20	0.2 ± 0.47	0	2.0

Site was sampled 30 times between 3/15/2012 and 7/17/2014.

Air and water temperature

Air and water temperatures were taken 28 times during this time period. The mean water temperature was 20.6°C and it ranged from low of 9°C in January, 2013, to a high of 29°C in August, 2013. The air temperature ranged from a low of 4°C in December of 2012, to a high of 26°C taken in August of 2013.

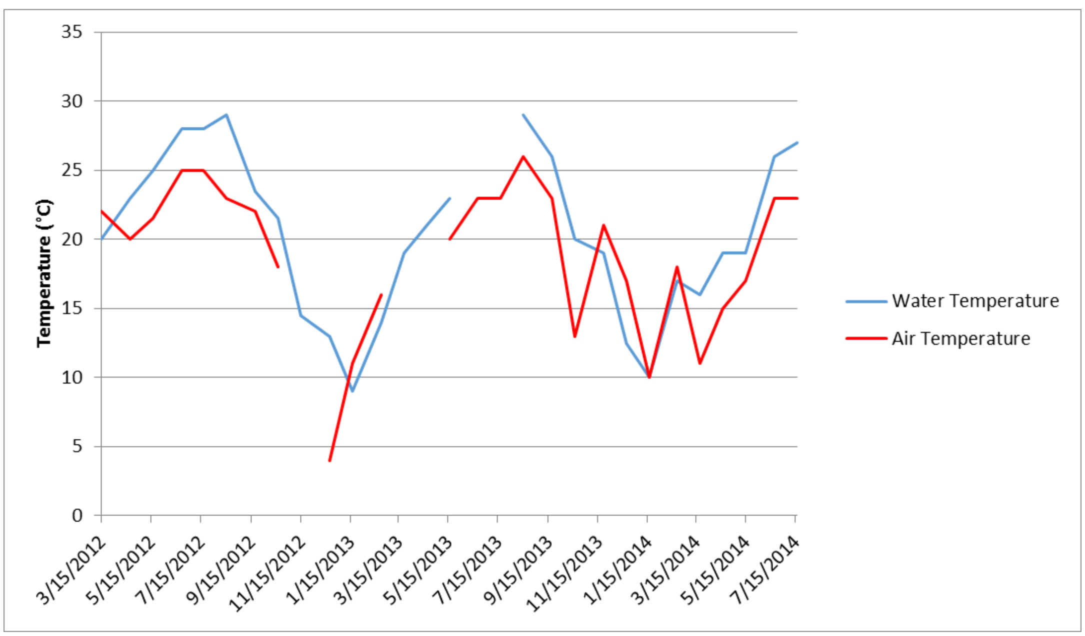

Figure 26: Air and water temperature at site 20823

Total Dissolved Solids

Citizen scientists collected 25 TDS samples during this time. The mean TDS concentration was 271 mg/L and it ranged from a minimum of 137 mg/L in May of 2014, to a maximum of 410 mg/L in April of 2012. There was a significant decrease in TDS concentrations over time observed at this site ($p = 0.038$). The R^2 value was 0.1739 indicating that this relationship explained about 17.4% of the variation in the data.

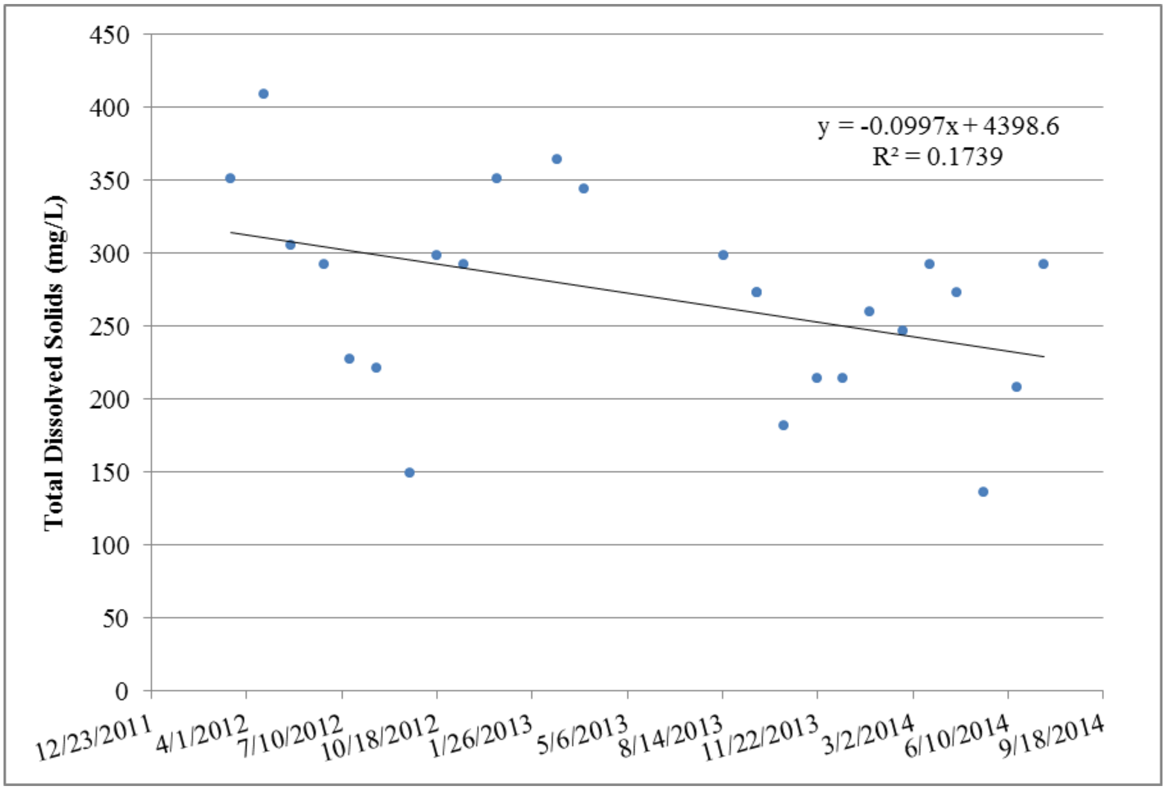

Figure 27: Total Dissolved Solids at site 20823

Dissolved Oxygen

Citizen scientists collected 30 DO samples at this site during this time. The mean DO concentration was 5.7 mg/L. The minimum DO concentration was 2.3 mg/L and was taken in August, 2013. The maximum DO concentration was 9.6 mg/L and was taken in February of 2014. There was no significant trend in DO concentration over time observed at this site.

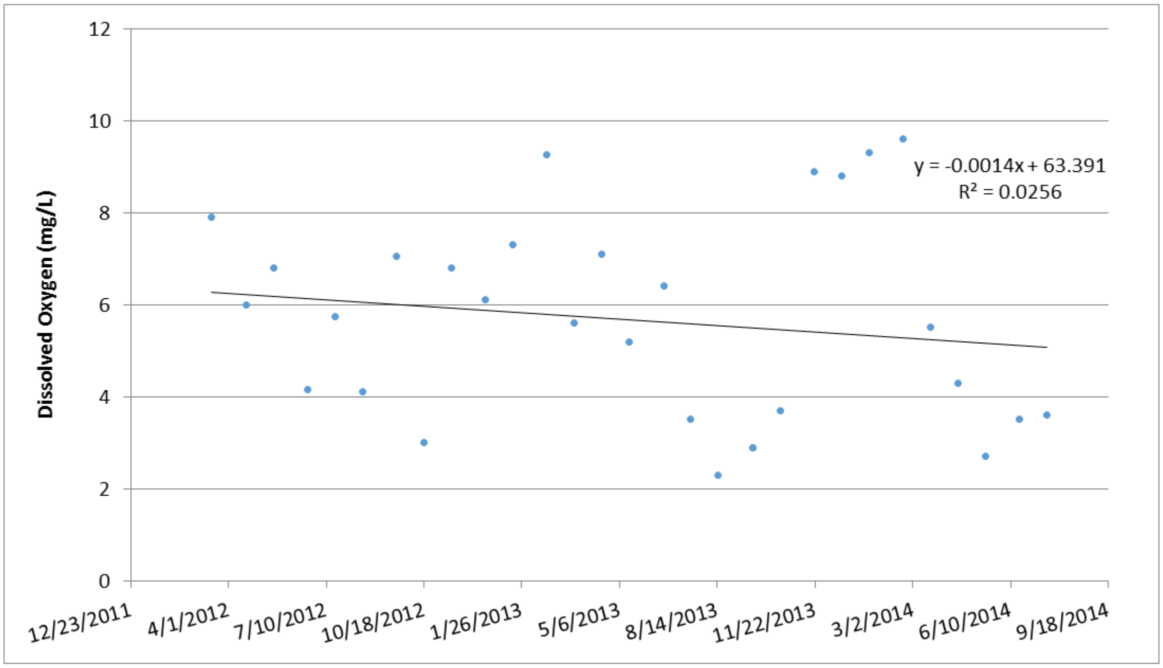

Figure 28: Dissolved Oxygen at site 20823

pH

Citizen scientists took 26 pH measurements at this site. The mean pH was 7.9 and it ranged from a low of 7.2 in July of 2014, to a high of 8.6 in April of 2014. There was no significant trend in pH over time detected for this site during this time.

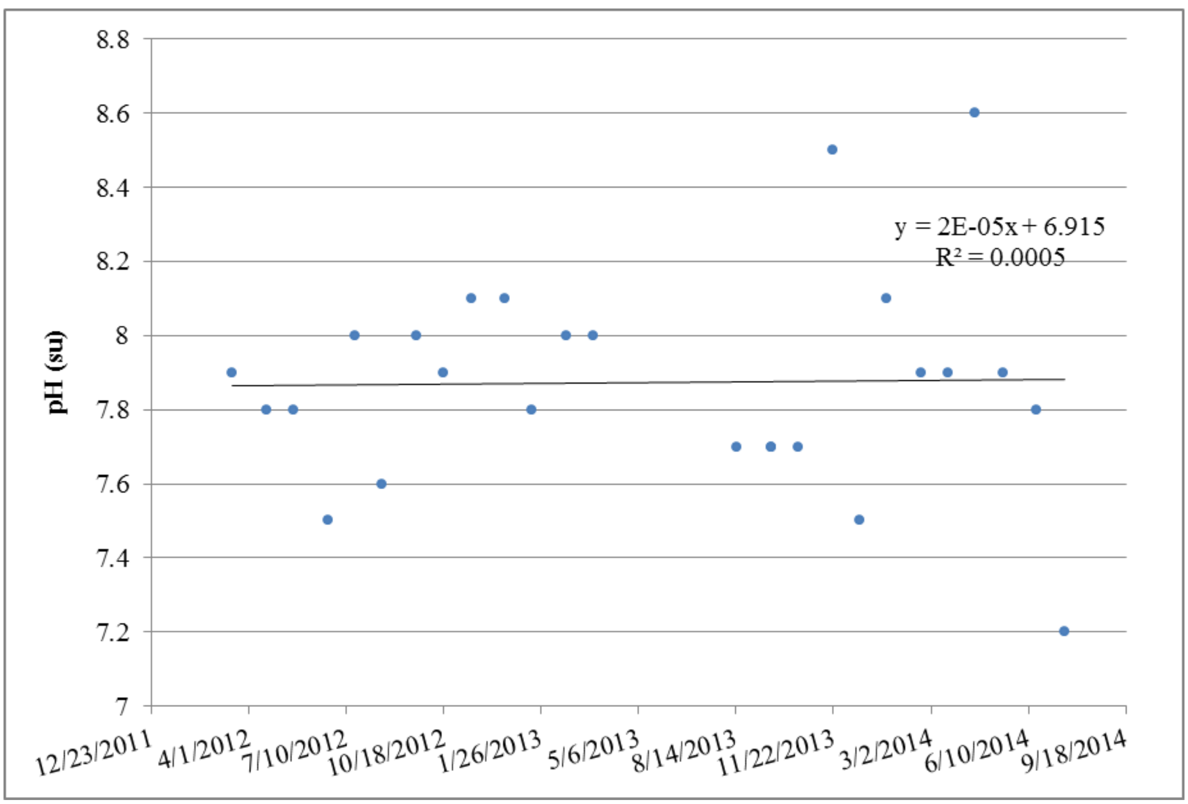

Figure 29: pH at site 20823

Secchi disk and total depth

The mean total depth at this site was 0.73 m. Secchi disk depth was typically less than total depth, indicating that the water clarity was not visible all the way to the creek bottom. The mean Secchi disk depth was 0.63 m and visibility ranged from 0.18 m to 1.30 m.

Field Observations

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 and on one occasion was tan. Water clarity was clear a majority of the time, but was described as cloudy for several monitoring events, and the water had no describable odor.

E. coli Bacteria

Citizen scientists collected 5 E. coli samples at this site. The geomean for E. coli was 604 CFU/100 mL. The minimum E. coli count was taken in September of 2012, and was 60 CFU/100 mL. The maximum E. coli count was taken in December of 2012, and was 2520 CFU/100 mL.

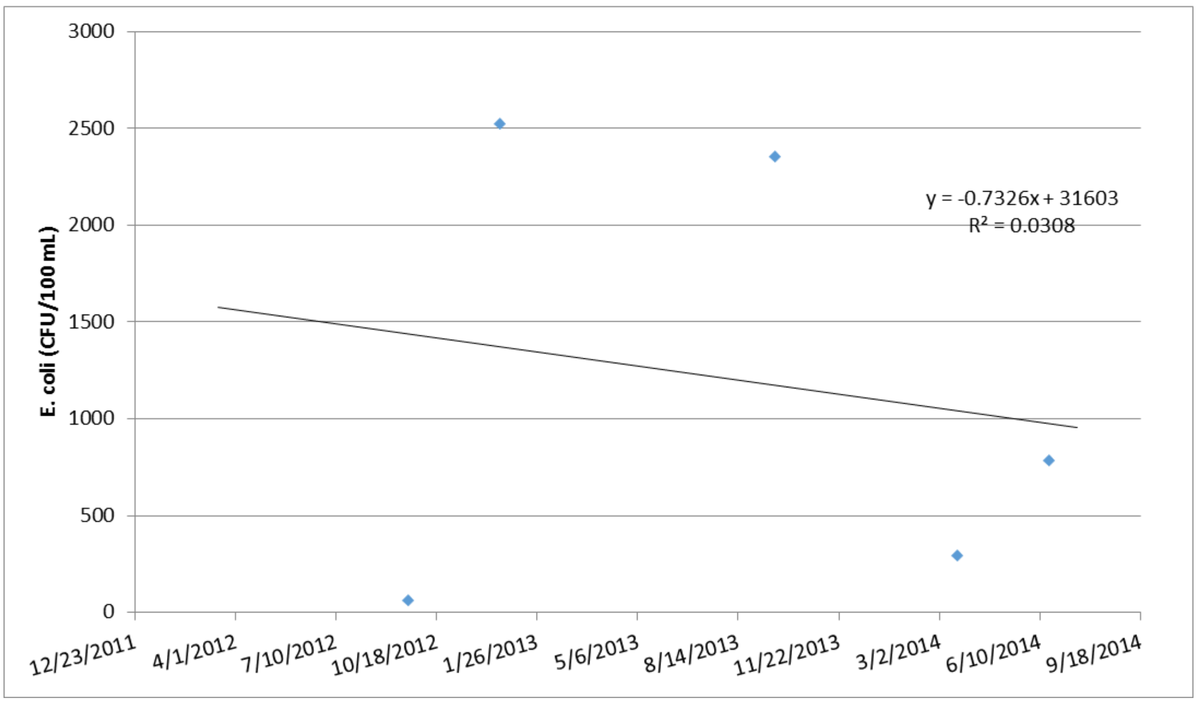

Figure 30: E. coli at site 20823

Orthophosphate

Citizen scientists collected 20 phosphate samples at this site. The mean phosphate concentration was 0.2 mg/L, and the concentration ranged from 0 mg/L to 2.0 mg/L in May of 2014. There was no significant trend in phosphate concentrations over time observed at this site.

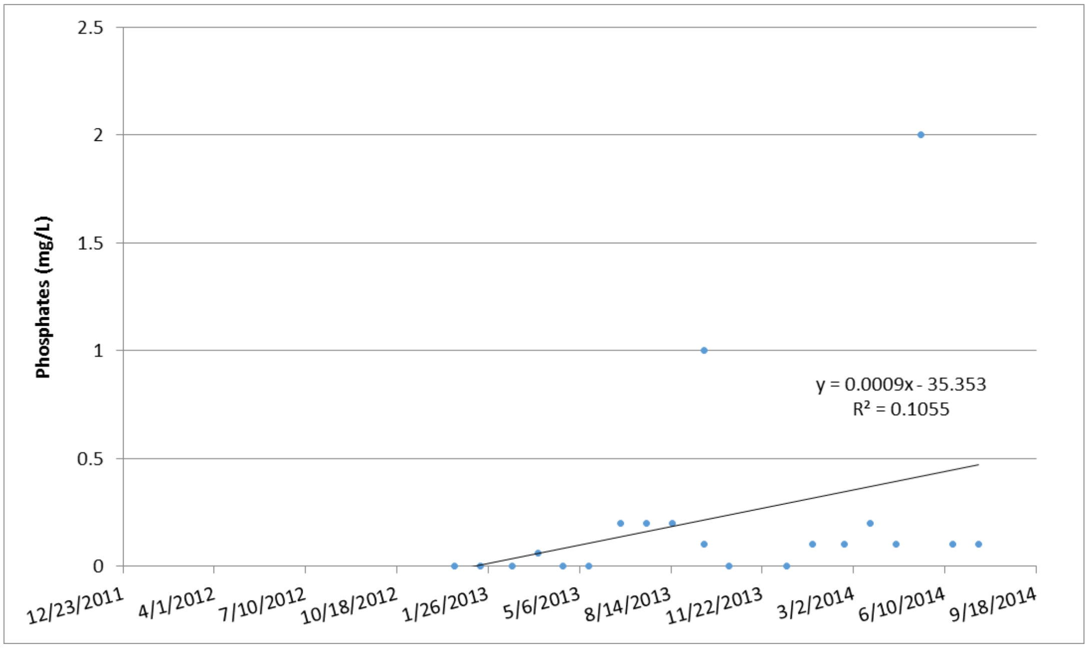

Figure 31: Phosphates at site 20823

Nitrate-Nitrogen

Citizen scientists collected 20 nitrate samples at this site during this time. The mean nitrate concentration was 0.95 mg/L. Nitrates ranged from 0 mg/L to 2.0 mg/L in May of 2013. There was no significant trend in nitrate concentration over time observed at this site.

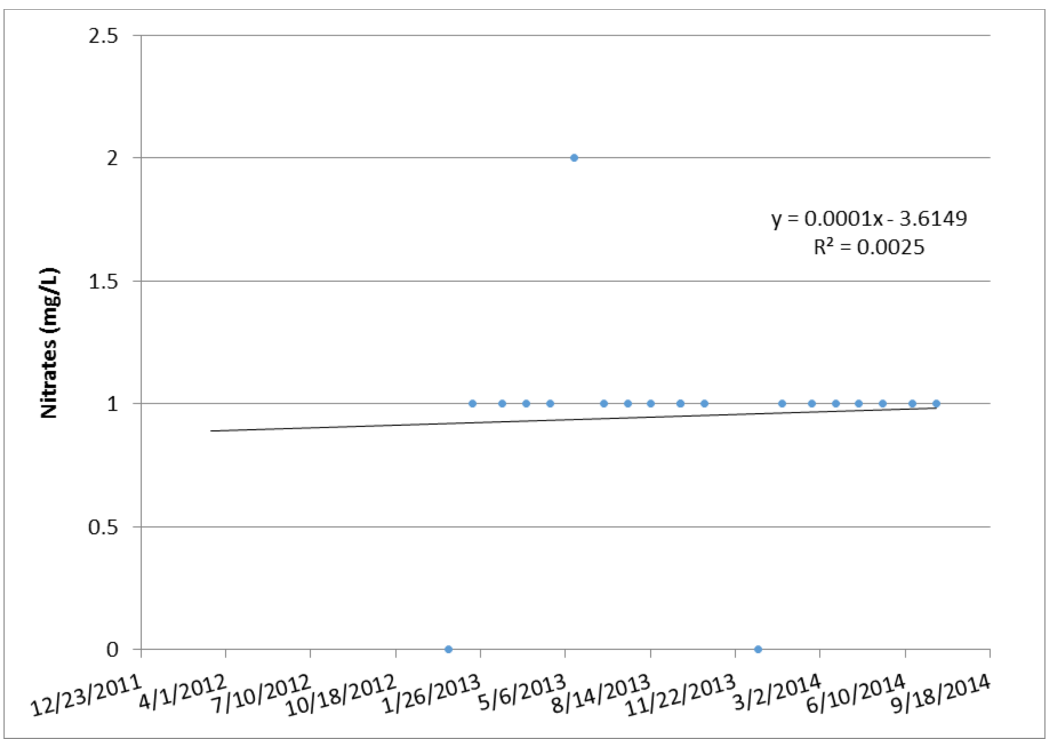

Figure 32: Nitrates at site 20823

Site 80966 – Currey Creek @ Boerne WWTP Effluent Outfall

Site Description

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

Sampling Information

This site is currently active. It has been sampled 16 times between 5/16/2013 and 7/17/2014. Sampling takes place in the morning from 09:00 to 11:00.

Table 9: Descriptive parameters for Site 80966

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	16	602 ± 29	559	676
Water Temperature (°C)	16	21.9 ± 4.2	14.0	27.0
Dissolved Oxygen (mg/L)	16	6.4 ± 0.7	5.4	8.2
pH	16	7.5 ± 0.3	7.0	7.9
Nitrates (mg/L)	16	15.0 ± 0.0	15.0	15.0
Phosphates (mg/L)	16	11.6 ± 3.5	0.0	16.0

Site was sampled 16 times between 5/16/2013 and 7/17/2014.

Air and water temperature

Air and water temperatures were taken 16 times at this site. The mean water temperature was 21.9°C and the water temperature varied from a low of 14°C in January of 2014 to a high of 27°C in August, 2013. The air temperature varied from a low of 10°C to a high of 25°C in June of 2013.

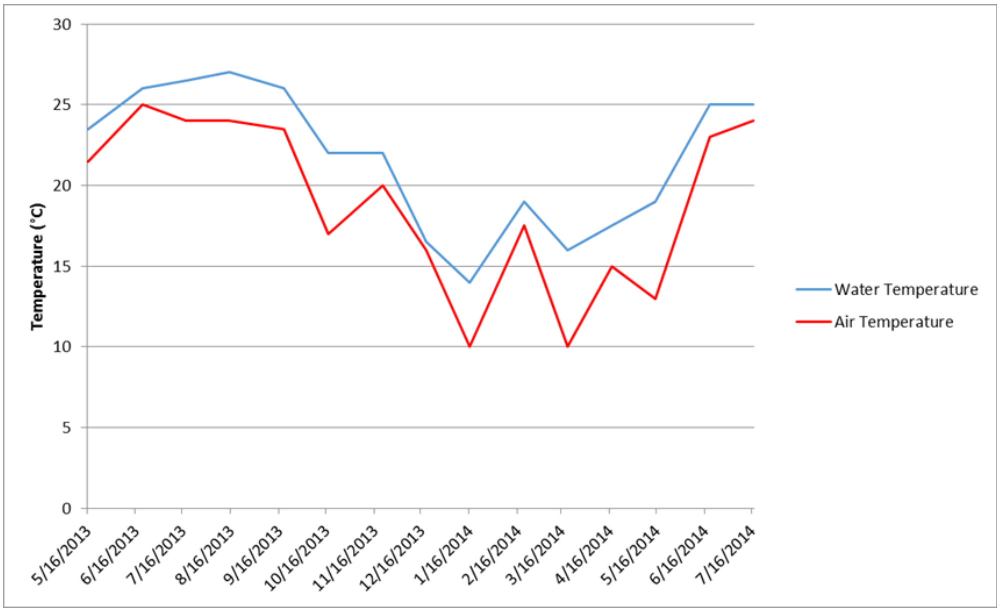

Figure 33: Air and water temperature at Site 80966

Total Dissolved Solids

Citizen scientists collected 16 TDS samples at this site during this time. The mean TDS concentration was 602 mg/L at this site. The minimum TDS concentration was 559 mg/L and was taken in January of 2014. The maximum TDS concentration was 676 mg/L taken in August of 2013. There was no significant trend in TDS concentration over time observed at this site.

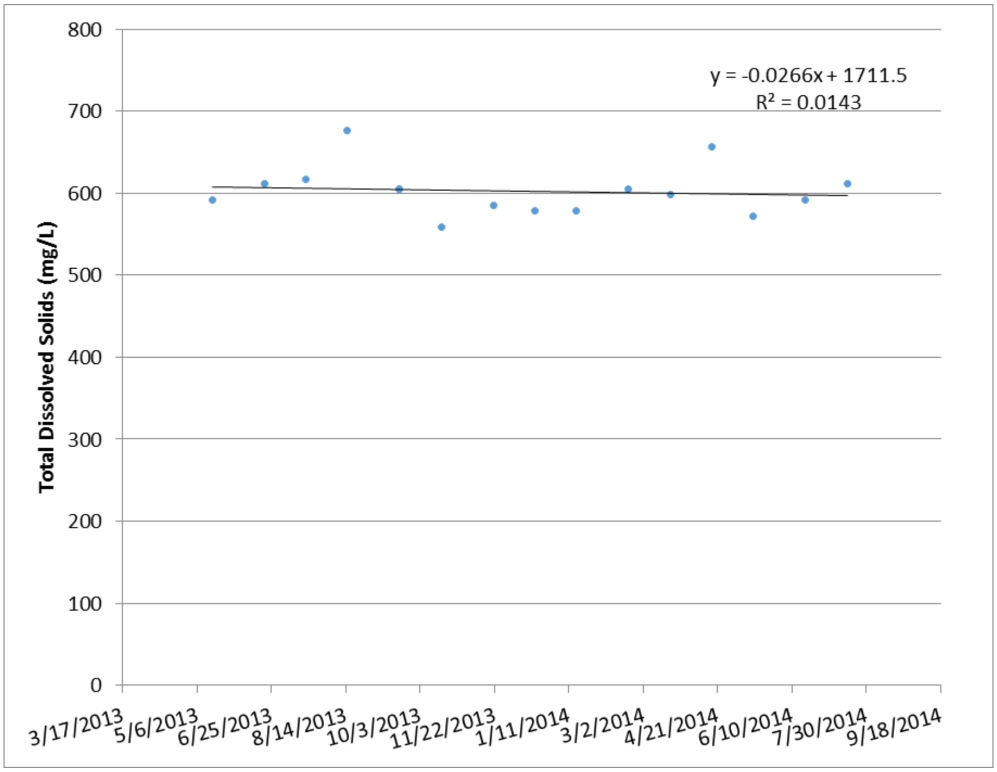

Figure 34: Total Dissolved Solids at Site 80966

Dissolved Oxygen

Citizen scientists collected 16 DO samples at this site during this time period. The mean DO concentration was 6.4 mg/L. The minimum DO concentration was 5.4 mg/L and was recorded in May of 2013. The maximum DO concentration was 8.2 mg/L and was recorded in January of 2014. There was no significant trend in DO concentration over time observed at this site.

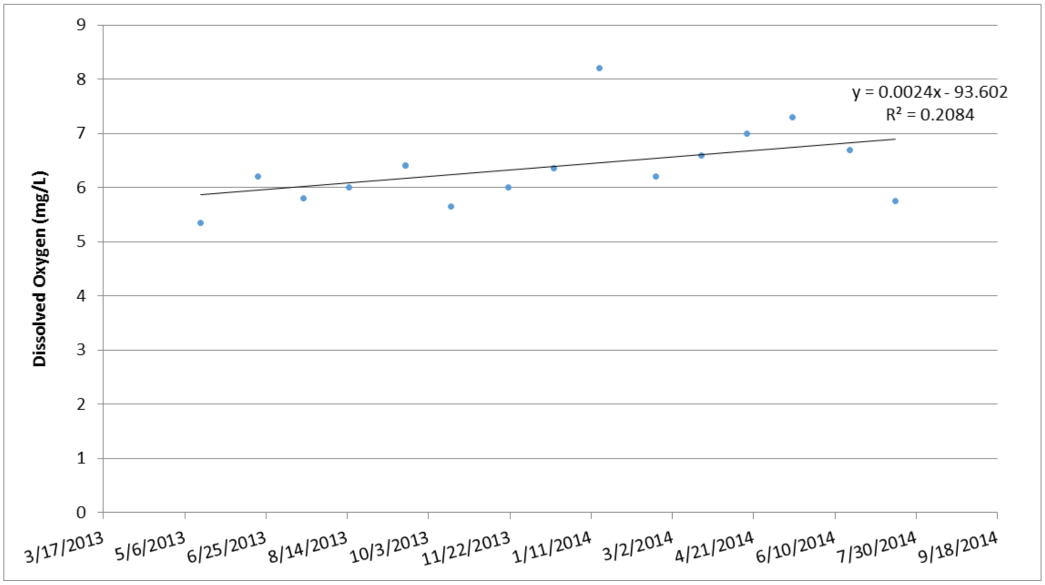

Figure 35: Dissolved Oxygen at Site 80966

pH

Citizen scientists took 16 pH measurements at this site. The mean pH was 7.5 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 no significant trend in pH observed for this site.

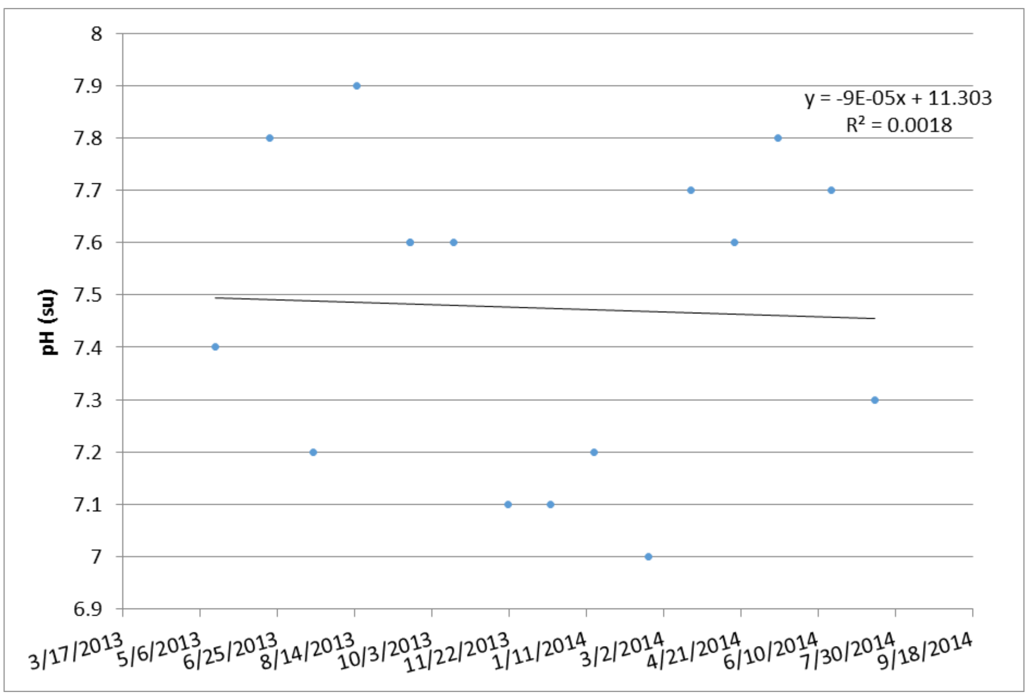

Figure 36: pH at Site 80966

Secchi disk and total depth

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 3 events. The algae cover was rare (< 25%) to common (26-50%). The water color was described as clear to light green, and water clarity was clear for all events except 2 that were recorded as cloudy. The water odor was described as musky in this area.

Orthophosphate

Citizen scientists collected 16 phosphate samples at this site. The mean phosphate concentration was 11.6 mg/L. The minimum phosphate concentration was 0 mg/L in October of 2013. The maximum phosphate concentration was 16.0 mg/L and was recorded in June of 2014. There was no significant trend in phosphate concentration over time observed at this site.

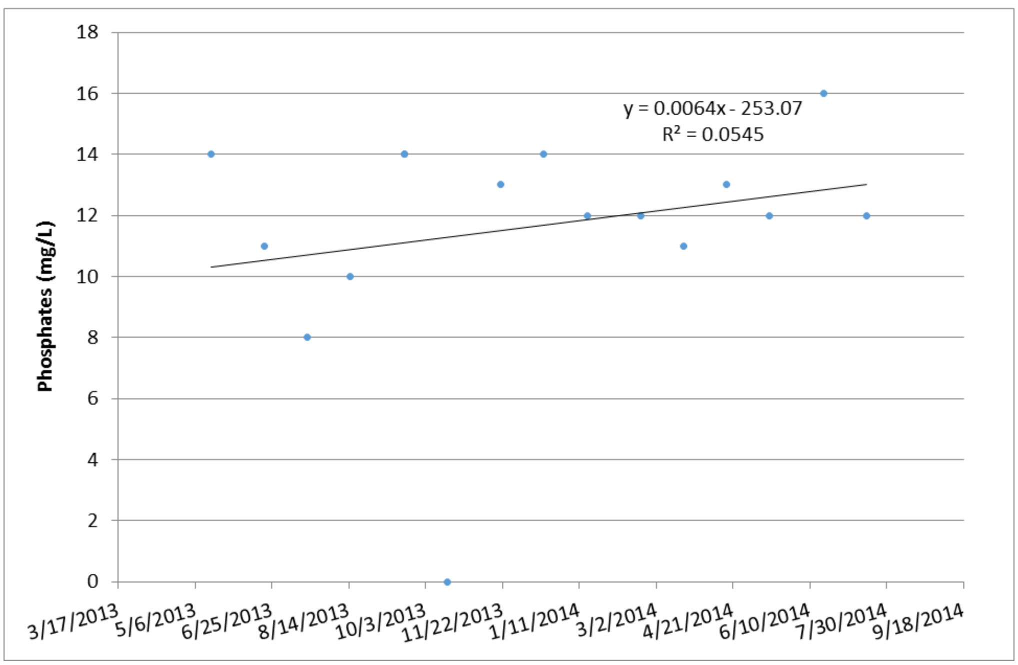

Figure 37: Phosphates at Site 80966

Nitrate-Nitrogen

Citizen scientists collected 16 nitrate samples at this site. Every nitrate sample at this site was recorded as 15 mg/L.

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 is an actively monitored site. It has been sampled 81 times between 1/24/1999 and 7/17/2014. Monitoring at this location took place between 08:00 and 16:00.

Table 10: Descriptive parameters for Site 80186

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	73	432 ± 78	254	618
Water Temperature (°C)	78	19.6 ± 6.9	0.0	34.5
Dissolved Oxygen (mg/L)	73	6.8 ± 2.7	1.0	13.7
pH	72	7.7 ± 0.2	6.9	8.1
E. coli (CFU/100 mL)	4	122	10	620

Site was sampled 81 times between 1/24/1999 and 7/17/2014.

Air and water temperature

There were 78 air and water temperatures taken at this site. The mean water temperature was 19.6°C. Water temperature varied from a low of 0°C in November of 2008, and a high of 34.5°C in August of 1999. The air temperature ranged from a low of 0°C in November of 2008 to a high of 37°C in August of 2005.

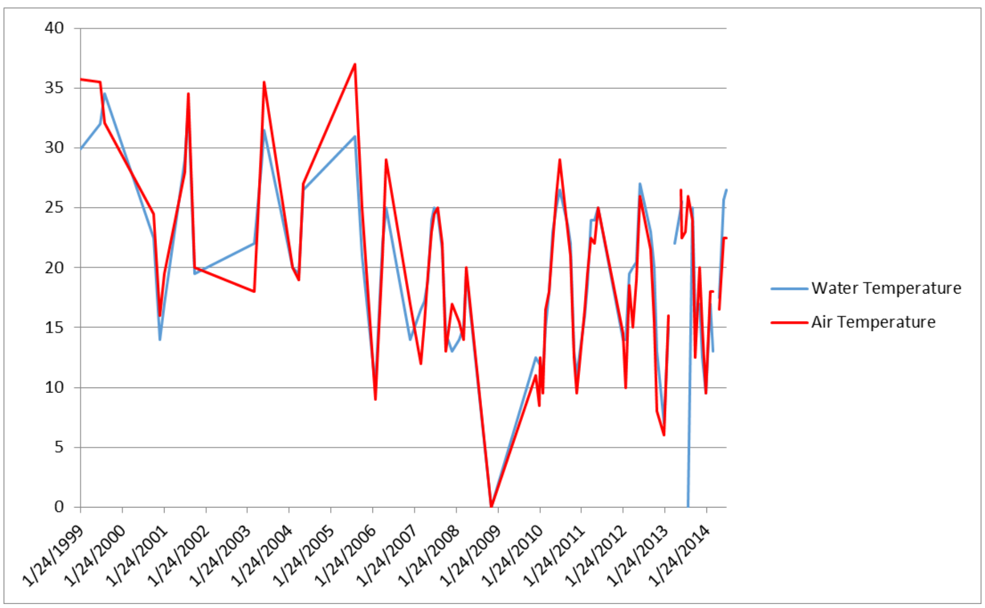

Figure 38: Air and water temperature at Site 80186

Total Dissolved Solids

Citizen scientists took 73 TDS samples at this site. The mean TDS concentration was 432 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 ($p = 0.029$). The R^2 value indicated that this relationship explained about 6.5% of the variation in the data.

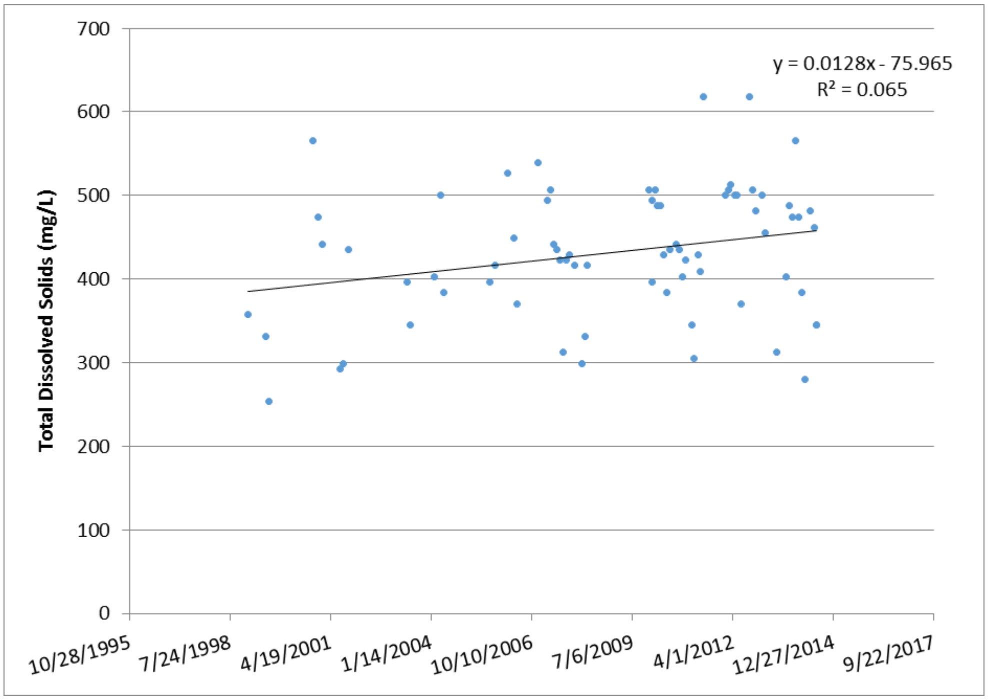

Figure 39: Total Dissolved Solids at Site 80186

Dissolved Oxygen

Citizen scientists collected 73 dissolved oxygen samples at this site during this time. The mean DO concentration was 6.8 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 = 0009). The R^2 value was 0.0919 indicating that this relationship explained about 9.2% of the variation in the data.

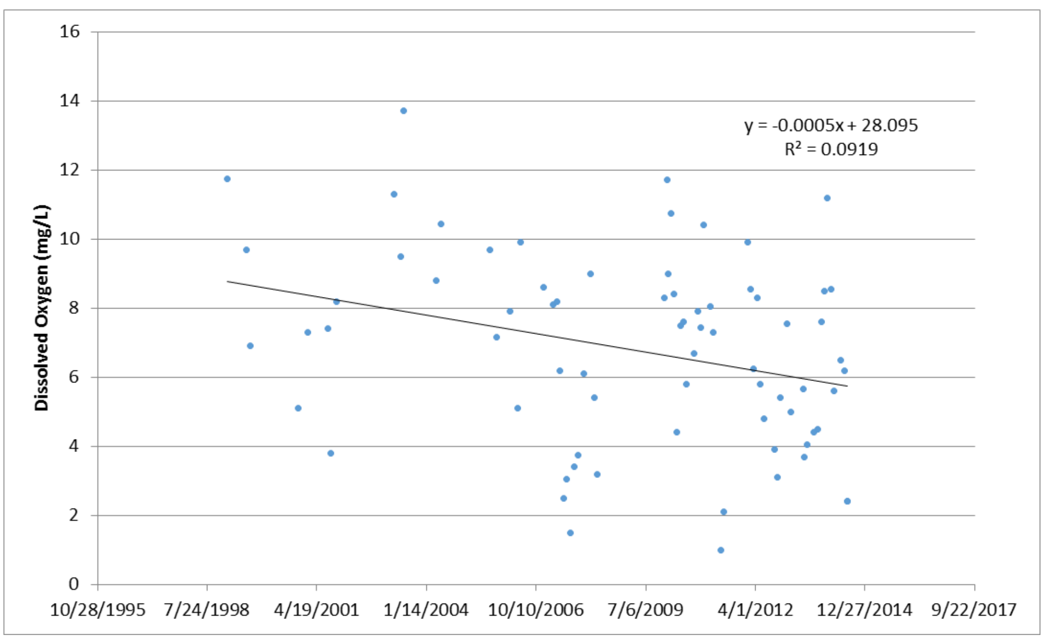

Figure 40: Dissolved Oxygen at Site 80186

pH

A total of 72 pH measurements were taken at this site. The mean pH was 7.2 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 ($p = 0.000$). The R^2 value was 0.1102 indicating that this relationship explained 11% of the variation in the data.

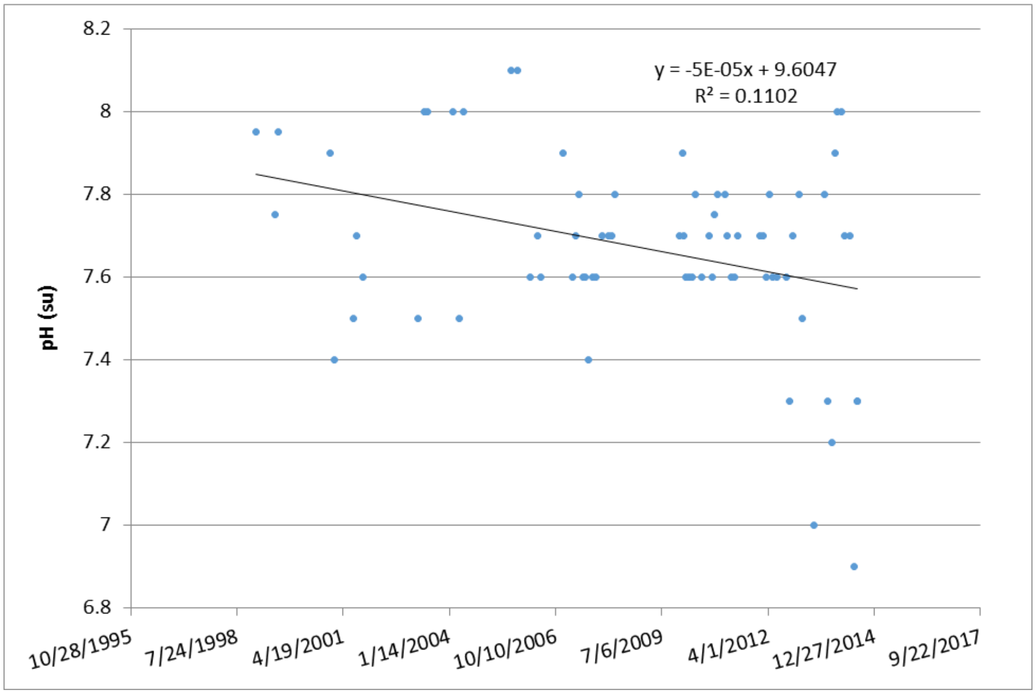

Figure 41: pH at Site 80186

Secchi disk and total depth

The mean total depth was 0.44 m. The Secchi disk depth was recorded as greater than 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 21 monitoring events where there was 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.

E. coli Bacteria

Citizen scientists collected 4 samples of E. coli from this site. The sampling was sporadic and occurred at the beginning of 2013. The geomean for bacteria was 122 CFU/100 mL. E. coli counts ranged from a low of 10 CFU/100 mL in March of 2013 to a high of 620 CFU/100 mL in September of 2013.

Site 15126 – Cibolo @ Menger Creek

Site Description

This site is located in at the confluence of 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 it enters into Cibolo Creek.

Sampling Information

This site is an actively monitored site. It has been monitored 157 times between 9/24/1999 and 7/17/2014. The site was initially monitored in the afternoon, but is now monitored in the morning between 09:00 and 11:00.

Table 11: Descriptive parameters for Site 15126

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	149	439 ± 115	169	728
Water Temperature (°C)	157	20.2 ± 5.3	8.5	32.0
Dissolved Oxygen (mg/L)	145	7.0 ± 1.8	3.3	12.0
pH	149	7.9 ± 0.2	7.0	8.5
E. coli	7	111	30	330
Nitrates (mg/L)	19	7.8 ± 4.9	0.0	15.0
Phosphates (mg/L)	19	3.2 ± 2.6	0.0	9.0

Site was sampled 157 times between 9/24/1999 and 7/17/2014.

Air and water temperature

Air and water temperatures were taken 157 times at this site. The mean water temperature was 20.2°C. Water temperature varied from a low of 8.5°C in January of 2009, 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 September of 2001 and August of 2004.

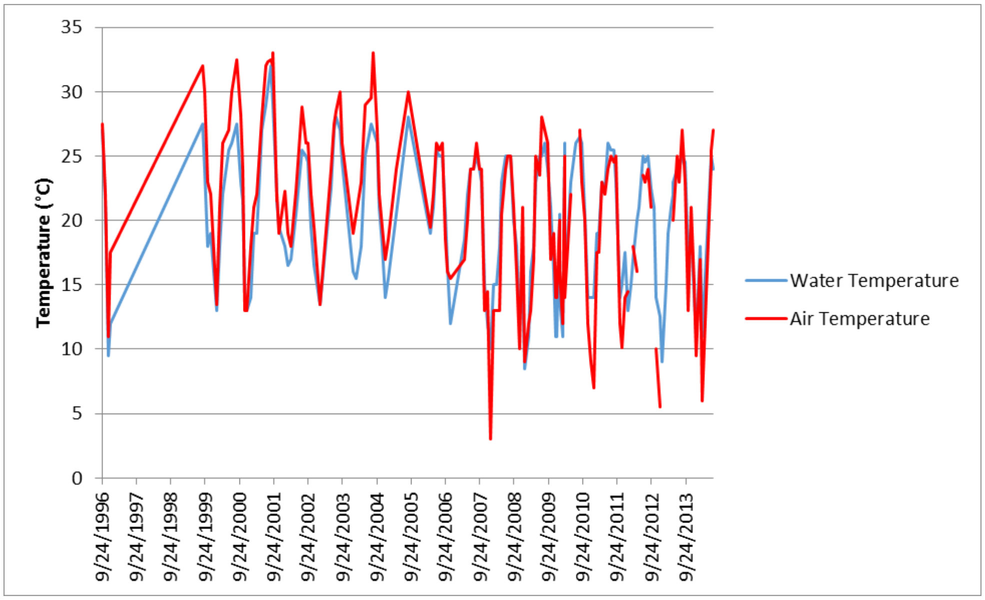

Figure 42: Air and water temperature at Site 15126

Total Dissolved Solids

Citizen scientists took a total of 149 TDS samples at this site during this time. The mean TDS concentration was 439 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 = 0.000). The relatively high R^2 value of 0.2615 indicates that this relationship explains about 26.2% of the variability in the data.

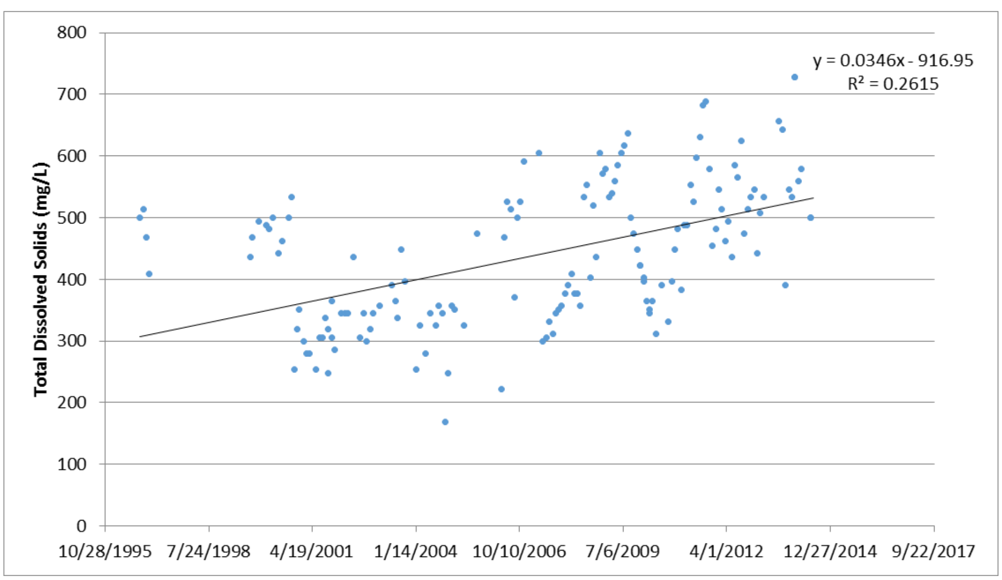

Figure 43: Total Dissolved Solids at Site 15126

Dissolved Oxygen

Citizen scientists took 145 dissolved oxygen samples at this site. The mean DO concentration was 7.0 mg/L. The minimum DO concentration was 3.3 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 – 0.000). The high R^2 value of 0.3626 indicates a high correlation between DO concentration and time at this site.

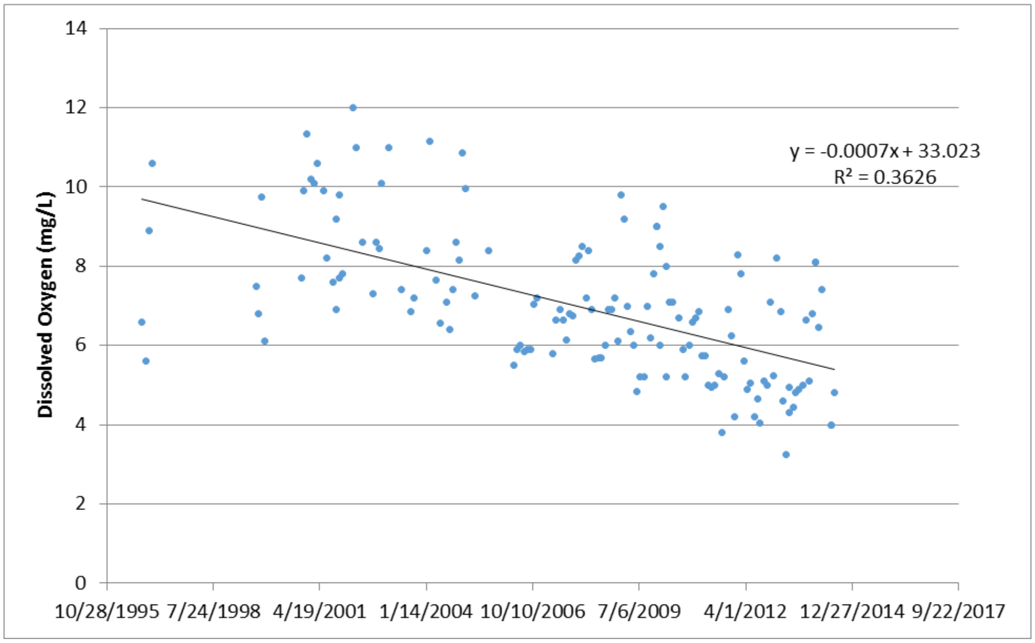

Figure 44: Dissolved Oxygen at Site 15126

pH

Citizen scientists took 149 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 8.5 taken on several occasions. There was a significant decrease in pH over time observed at this site (p = 0.003). The R^2 value of 0.0598 indicated a small correlation between pH and time.

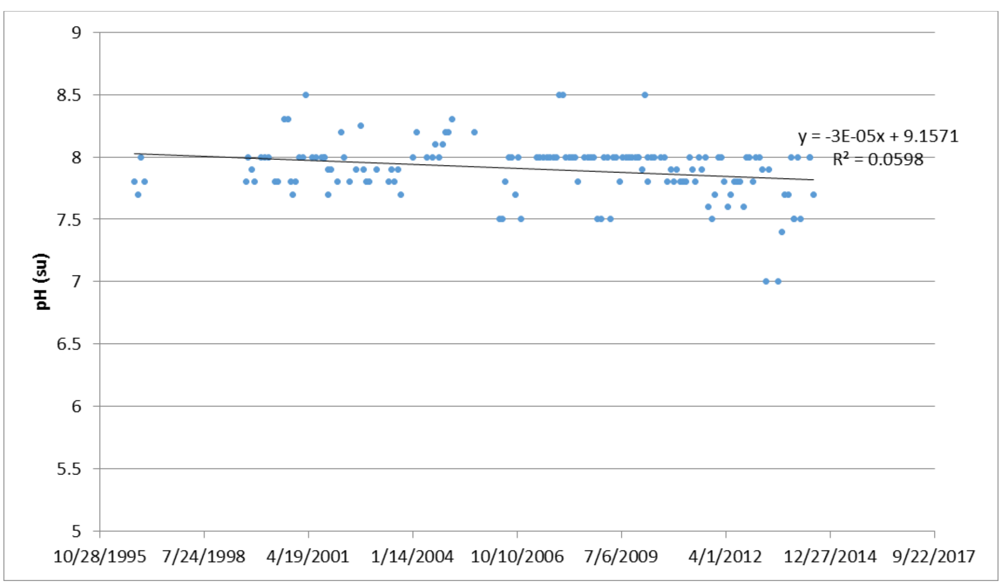

Figure 45: pH at Site 15126

Secchi disk and total depth

The mean total depth at this site was 0.50 m. In all cases, the Secchi disk depth was greater than 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. Algae cover was typically recorded as rare (< 25%). Water color was typically clear to light green, 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, it was described as fishy or musky.

E. coli Bacteria

Citizen scientists collected 7 E. coli samples. The geomean for E. coli was 111 CFU/100 mL. The minimum E. coli count was 30 CFU/100 mL and was recorded in December of 2012. The maximum E. coli count was 330 CFU/100 mL and was collected in September of 2013.

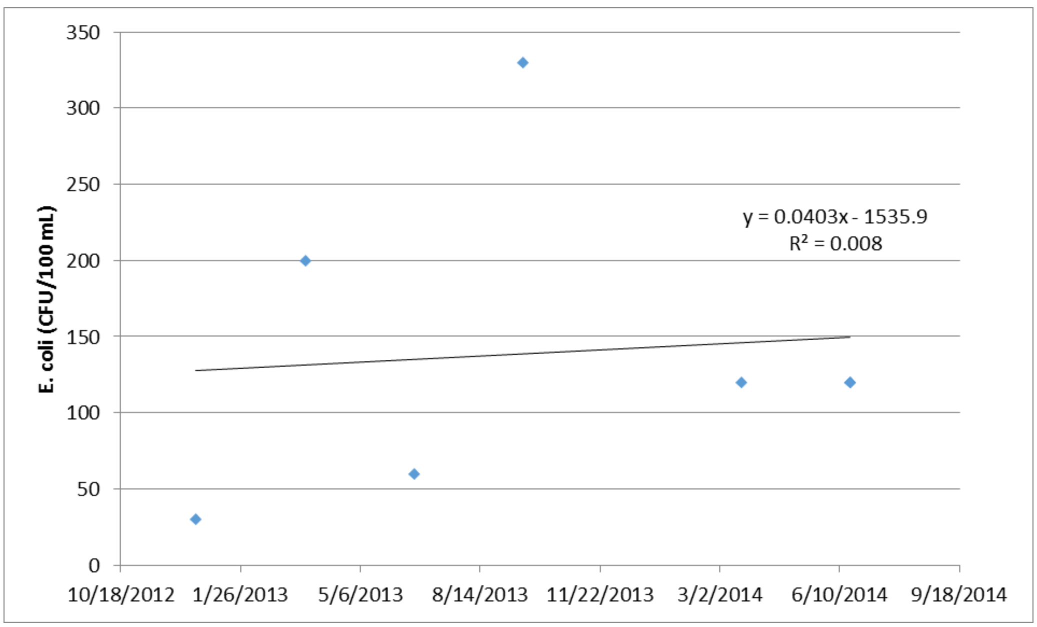

Figure 46: E. coli at Site 15126

Orthophosphate

Citizen scientists collected 19 phosphate samples at this site during this time period. The mean phosphate concentration was 3.2 mg/L. Phosphate concentrations ranged from 0.0 mg/L to 9.0 mg/L recorded in June of 2014. There was a significant increase in phosphates at this site over time ($p = 0.002$). The high R^2 value of 0.3853 indicates a strong correlation between phosphates and time.

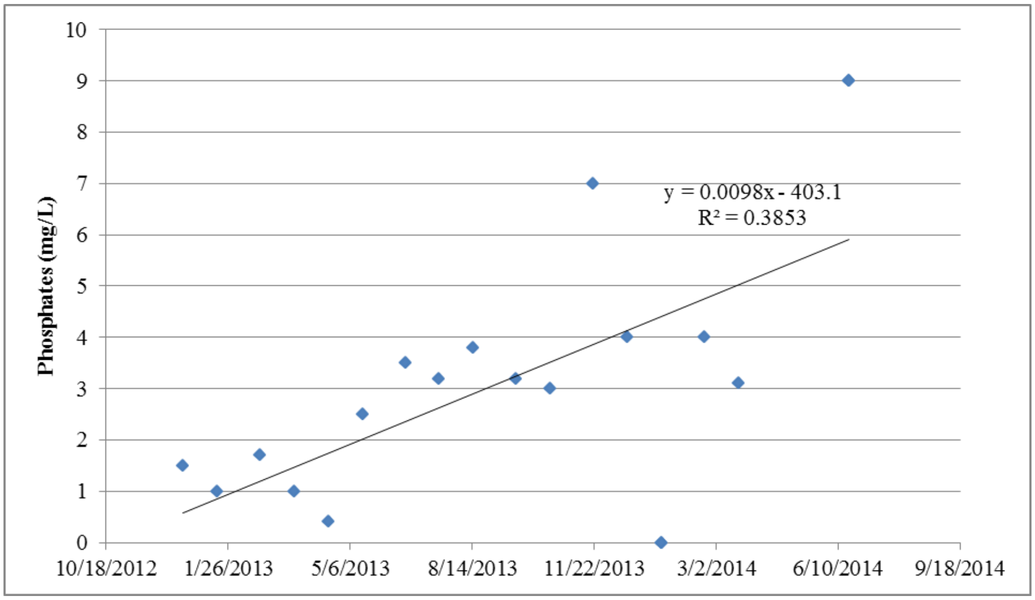

Figure 47: Phosphates at Site 15126

Nitrate-Nitrogen

Citizen scientists collected 19 nitrate samples at this site during this time. The mean nitrate concentration was 7.8 mg/L. Nitrates 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 a significant increase in nitrate concentrations over time observed at this site ($p = 0.001$). The high R^2 value of 0.4571 indicates a strong correlation between nitrates and time.

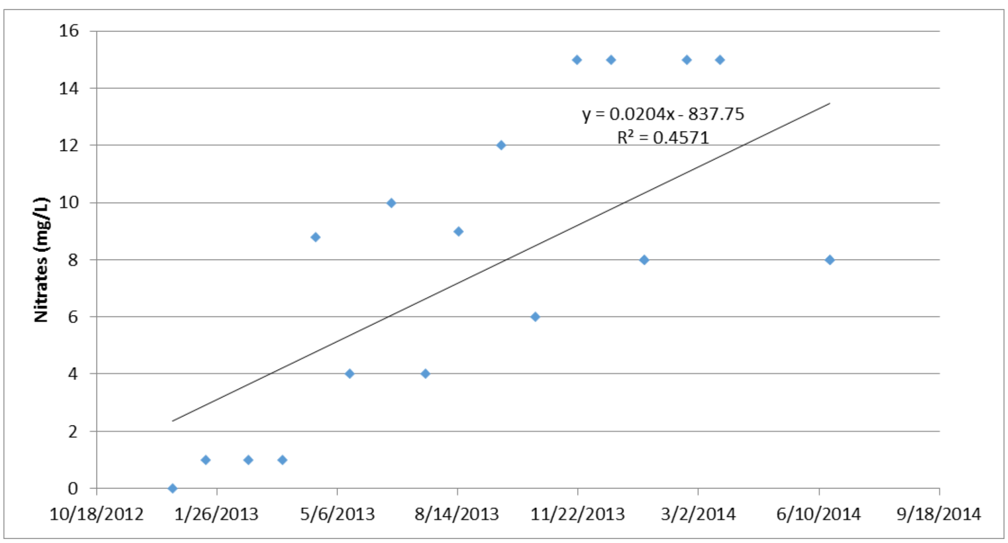

Figure 48: Nitrates at Site 15126

Site 12804 – Cibolo Creek @ SH 97

Site Description

This site is located southeast of San Antonio at the State Highway 97 crossing over Cibolo Creek. This is a rural area with a few houses scattered about and large parcels of cropland. The creek banks contain a mixture of hardwood trees.

Sampling Information

This site is no longer active. It was sampled 8 times between 7/1/2012 and 2/3/2013. The site was monitored in the morning hours between 10:00 and 11:00.

Table 12: Descriptive parameters for Site 12804

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	7	505 ± 87	312	592
Water Temperature (°C)	8	22.8 ± 6.5	11.0	29.5
Dissolved Oxygen (mg/L)	5	7.2 ± 2.2	4.3	10.0
pH	5	7.4 ± 0.1	7.3	7.5

Site was sampled 8 times between 7/1/2012 and 2/3/2013.

Air and water temperature

Air and water temperatures were measured 8 times at this site. The mean water temperature was 22.8°C. Water temperature varied from a low of 11.0°C in January, 2013, to a high of 29.5°C in August of 2012. Air temperature varied from a low of 10.0°C in January, 2013 to a high of 27.5 in August of 2012.

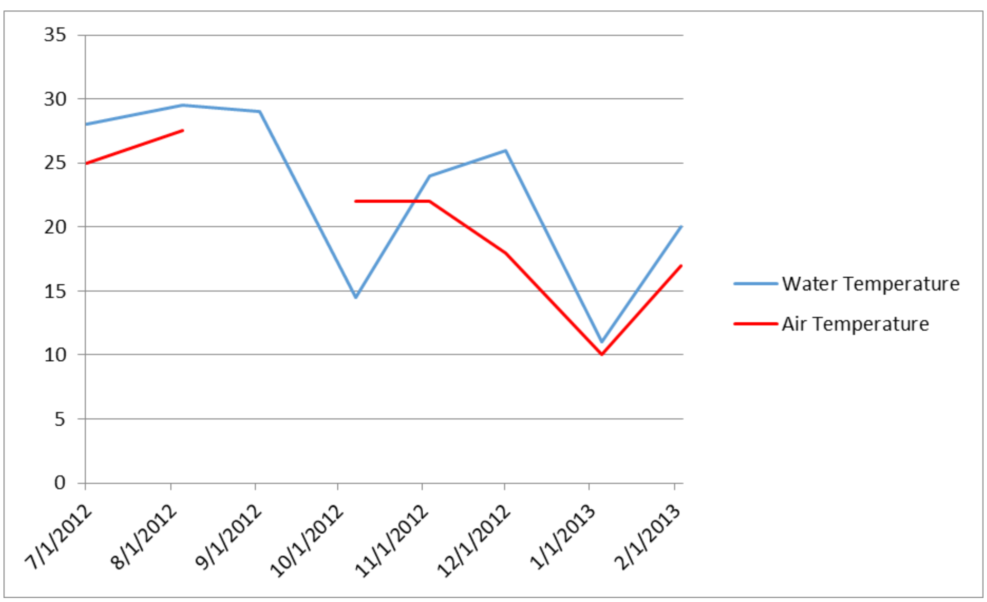

Figure 49: Air and water temperatures at Site 12804

Total Dissolved Solids

Citizen scientists collected 7 TDS samples at this site. The mean TDS concentration was 505 mg/L. The minimum TDS concentration was 312 mg/L and was collected in October, 2012. The maximum TDS concentration was 592 mg/L and was taken in December of 2012. There was no significant trend in TDS over time observed at this site.

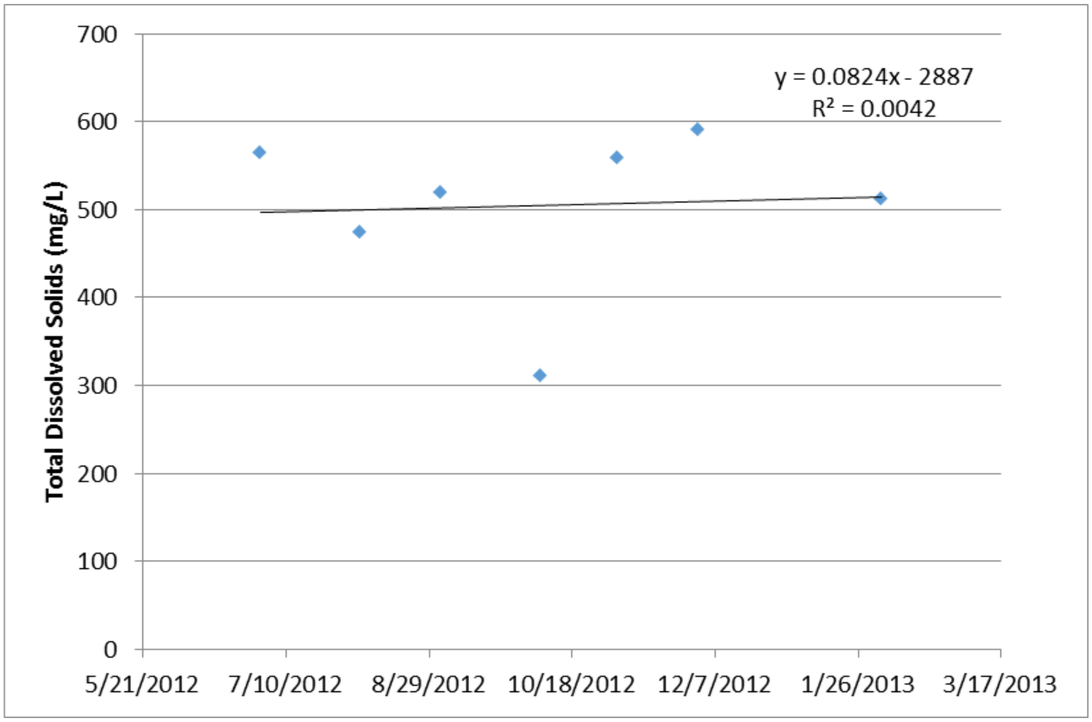

Figure 50: Total Dissolved Solids at Site 12804

Dissolved Oxygen

Citizen scientists collected 5 DO samples at this site during this time. The mean DO concentration was 7.2 mg/L. The minimum DO concentration was 4.3 mg/L and was taken in August of 2012. The maximum DO concentration was 10.0 mg/L and was taken in January of 2013.

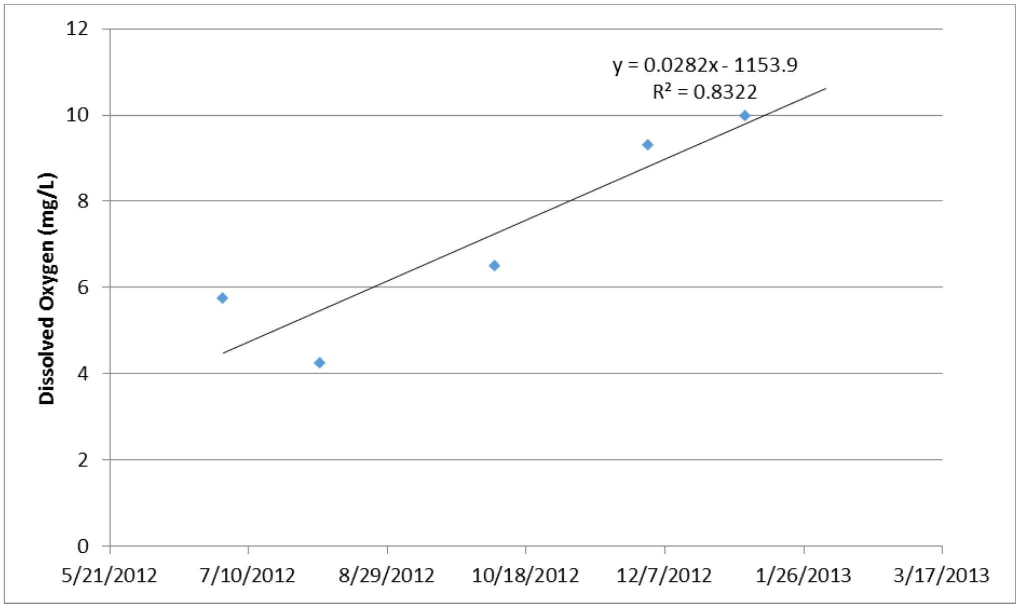

Figure 51: Dissolved Oxygen at Site 12804

pH

Citizen scientists took 5 pH measurements at this site. The mean pH was 7.4, and it ranged from a high of 7.5 taken in October of 2012 and January of 2013, to a low of 7.3 taken in August of 2012.

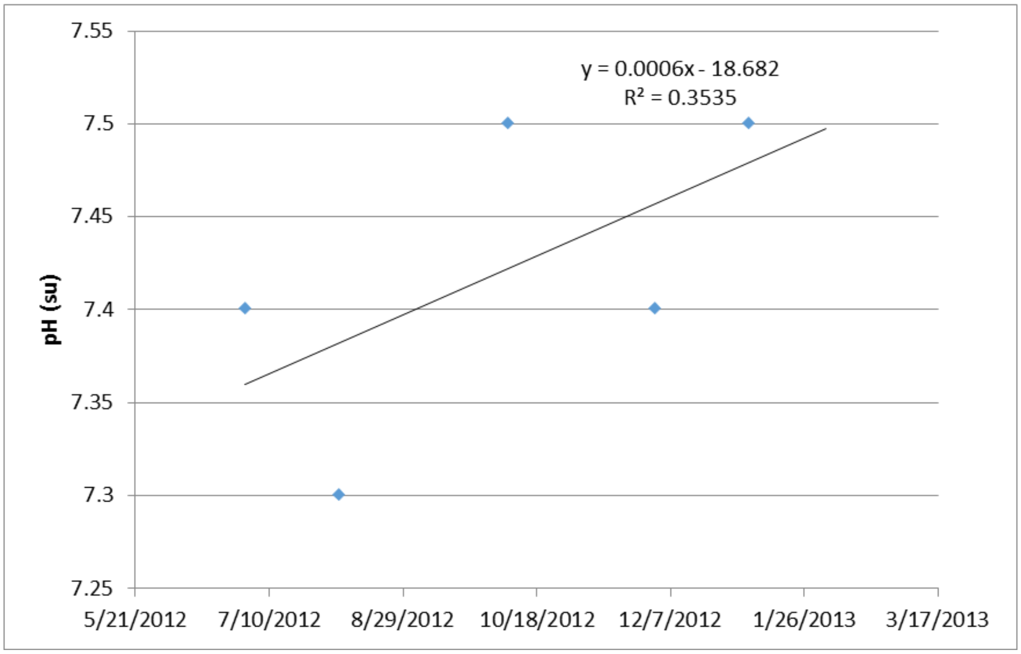

Figure 52: pH at Site 12804

Secchi disk and total depth

The mean total depth at this site was 0.68 m. In all monitoring events except for 2, the Secchi disk depth was less than the total depth indicating that the water clarity was such that the bottom of the creek was not visible at this site. The mean Secchi disk depth was 0.53 m.

Field Observations

The flow ranged from low to high and was mostly described as normal. The algae cover was described as common (26 – 50%). The water color was light green. Water clarity was clear, and there was no odor detected.

Get Involved with Texas Stream Team!

Once trained, citizen monitors 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 Texas Commission on Environmental Quality (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, Texas Stream Team 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.

References

Cibolo Nature Center, "The Cibolo Corridor Conservation Initiative Protecting the Cibolo Creek Watershed: Protecting the Cibolo Creek Watershed." Last modified 2006. Accessed December 9, 2013. http://www.cibolo.org/conservation.

City of Boerne, "Upper Cibolo Creek Watershed." Accessed December 9, 2013. http://www.ci.boerne.tx.us/index.aspx?NID=147.

Texas Commission on Environmental Quality, "Lower Cibolo Creek (1902) Recreational Use Attainability Analysis Summary and Recommendation." Accessed December 9, 2013. http://www.tceq.texas.gov/assets/public/waterquality/standards/swqsawg2013/swqsawg_5-2012_RUAA_1902.pdf.

Texas Commission on Environmental Quality, "Upper Cibolo Creek Watershed Protection Plan." Last modified December 2012. Accessed December 9, 2013. http://www.tceq.texas.gov/assets/public/compliance/monops/nps/projects/77093_FS_UpCiboloWPP.pdf.

Texas Parks & Wildlife Department, "An Analysis of Texas Waterways." Accessed December 9, 2013. http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1047/25_c_tx_seas_restrict.phtml.

Texas Parks & Wildlife Department, "Ecoregion 4 - The Blackland Prairies." Accessed December 9, 2013. http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/wildscapes/ecoregions/ecoregion_4.phtml.

Texas Parks & Wildlife Department, "Ecoregion 7 - Edwards Plateau." Accessed December 9, 2013. http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/wildscapes/ecoregions/ecoregion_7.phtml.

Texas Parks & Wildlife Department, "Ecoregion 6 - South Texas Brush Country." Accessed December 9, 2013. http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/wildscapes/ecoregions/ecoregion_6.phtml.

Texas Parks & Wildlife Department, "Region 7 - Edwards Plateau." Accessed December 9, 2013. http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml.

Texas Parks & Wildlife Department, "Region 3 - Oaks and Prairies." Accessed December 9, 2013. http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_3.phtml.

Texas Parks & Wildlife Department, "Region 8 - South Texas Brushlands." Accessed December 9, 2013. http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_8.phtml.

Texas State Historical Association, "Cibolo Creek (Kendall County)." Accessed December 9, 2013. http://www.tshaonline.org/handbook/online/articles/rbcee.

Appendix A- List of Maps, Tables, and Figures

Tables

Figures