Cypress Creek Watershed Data Report

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THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

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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

The Cypress Creek Watershed covers approximately 24,320 acres or 38 square miles through the city of Woodcreek and the city of Wimberley in the Central Texas Hill Country. Cypress Creek is a tributary that flows into the Blanco River on the south side of Wimberley, just upstream from where RR12 crosses over the Blanco River (Meadows Center for Water and the Environment, 2010). The Cypress Creek Watershed is located within the larger regional Hays-Trinity Watershed. Jacobs Well, a natural artisan spring, is a critical discharge point for the Hays-Trinity Aquifer and functions as the head waters for the perennial portion of Cypress Creek (Jones, 2004). In this area the "the banks are lined with bald cypress, pecan, willow, and sycamore trees, while the hills away from the [creek] are covered with live oaks and cedars (Texas Parks & Wildlife Department, 1974)." The climate here is considered to temperate and semi-arid, with an average precipitation rate of 34 inches annually and long, hot summers (Hays County Historical Commission, 2011).

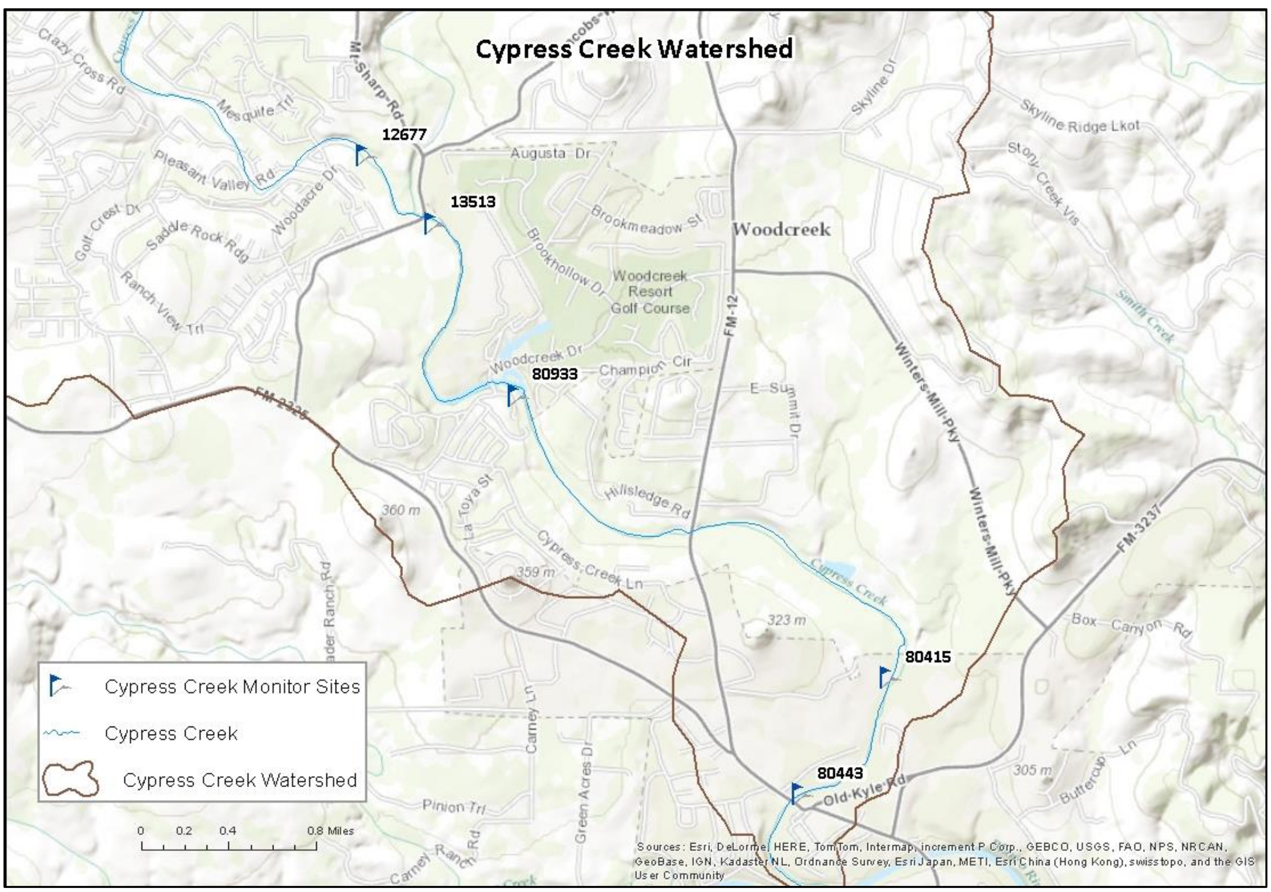

Figure 1:Map of the Cypress Creek Watershed with Texas Stream Team Monitor Sites

Physical Description

The Cypress Creek watershed is essential in terms of ecological services, regarding the larger Hays-Trinity Aquifer, and in terms of the human services ranging from contact recreation and tourism to public water supply (USGS). Interactions between the surface and groundwater in the karstic Cypress Creek watershed are very complex and require a large degree of geologic understanding in order to calculate the recharge rate for the area. The soils in the Cypress Creek watershed are comprised primarily of shallow clay loams but the underlying geology is primarily karstic in nature. According to hydrologic soil grouping, the shallow clays are classified as hydrologic group D, or low permeability soils, while the underlying geology is highly permeable, thus, the groundwater receives recharge in very specific locations throughout the watershed (Jones, 2004). According to Dr. Ian Jones of the Texas Water Development Board, the Trinity Aquifer, which is the primary watershed that houses the Cypress Creek watershed, receives an estimated 4.7% annual recharge in the form of precipitation. This number was calculated based on mean annual rainfall over two 30 year periods, 1961 to 1990 and 1971 to 2000, utilizing the Groundwater Availability Model or GAM (Jones, 2004). While there is a large degree of surface runoff in the area, Cypress Creek is largely a gaining stream and is heavily influenced by the groundwater discharge at Jacobs Well from the Trinity Aquifer. In order to understand the hydrologic budget in the Cypress Creek watershed, it is important to understand the complex interaction between groundwater and surface water. Evidence of this can be seen in separation of the ephemeral and perennial portions of the creek. The ephemeral portion of the creek is located in the higher elevation areas and the perennial portion of the creek is located from the Trinity aquifer discharge site at Jacobs Well to the confluence into the Blanco River.

Land use

Land use in the Cypress Creek watershed is three fourths Agriculture/Rangeland, with only a small percentage of the land being utilized by residential or urban uses. The ecology of the land makes crop farming difficult due to the thin top soil and semi-arid climate, so the majority of land that is classified in the Agricultural/Rangeland category can be thought of as primarily grazing land, with no intensive crop farming taking place (Meadows Center for Water and the Environment, 2010). Furthermore, the majority of urban density is located in the southern portion of the Cypress Creek Watershed, which is also where the perennial portion of the creek is located. This is an important distinction to note, as the largest density occurs on the most vulnerable area of the creek.

Hays County, according to the Texas State Data Center, is listed as the 31st fastest growing county in the United States. Additionally, from 2000 to 2009 the population of Wimberley and Woodcreek grew approximately 21% (Texas State Data Center, 2009). As a result, there is a large degree of projected growth for the area, with population projected to increase overall in Hays County at a rate of 15% annually according to the Hays County Extension office for Texas AgriLife (Texas AgriLife, 2010).

Much of the area that is available for development is in the 'unincorporated' sections of Hays County. According to the zoning bylaws of both Wimberley and Woodcreek, both jurisdictions place a large degree of focus on maintaining the "quaint" rural Texas feel of the region. However, according to population and growth projections there will be growth in the region regardless. As 75% of the land use within the watershed is associated with Agricultural/Rangeland, there is quite a bit of open land that could potentially be developed for Residential purposes, pending zoning changes.

History

Dating back to the origins of Wimberley, Cypress Creek was home to the very first grist mill, under the ownership of Pleasant Wimberley in 1847. The mill was expanded in later years to also be a saw mill, shingle mill, molasses mill, and cotton gin (Hays County Historical Commission, 2010). The city of Woodcreek was incorporated as a city in 1984 and Wimberley received incorporation in 2000. Woodcreek has a population of 1,300 and is primarily comprised of residential homes interweaved with an 18 hole golf course. Wimberley has a population of 3,797 but includes a much larger community from the surrounding unincorporated areas. Wimberley has historically been a mill town and later became a rural tourist destination and a retirement community. The historical land uses in the Cypress Creek Watershed range from mills to agricultural (primarily grazing livestock) uses and as a tourist destination, known for its raw natural beauty (Hays County Historical Commission, 2010).

Watershed Protection Plan

In April 2014, the Cypress Creek Watershed Protection Plan was approved by the Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality (TCEQ). The watershed protection plan targets point and non-point sources of bacteria and other pollutants through monitoring and best management practices to improve water quality and restore its approval for contact recreation activities.

According to the Texas Commission on Environmental Quality (TCEQ) Cypress Creek is classified for Primary Contact Recreation, Public Water Supply, Aquifer Protection and Exceptional Aquatic Life use (TCEQ, Texas Commission on Environmental Quality, 2007). Cypress Creek provides the surrounding area with a precious natural resource replete with raw, untainted beauty and recreational value. The Cypress Creek Protection Plan aims to ensure the integrity of the creek for generations to come.

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.

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 2014Texas Surface Water Quality Standards report was used to reference the exceedances for the Cypress Creek Watershed, as seen below in Table 2.

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

Parameter	2014 Texas Surface Water Quality Standards for Cypress Creek	
Water Temperature (°C)	30.0° C (Maximum)	
Total Dissolved Solids (mg/L)	400 mg/L (Maximum)	
Dissolved Oxygen (mg/L)	6.0 mg/L (Minimum)	
pH	6.5-9.0 (Range)	
E. coli (CFU)	399 CFU/100mL	Single Sample
	126 CFU/100mL	Geometric Mean

Methods of Analysis

All data collected from Cypress 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 citizen scientists 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.

Cypress Creek Watershed Data Analysis

Cypress Creek Watershed 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 monitoring locations in the watershed. 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.

Cypress Creek Watershed Trends over Time

Sampling Trends over Time

Sampling in the Cypress Creek Watershed began in 1995 and continues to this day. A total of 144 individual monitoring events from 5 sites were analyzed. The time of sampling ranged from 07:00 to 20:00, with 09:00 being the most common hour for sampling to occur.

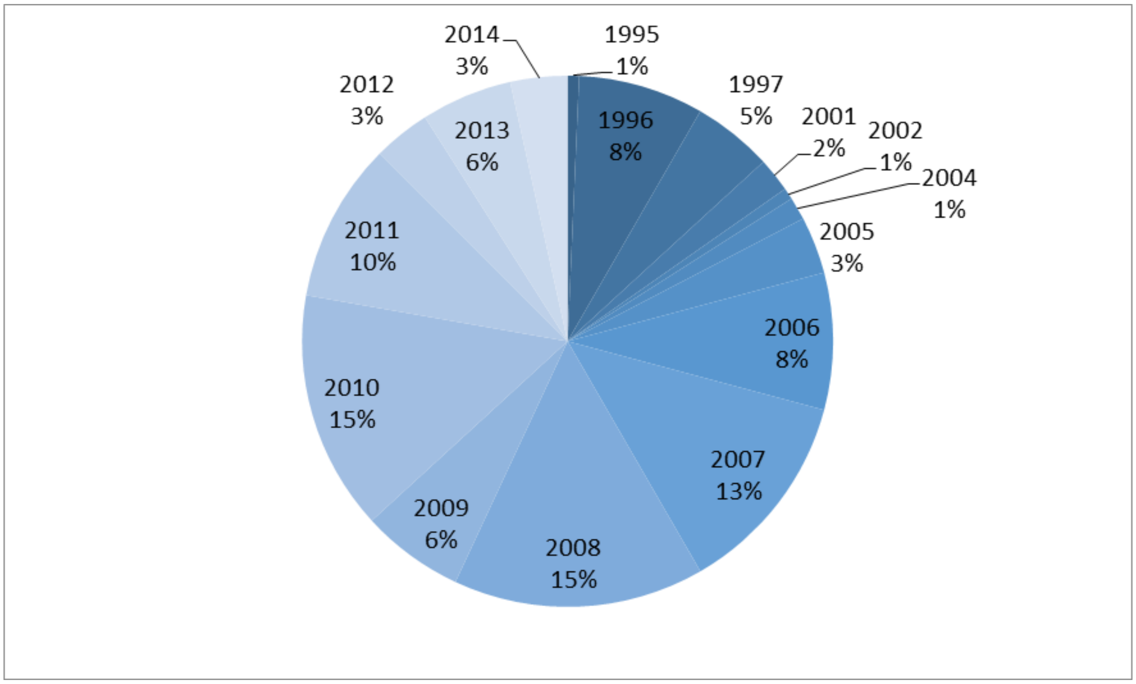

Figure 2: Breakdown of monitoring events by year.

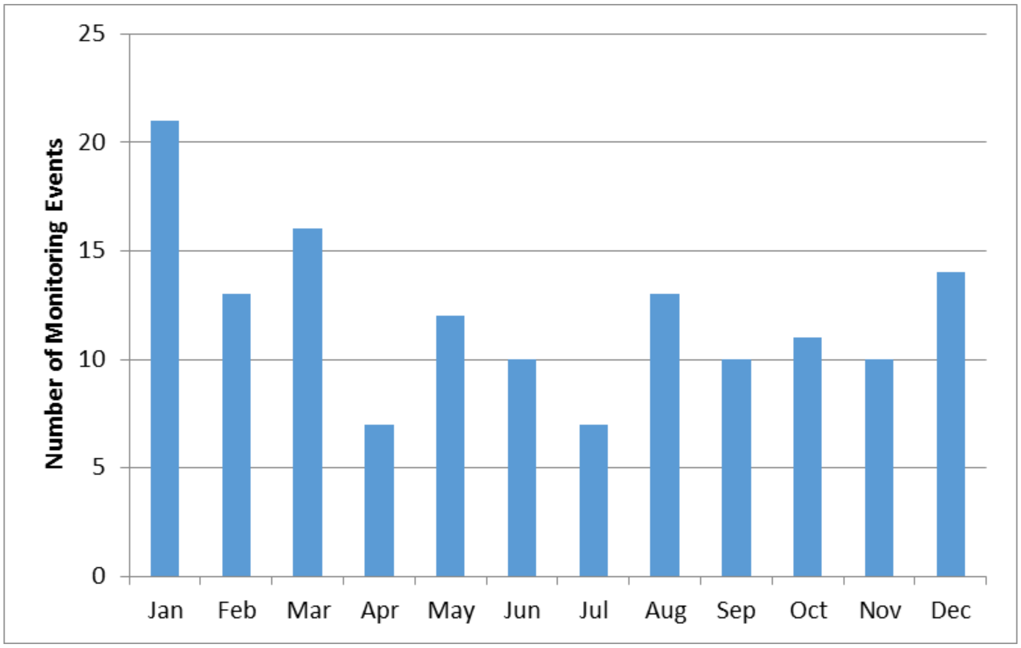

Figure 3: Breakdown of monitoring events by month.

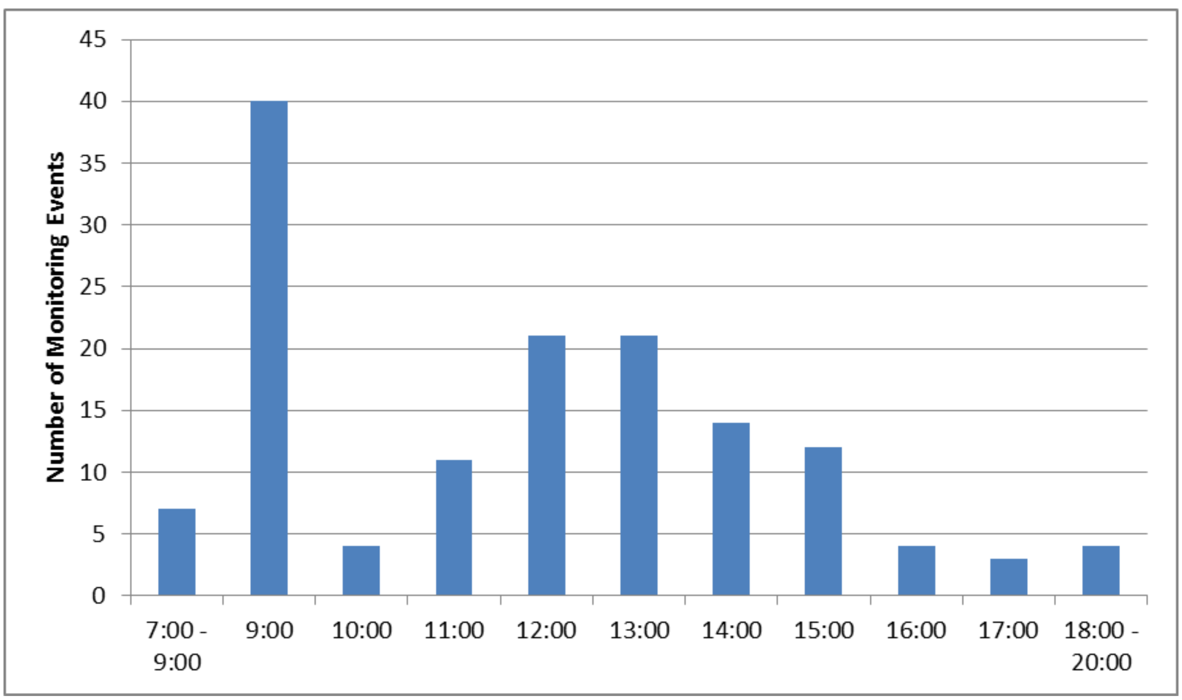

Figure 4: Breakdown of time of monitoring in the Cypress Creek Watershed

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

Cypress Creek December 1995 – March 2014				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	124	371 ± 31	215	442
Water Temperature (°C)	142	19.5 ± 4.6	0	30
Dissolved Oxygen (mg/L)	131	6.8 ± 2.0	3.1	12.3
pH	134	7.35 ± 0.36	6.5	8.5
E. coli Bacteria (CFU/100 mL)	0	--	--	--

There were a total of 144 sampling events between 12/1995 and 03/2014. Mean, calculated in Microsoft Excel, is listed for all parameters except E. coli, where a geomean, calculated in Minitab v15, was used.

Trend Analysis over Time

Air and water temperature

A total of 142 water temperatures and 144 air temperatures were collected within the Cypress Creek Watershed between 1995 and 2014. Water temperature never exceeded the TCEQ optimal temperature standard of 30°C. Air temperature varied between 0°C and 35°C.

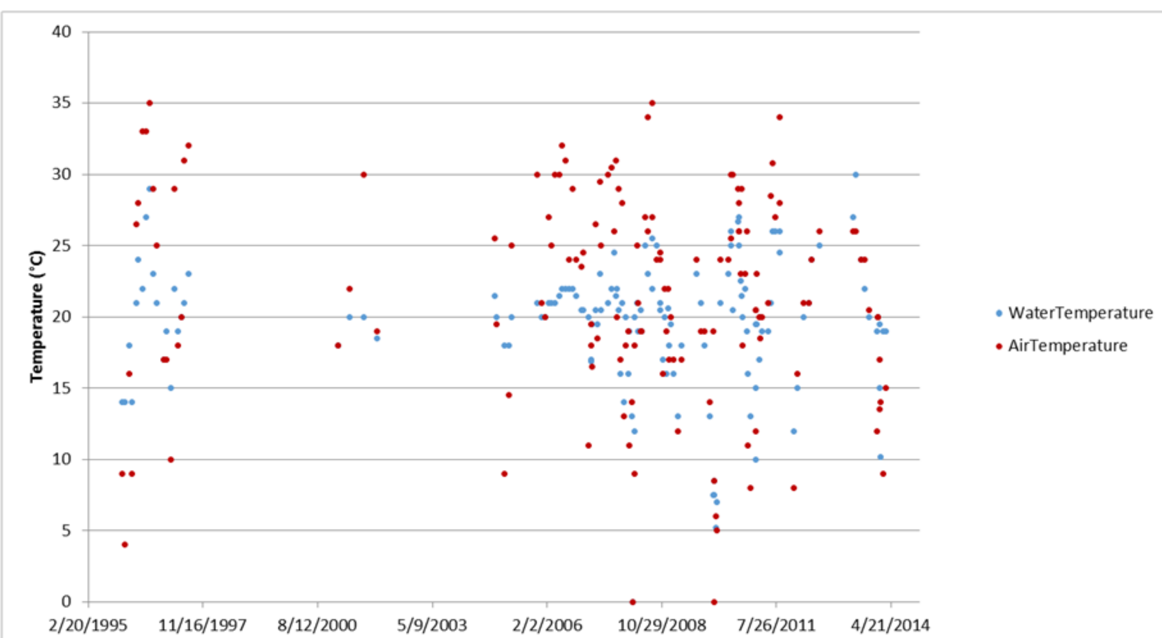

Figure 5: Air and water temperature over time at all sites within the Cypress Creek Watershed

Total Dissolved Solids

Citizen scientists collected 124 TDS samples within the watershed. The TDS measurement was completed for 86.1% of all monitoring events. The average TDS measurement for all sites was 371 mg/L and there was no significant increase or decrease in TDS values over time.

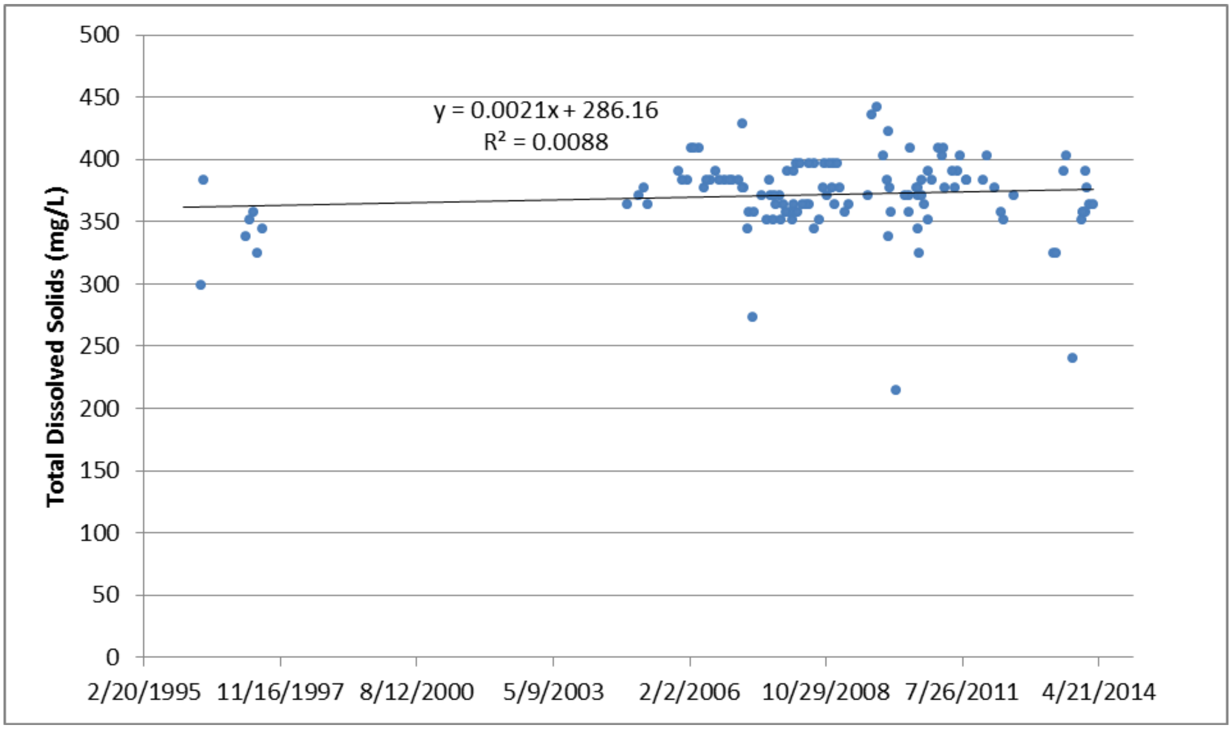

Figure 6: Total Dissolved Solids over time at all sites within the Cypress Creek Watershed

Dissolved Oxygen

Citizen scientists collected a total of 131 DO samples within the Cypress Creek Watershed. Dissolved oxygen fluctuated seasonally with values typically higher in the winter months than the summer months. This is because colder water holds more dissolved gasses than warmer water. The mean DO was 6.8 mg/L and it ranged from a low of 3.1 mg/L on August 31, 2013 to 12.3 mg/L on May 3, 1996. 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.

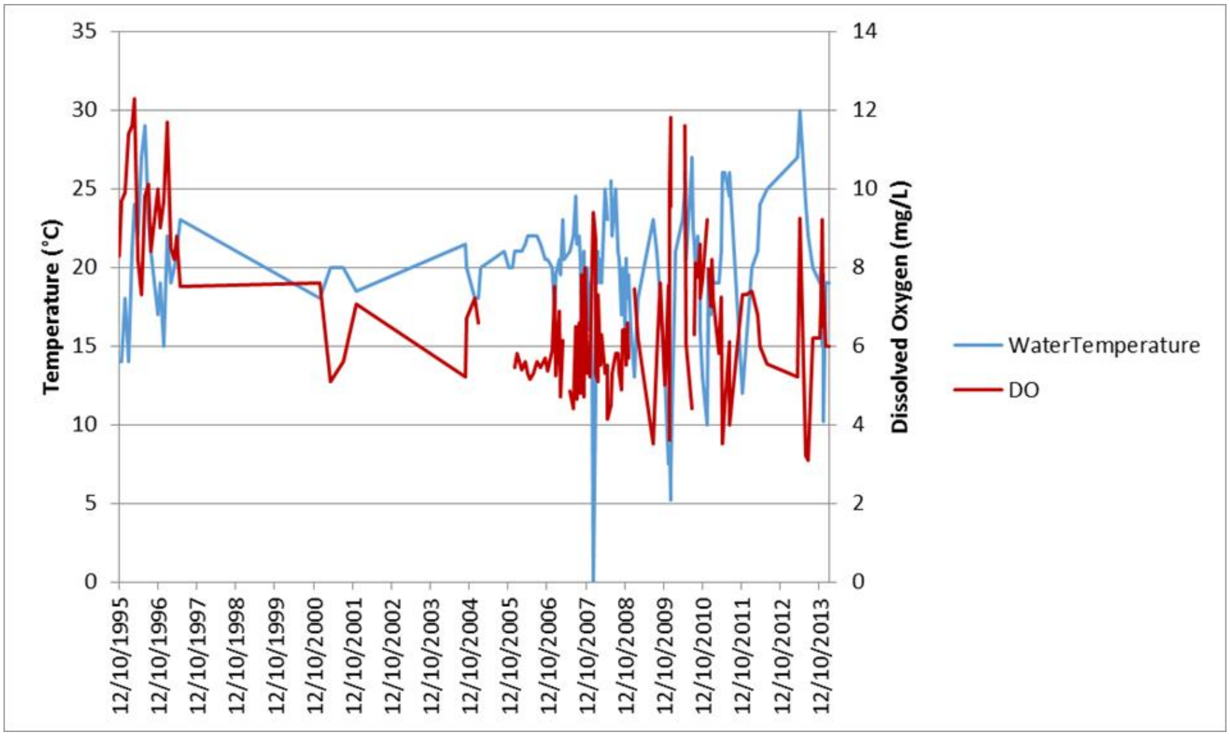

Figure 7: Dissolved Oxygen at all sites within the Cypress Creek Watershed

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

Time	**Average DO (mg/L)**	**Standard Deviation**
7:00 – 9:00	5.68	1.99
9:00 – 10:00	6.49	1.39
10:00 – 11:00	7.92	1.62
11:00 – 12:00	7.04	1.88
12:00 – 13:00	6.90	2.03
13:00 – 14:00	6.46	2.34
14:00 – 15:00	6.55	2.00
15:00 – 16:00	6.66	1.05
16:00 – 19:00	9.54	2.55

pH

pH was successfully completed for 96.5% of all sampling events. There were 139 pH measurements taken in the Cypress Creek Watershed, and the mean pH was 7.35. The pH for all of the sites ranged from 6.7 to 8.5. There was no significant increase or decrease in pH over time observed in the Cypress Creek Watershed during the study period.

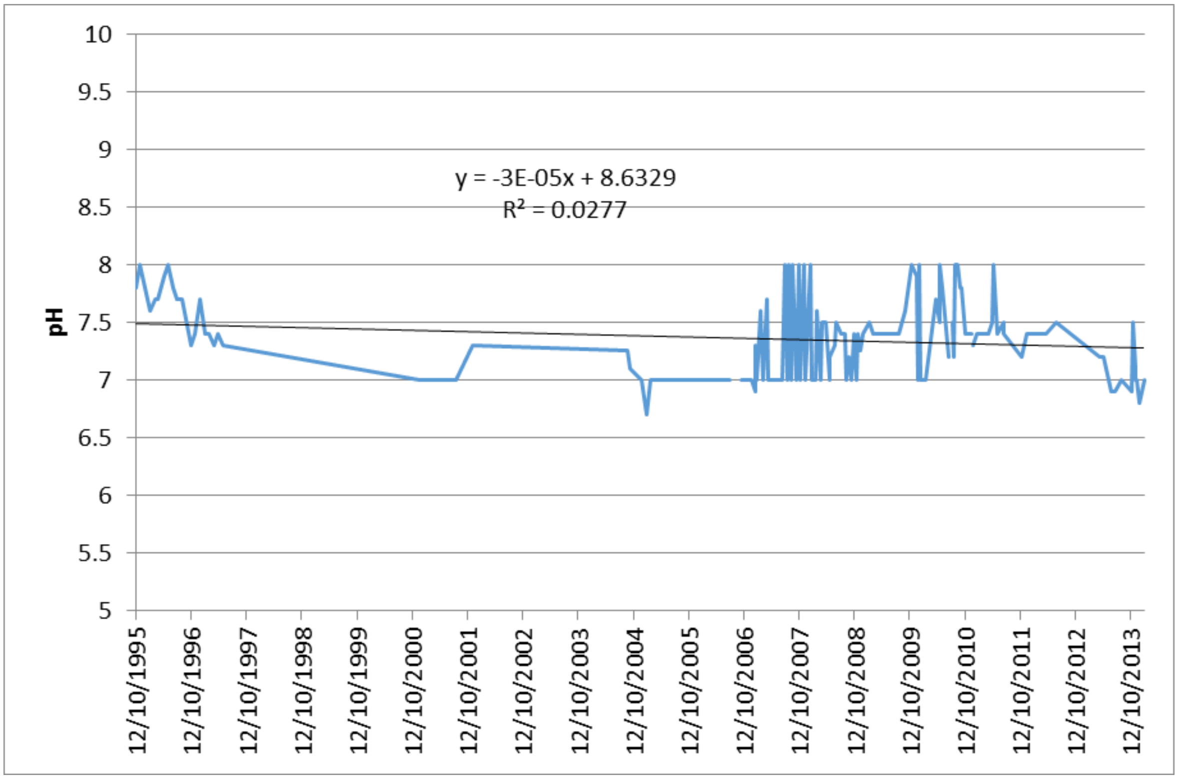

Figure 8: Changes in pH over time at all sites within the Cypress Creek Watershed

Cypress Creek Upstream to Downstream Trends

Total Dissolved Solids

There was no significant downstream trend in TDS concentrations observed for the study.

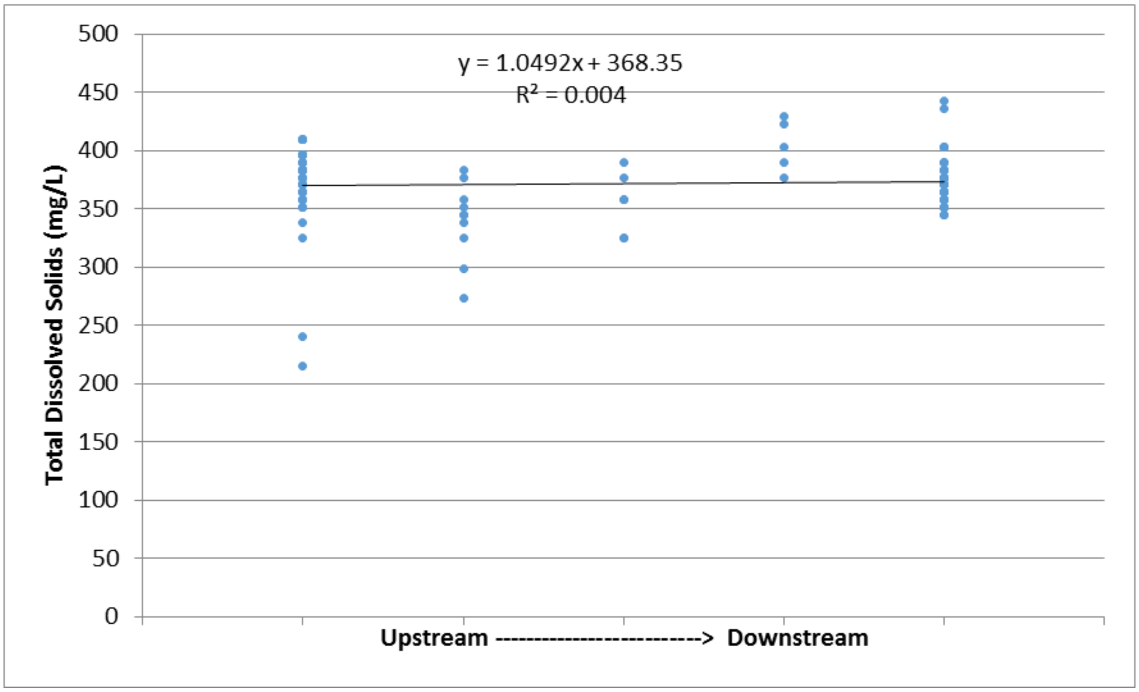

Figure 9: Downstream trends in Total Dissolved Solids in the Cypress Creek Watershed

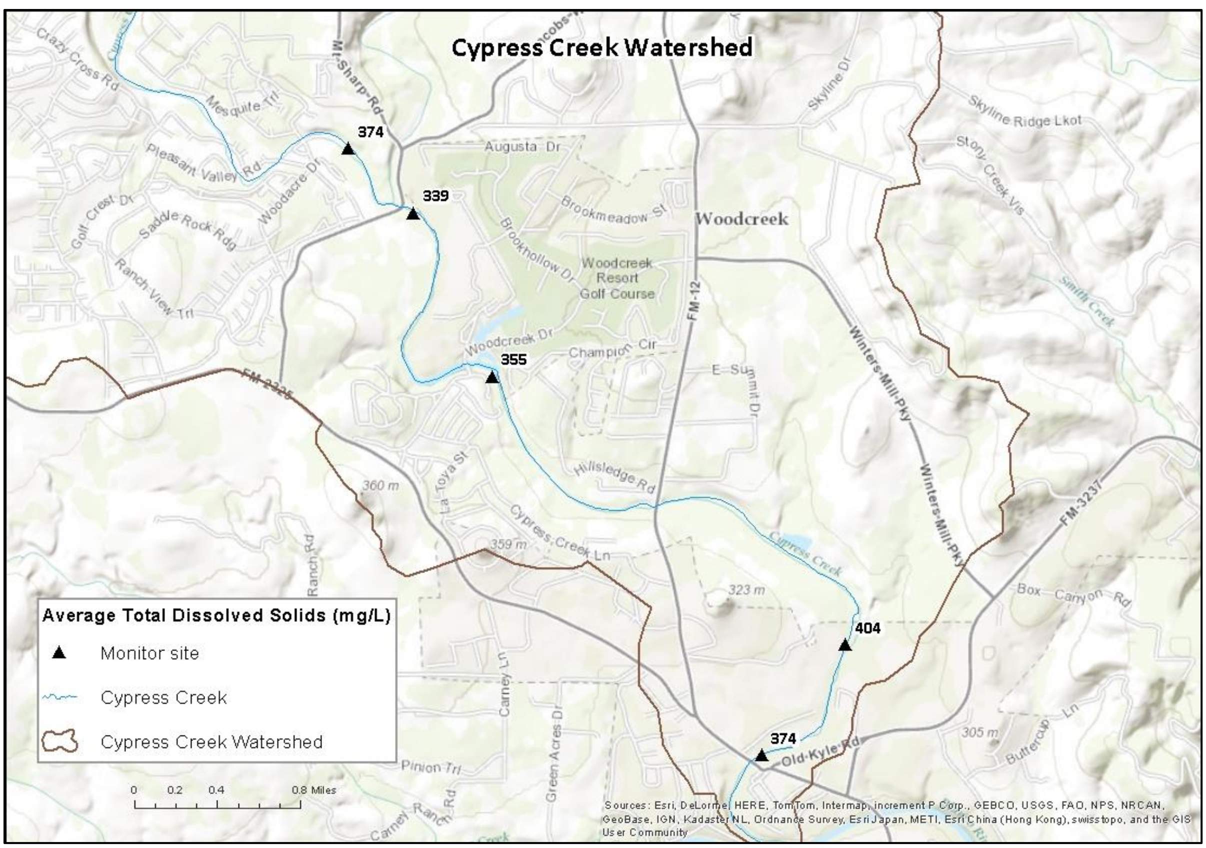

Figure 10: Map of average Total Dissolved Solids in the Cypress Creek Watershed

Dissolved Oxygen

There was no significant correlation between DO measurements and distance downstream.

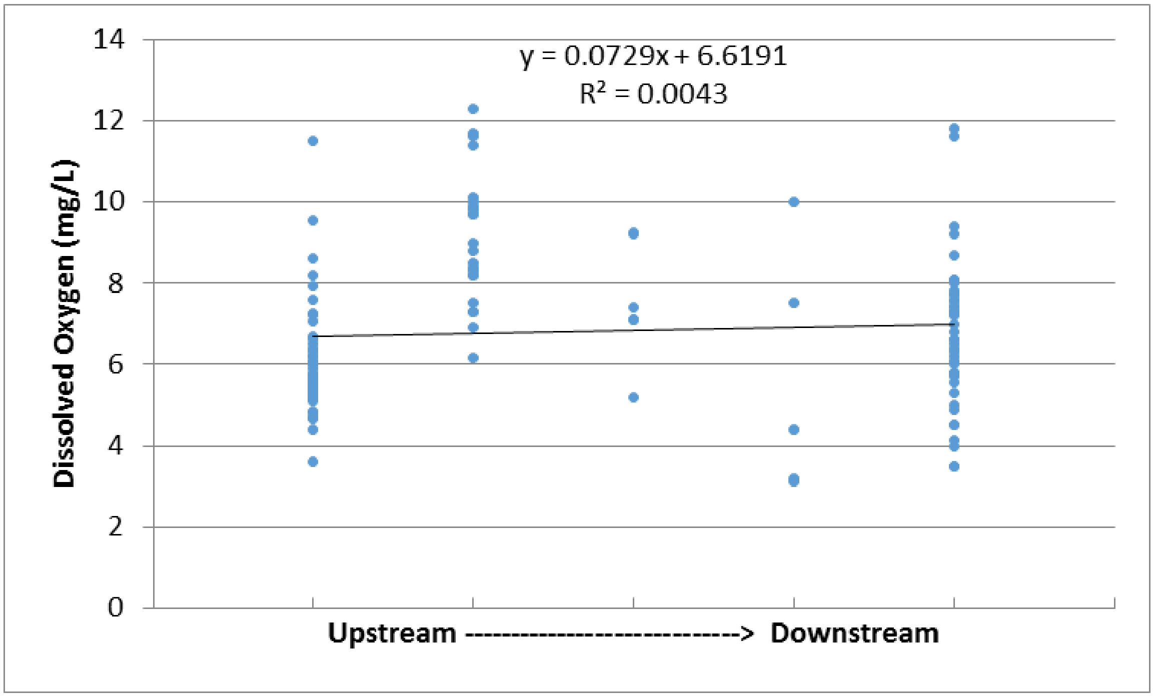

Figure 11: Downstream trends in Dissolved Oxygen in the Cypress Creek Watershed

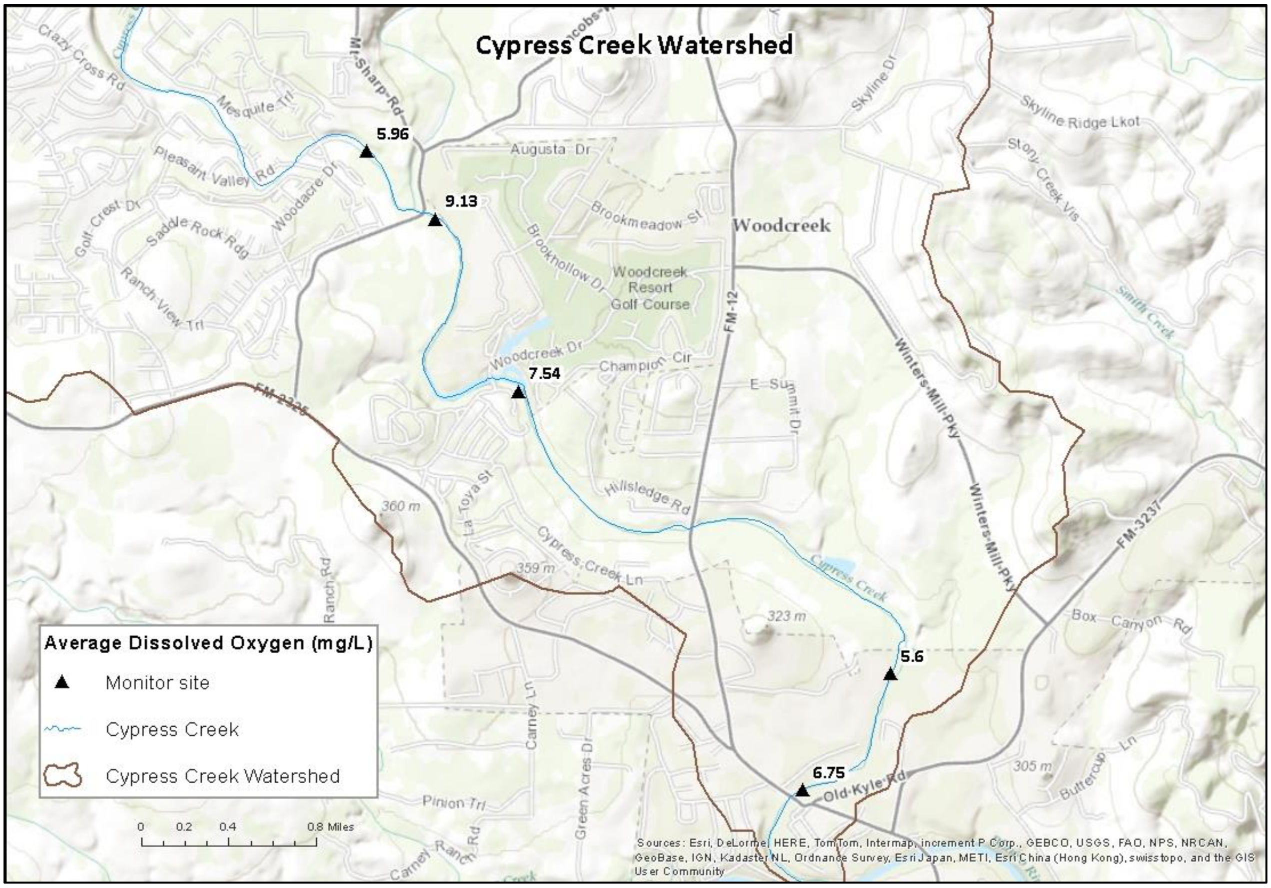

Figure 12: Map of Dissolved Oxygen over time at all sites within the Cypress Creek Watershed

pH

There was a significant correlation between pH and distance downstream with pH increasing as one moves downstream Cypress Creek (p = 0.000). The relationship between pH and distance downstream explains 29.2% of the variation in the data collected.

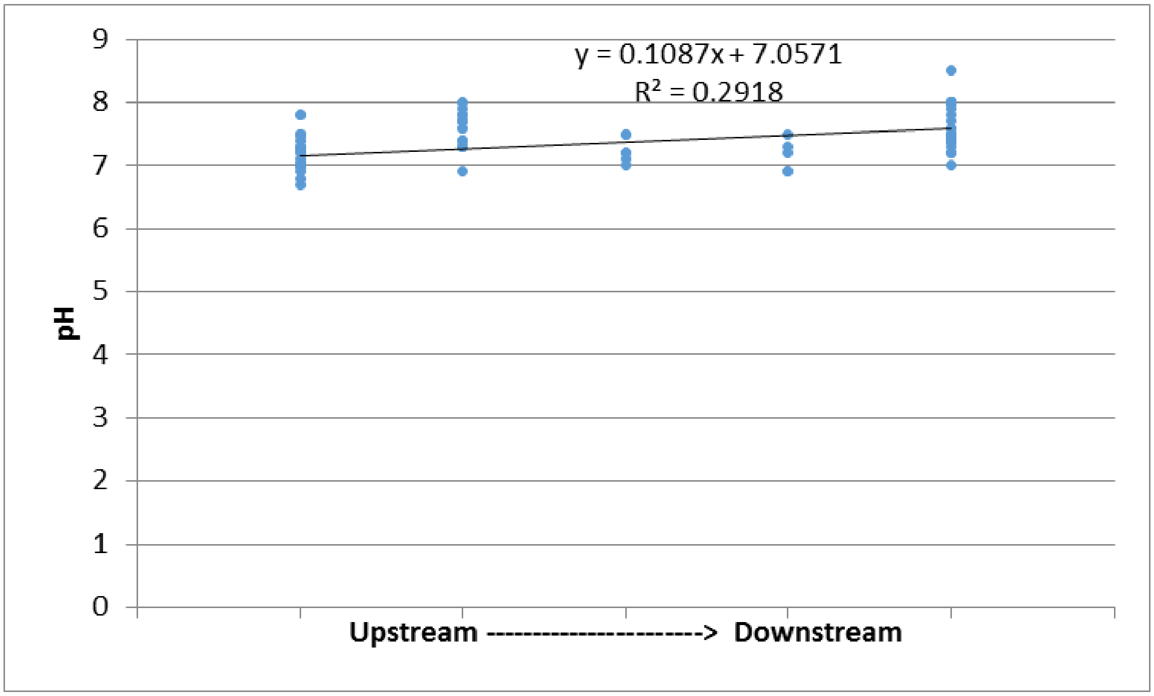

Figure 13: Downstream trends in pH in the Cypress Creek Watershed

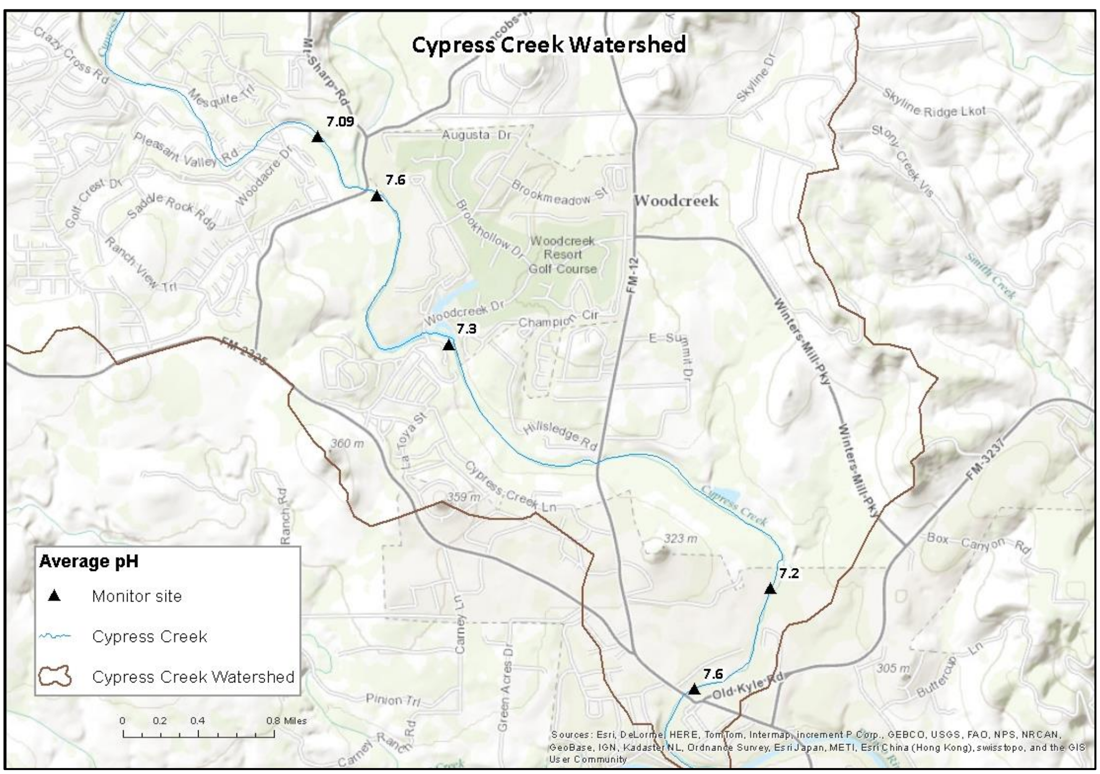

Figure 14: Map of pH at all sites within the Cypress Creek Watershed

Cypress 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 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 80415 had the highest overall average for TDS, with a result of 404 ± 19 mg/L. Site 13513 had the lowest average TDS, with a result of 339 ± 30 mg/L.

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 80415 had the lowest average DO reading, with a result of 5.6 ± 2.7 mg/L. Site 13513 had the highest average DO reading, with a result of 9.13 ± 1.62 mg/L.

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. Sites 13513 and 80443 had the highest average pH level, with a result of 7.6 ± 0.26 and 7.6 ± 0.30 respectively. Site 12677 had the lowest average pH level, with a result of 7.09 ± 0.21.

Please see Table 5 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. 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 sites

Site Number	TDS (mg/L)	DO (mg/L)	pH
12677	374 ± 34	5.96 ± 1.31	7.09 ± 0.21 (min)
13513	339 ± 30 (min)	9.13 ± 1.62 (max)	7.6 ± 0.26 (max)
80933	355 ± 27	7.54 ± 1.52	7.3 ± 0.2
80415	404 ± 19 (max)	5.6 ± 2.7 (min)	7.2 ± 0.3
80443	374 ± 20	6.8 ± 1.8	7.6 ± 0.3 (max)

Site 12677– Cypress Creek at Jacobs Well

Site Description

This site is at the perennial headwaters of Cypress Creek. The creek continues upstream of Jacobs Well, but this section is usually dry unless there is precipitation. Jacobs Well is an artesian spring. The Well is approximately 3 – 4 m wide and about 13 m deep. At the bottom of Jacobs Well is an entrance to an underwater network of caves that enters into the Hays Trinity Aquifer. The spring flow of Jacobs Well is around 1 – 3 cubic feet per second and is the major source of water in Cypress Creek. The surrounding area contains limestone boulders, and the riparian vegetation consists of cypress, junipers and live oaks. Jacob's Well is part of a nature preserve and interpretive center.

Sampling Information

This site is still actively monitored, but for the purposes of this study, data from 2/3/2001 to 3/8/2014 was analyzed. This site was monitored 61 times during that period. The time of the monitoring at this site has ranged from 07:00 to 17:00 throughout the years.

Table 6: Descriptive parameters for Site 12677

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	55	374 ± 34	215	410
Water Temperature (°C)	61	20.1 ± 2.7	7.0	25.0
Dissolved Oxygen (mg/L)	54	5.96 ± 1.31	3.6	11.5
pH	59	7.09 ± 0.21	6.7	7.8
Secchi Disk Transparency (m)	58	2.5 ± 3.5	0.1	18.0

Site was sampled 61 times between 2/3/2001 and 3/8/2014.

Air and water temperature

Air and water temperature were measured 61 times during this period. Air temperatures fluctuated in a seasonal pattern with a minimum of 5°C in February of 2010, and a maximum of 35°C in August, 2008. The minimum water temperature recorded was 7°C in February 2010, and the maximum temperature was 25°C which was recorded in July, 2010. Most of the water temperatures hovered around the average of 20.1°C due to the constant temperature of the groundwater coming up from the spring.

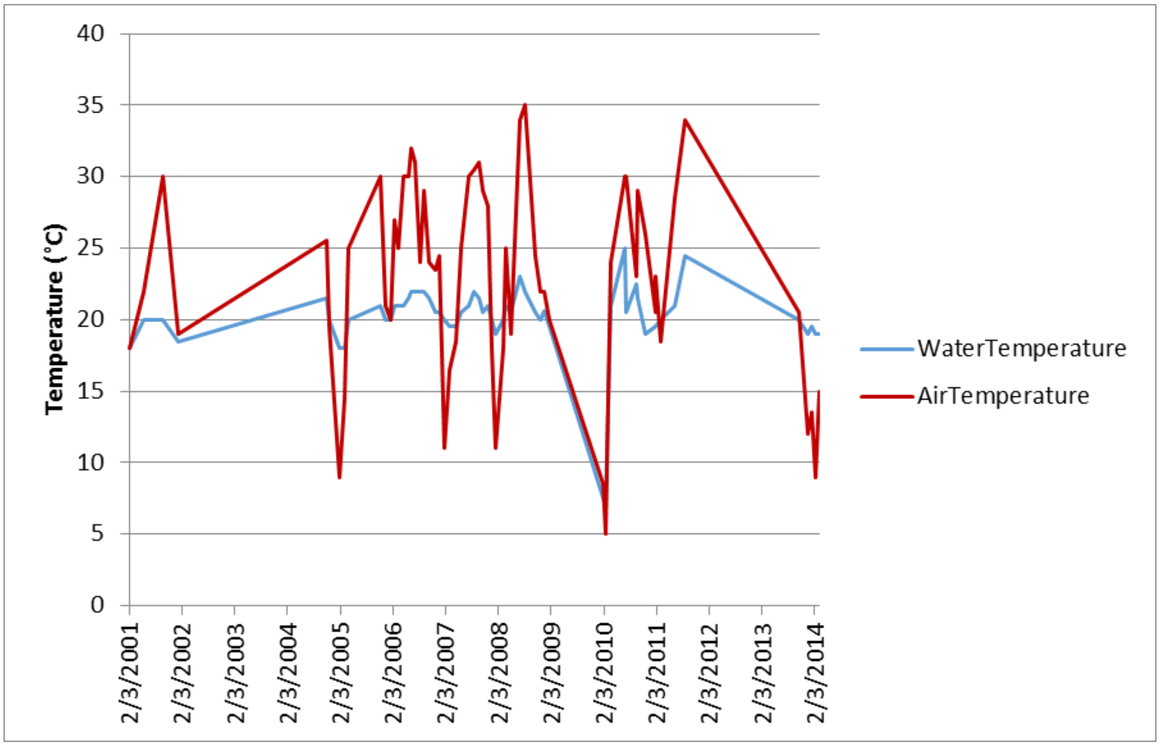

Figure 15: Air and water temperature at Site 12677

Total Dissolved Solids

Citizen scientists collected 55 TDS samples at this site. The maximum value was 410 mg/L sampled in April, 2006, and the minimum value was 215 mg/L sampled in March of 2010. There was a significant downward trend in TDS concentrations over time at this site ($p = 0.011$). The low R^2 value, however, indicated that this relationship only accounted for about 11.5% of the variation in the data.

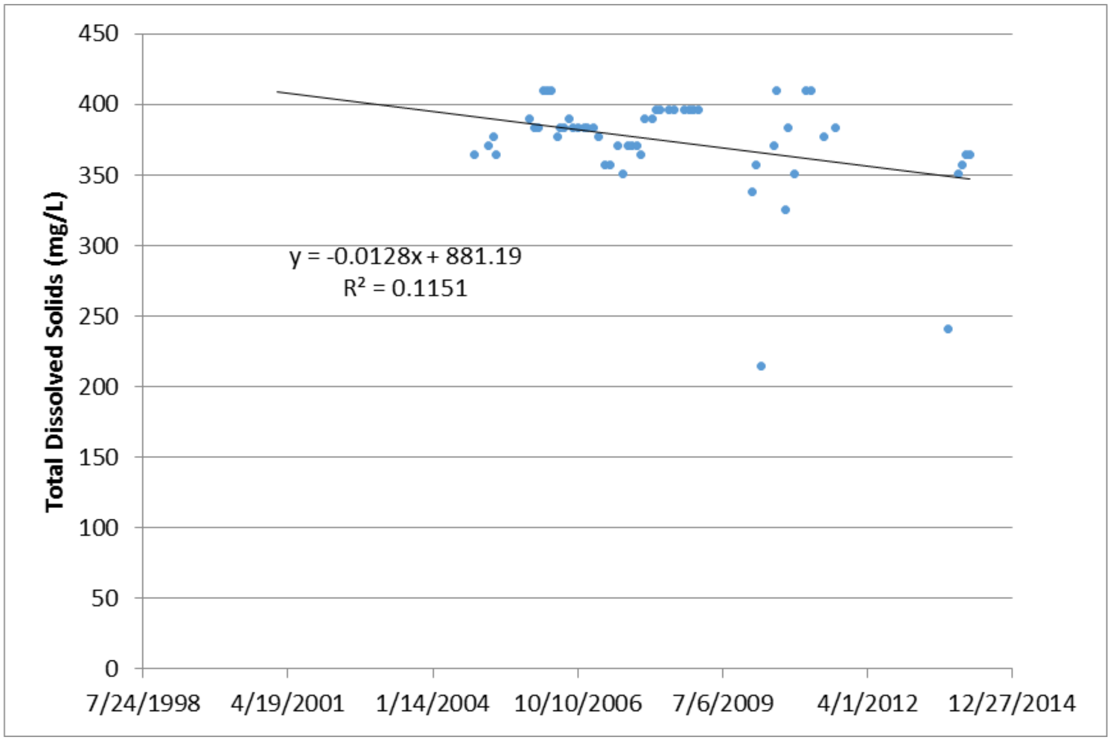

Figure 16: Total Dissolved Solids at Site 12677

Dissolved Oxygen

A total of 54 dissolved oxygen samples were taken at this site. The mean DO concentration was 5.96 mg/L. The minimum DO value was 3.6 mg/L and was recorded in January, 2010. The maximum DO value recorded at this site was 11.5 mg/L and was recorded in June, 2010. There was no significant increasing or decreasing trend in DO concentrations over time observed at this site.

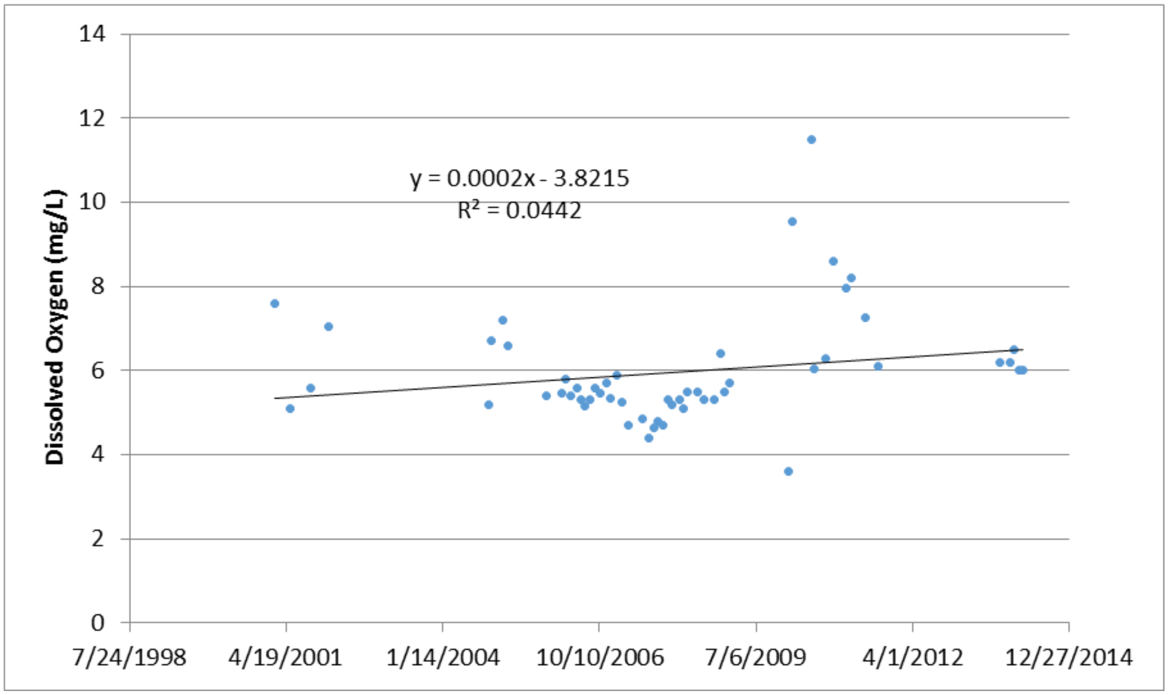

Figure 17: Dissolved Oxygen at Site 12677

pH

A total of 59 pH samples were taken at this site. The mean pH was 7.09 and was the lowest pH of all of the sites in the watershed. The minimum pH was 6.7 and was recorded in March, 2005. The maximum pH was 7.8 and was recorded in November of 2010. There was no significant increase or decrease in pH over time observed for this site.

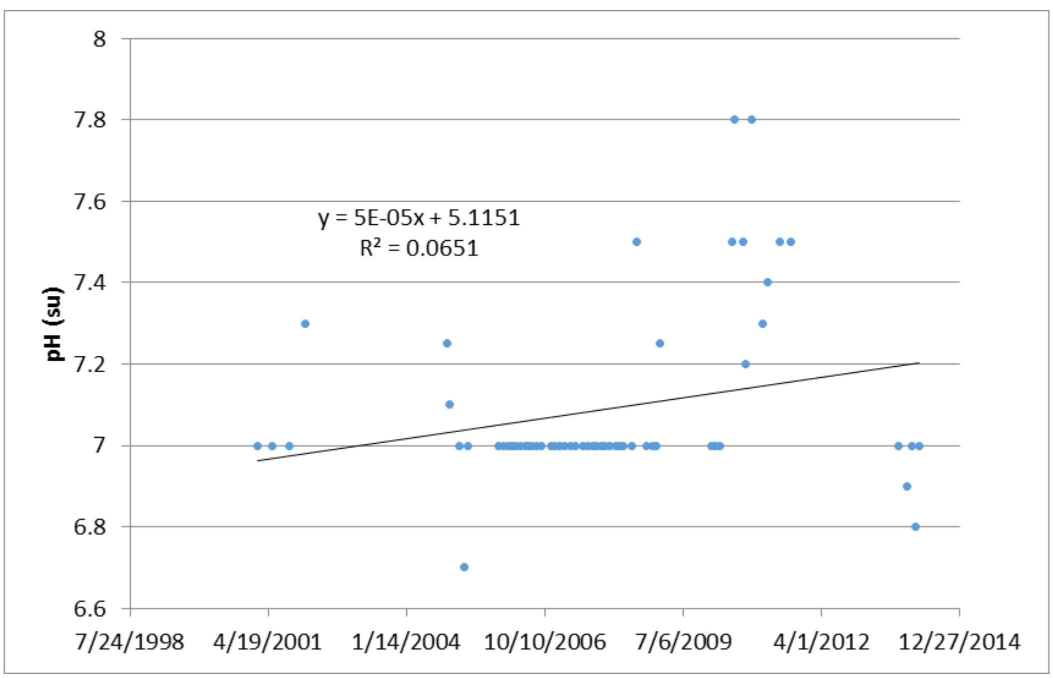

Figure 18: pH at Site 12677

Secchi disk and total depth

There were 54 events where Secchi disk depth and total depth were recorded. The ratio of Secchi disk depth to total depth was 0.95 indicating that the water was visible all the way to the bottom of the creek in almost all sampling events.

Field Observations

Algae cover was reported as absent or rare a majority of the time. There were 4 instances where the algae was reported as abundant (51 – 75% algae coverage), and one instance where it was recorded as dominant (>75% algae coverage). The water was described as having no color to a light green color, and the clarity was clear in all instances but two where the water was reported as being cloudy. The water had no distinguishable odor.

Site 13513 – Cypress Creek at County Road 220 Downstream of Jacobs Well

Site Description

This site is downstream of a low water crossing of County Road 220. Both banks of the creek are heavily wooded with live oaks and cypress trees. This site is in a flat flood plain that is undeveloped and part of a nature preserve.

Sampling Information

This site was sampled 22 times between December, 2010 and May, 2007. It is no longer being monitored. The time of monitoring ranged from 08:00 to 18:00, but was typically monitored at 12:00.

Table 7: Descriptive parameters for Site 13513

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	12	339 ± 30	273	384
Water Temperature (°C)	22	20.2 ± 3.9	14	29
Dissolved Oxygen (mg/L)	22	9.13 ± 1.62	6.2	12.3
pH	22	7.60 ± 0.26	6.9	8.0

Site was sampled 22 times between 12/10/1995 and 5/9/2007.

Air and water temperature

Air and water temperatures were measured 22 times during this time period. Air temperatures fluctuated in a seasonal pattern with a minimum temperature of 4°C taken in January, 1996 and a maximum of 35°C in August, 1996. Water temperature ranged from a minimum of 14°C recorded in January of 1996 to a maximum of 29°C on August, 1996.

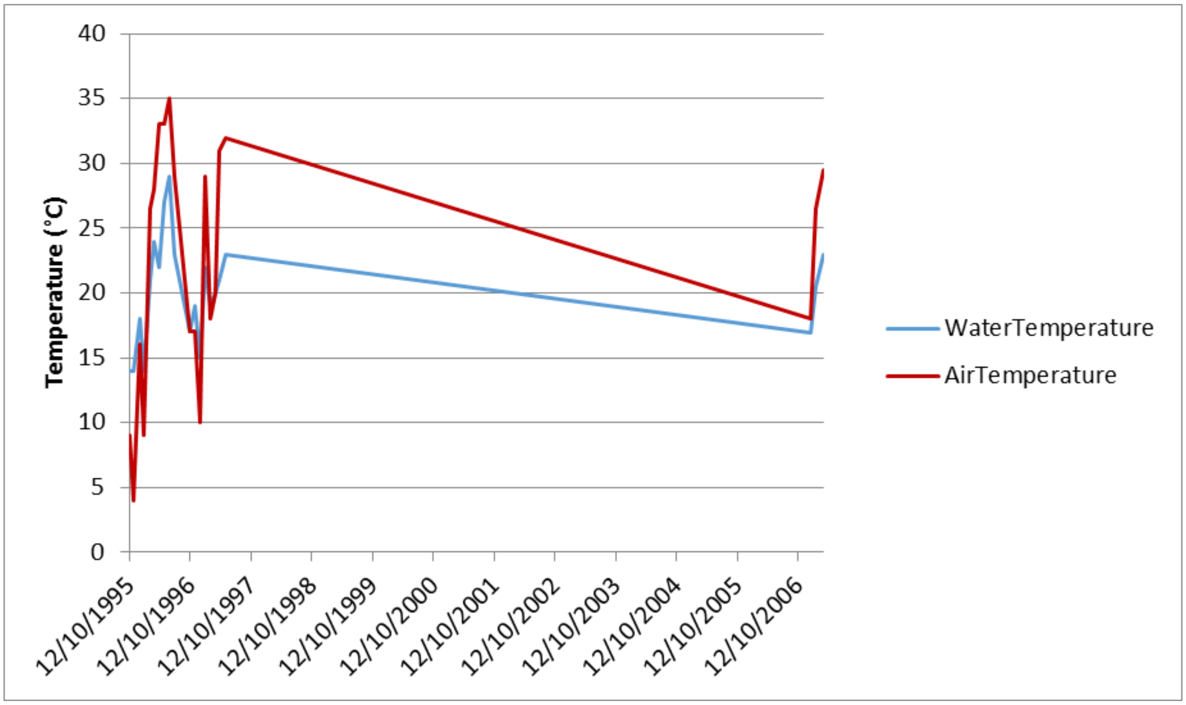

Figure 19: Air and water temperature at Site 13513

Total Dissolved Solids

Citizen scientists collected 10 TDS samples at this site. The mean value for this site was 339 mg/L and was the lowest mean TDS value for all sites within the watershed. The maximum TDS value measured was 384 mg/L and was recorded in May, 1996. The minimum TDS value measured was 273 mg/L and was recorded in May, 2007. There was no significant increase or decrease in TDS concentrations over time observed at this site.

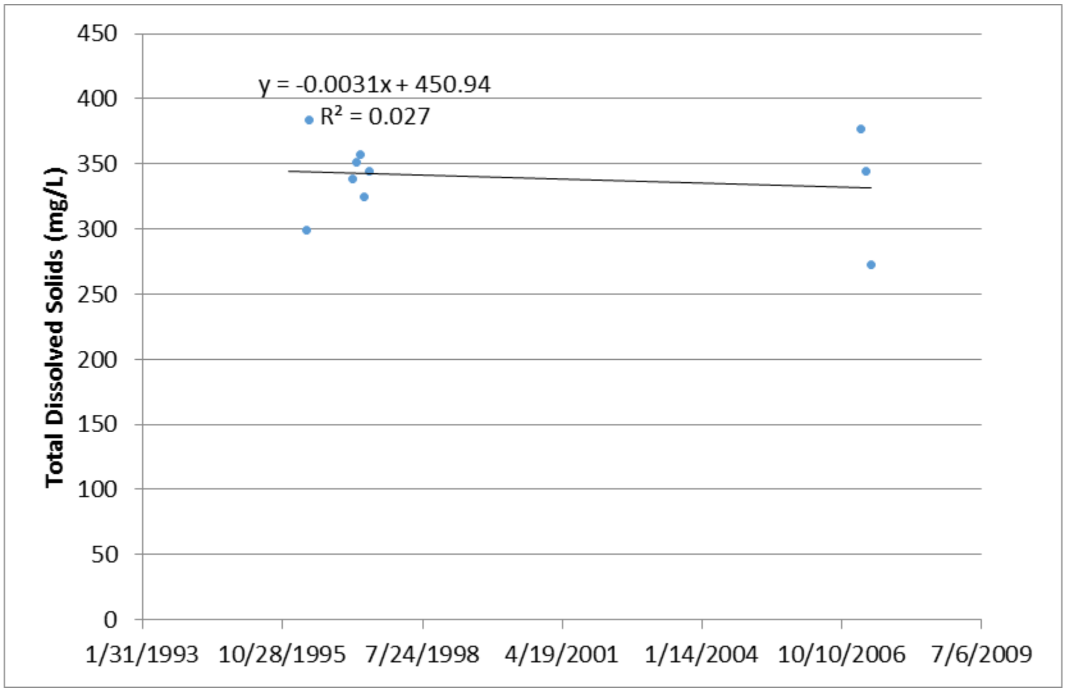

Figure 20: Total Dissolved Solids at Site 13513

Dissolved Oxygen

A total of 22 dissolved oxygen samples were taken at this site. The mean DO concentration was 9.13 and was the highest mean DO concentration of all the sites in the watershed. The minimum DO value was 6.15 mg/L and was recorded in May, 2007. The maximum DO value was 12.3 mg/L and was recorded in May, 1996. There was a significant decrease in DO concentrations over time, and the large R^2 value of 0.3613 indicated that this relationship was relatively strong.

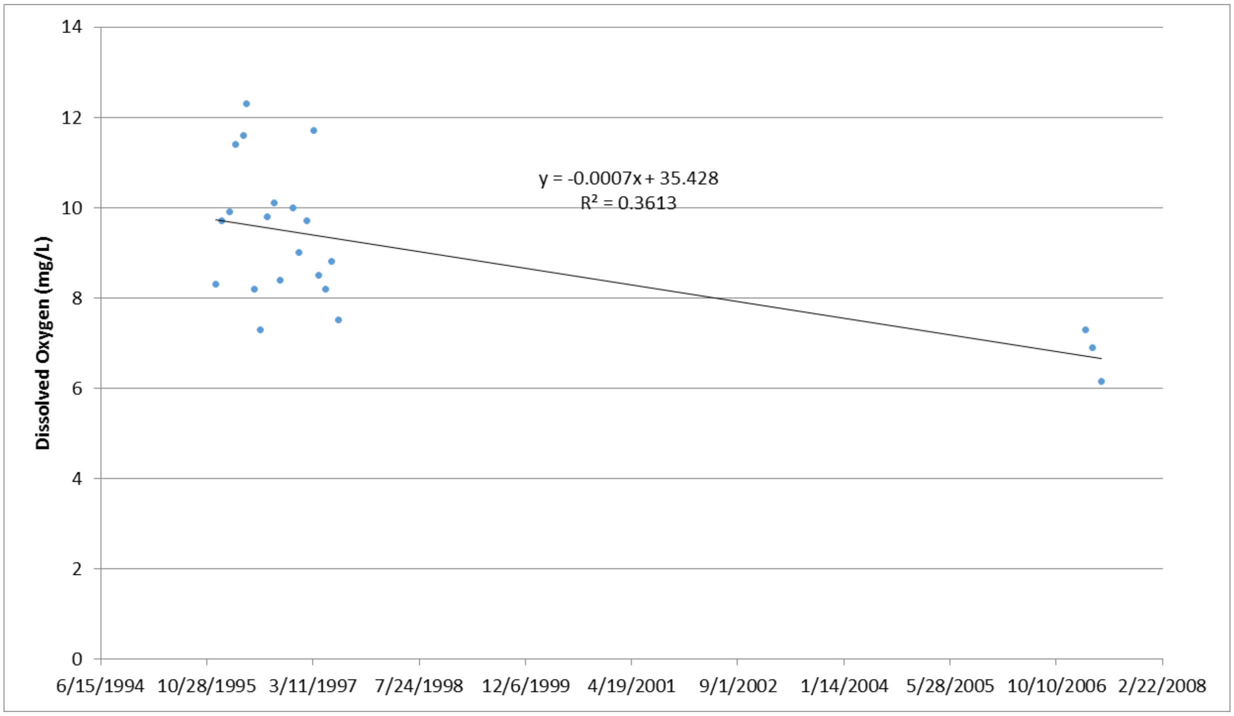

Figure 21: Dissolved Oxygen at Site 13513

pH

A total of 22 pH samples were taken at this site. The mean pH was 7.6 and was tied for the highest mean pH of all the sites in the watershed. The pH ranged from a minimum of 6.9 in February of 2007, to a maximum of 8.0 on January, 1996. There was no significant increase or decrease in pH over time observed at this site.

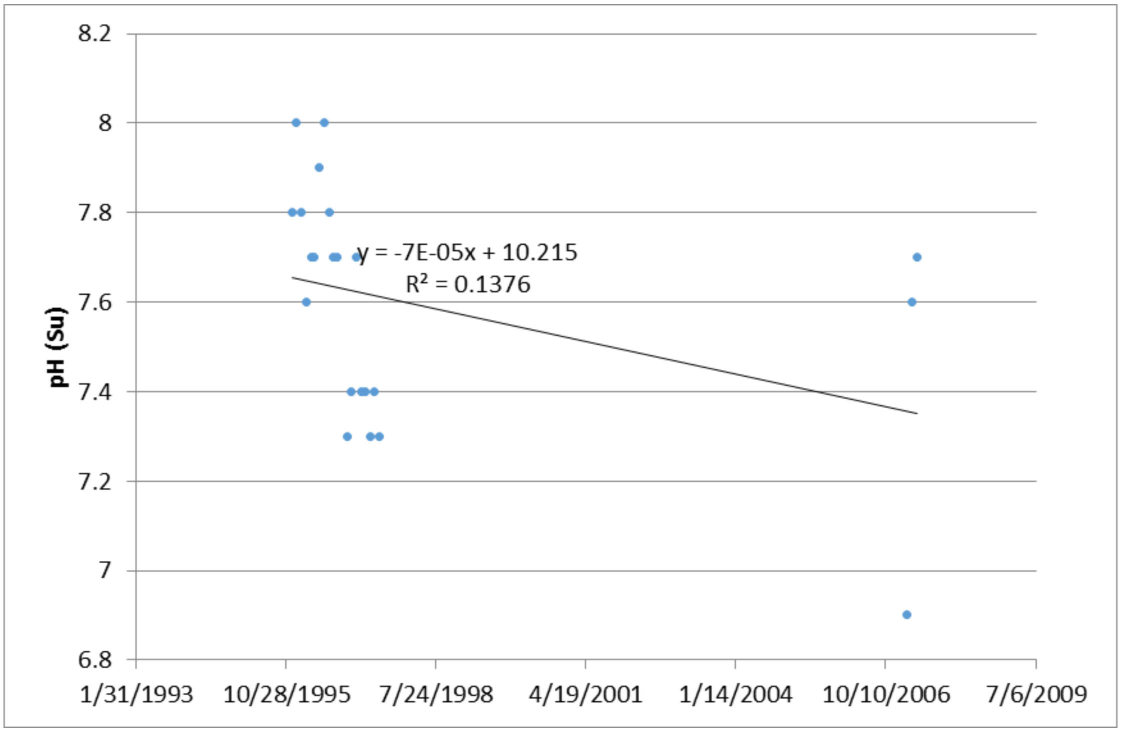

Figure 22: pH at Site 13513

Field Observations

Algae was absent at this site. The color was predominately a reddish color and was clear. The water odor was described as either fishy or a rotten egg smell.

Site 80933 – Cypress Creek at First Dam

Site Description

This site is located beneath a low water dam that creates a small lake on Cypress Creek. The lake is in a suburban neighborhood of Woodcreek, TX. A golf course is located on the northern bank of the creek.

Sampling Information

This site was sampled 4 times between 5/21/2013 and 1/20/2014, and is currently still being monitored. The time of the monitoring ranged from 08:00 to 19:00.

Table 8: Descriptive parameters for Site 80933

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	4	355 ± 27	325	390
Water Temperature (°C)	4	20.4 ± 6.7	10.2	30.0
Dissolved Oxygen (mg/L)	4	7.54 ± 1.52	5.2	9.3
pH	4	7.3 ± 0.2	7.0	7.5
Secchi Disk Transparency (m)	4	1.20 ± 0.64	0.32	2.50
Depth (m)	4	1.20 ± 0.64	0.32	2.50

Site was sampled 4 times between5/21/2013 and 1/20/2014.

Air and water temperature

Air and water temperatures were taken 4 times during this time period. Air temperatures fluctuated between 14°C in January, 2014 to 26°C in June, 2013. Water temperature ranged from 10.2°C in January 2014, to 30°C in June, 2013.

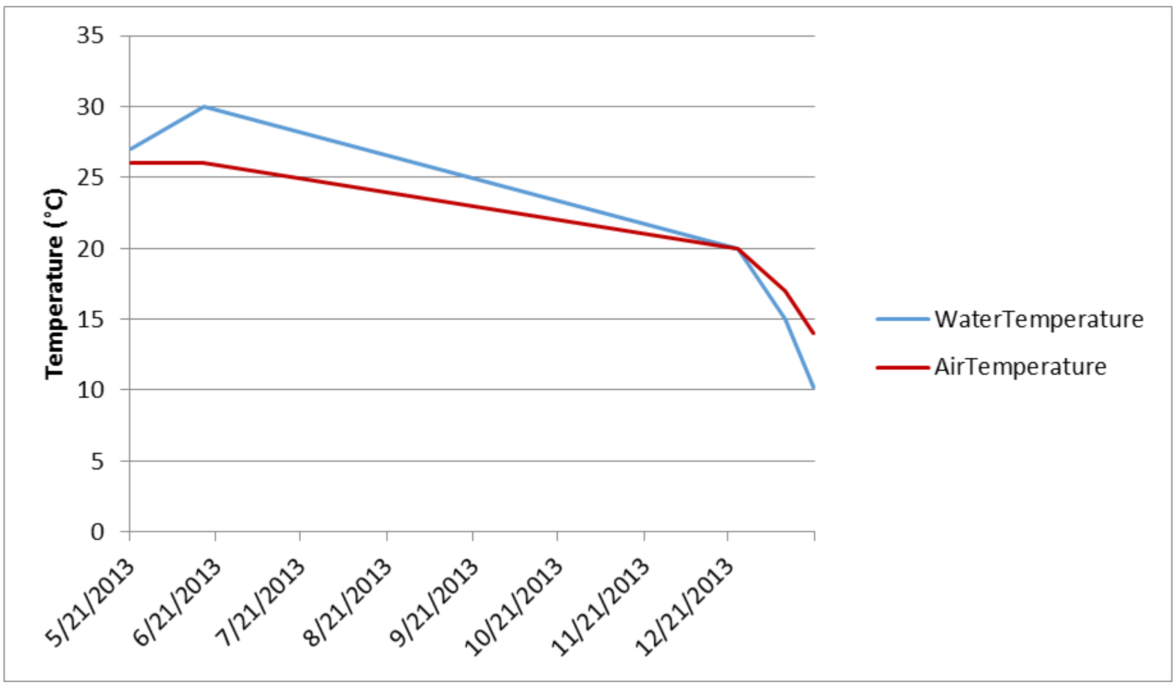

Figure 23: Air and water temperature at Site 80933

Total Dissolved Solids

Citizen scientists collected 4 TDS samples at this site. The maximum value was 390 mg/L and was recorded in January, 2014. The minimum TDS value was 325 mg/L and was recorded in both May and June of 2013.

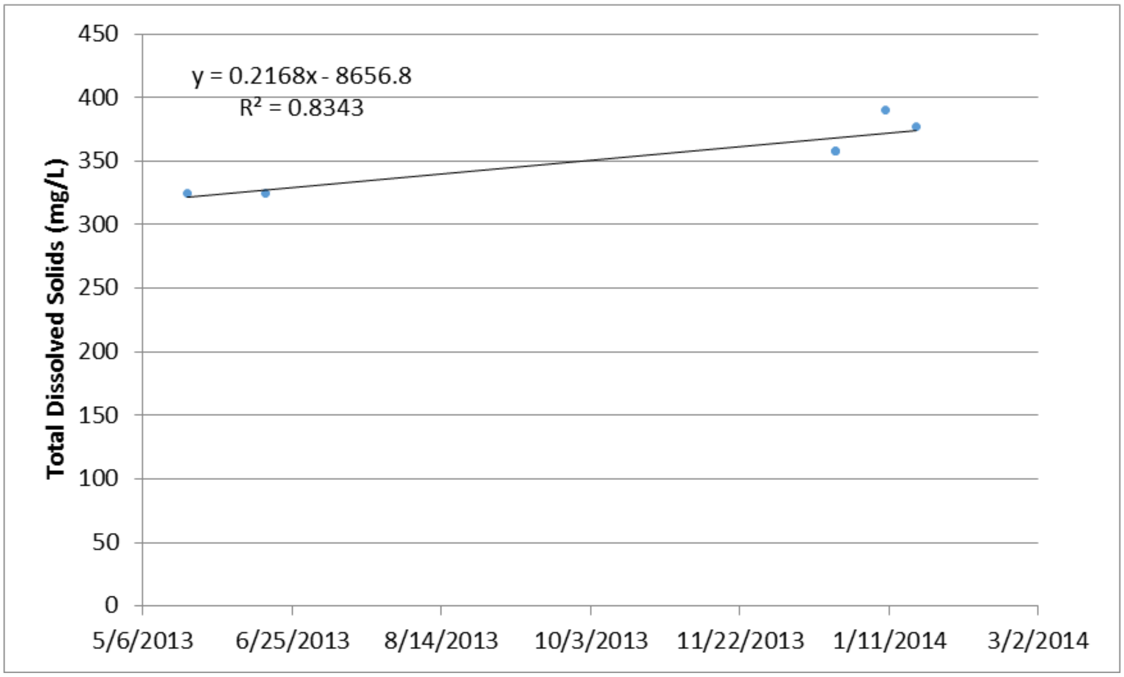

Figure 24: Total Dissolved Solids at Site 80933

Dissolved Oxygen

Citizen scientists collected 4 DO samples at this site. Dissolved oxygen at this site ranged from a minimum of 5.2 mg/L in May, 2013, to a maximum of 9.3 mg/L in June of 2013.

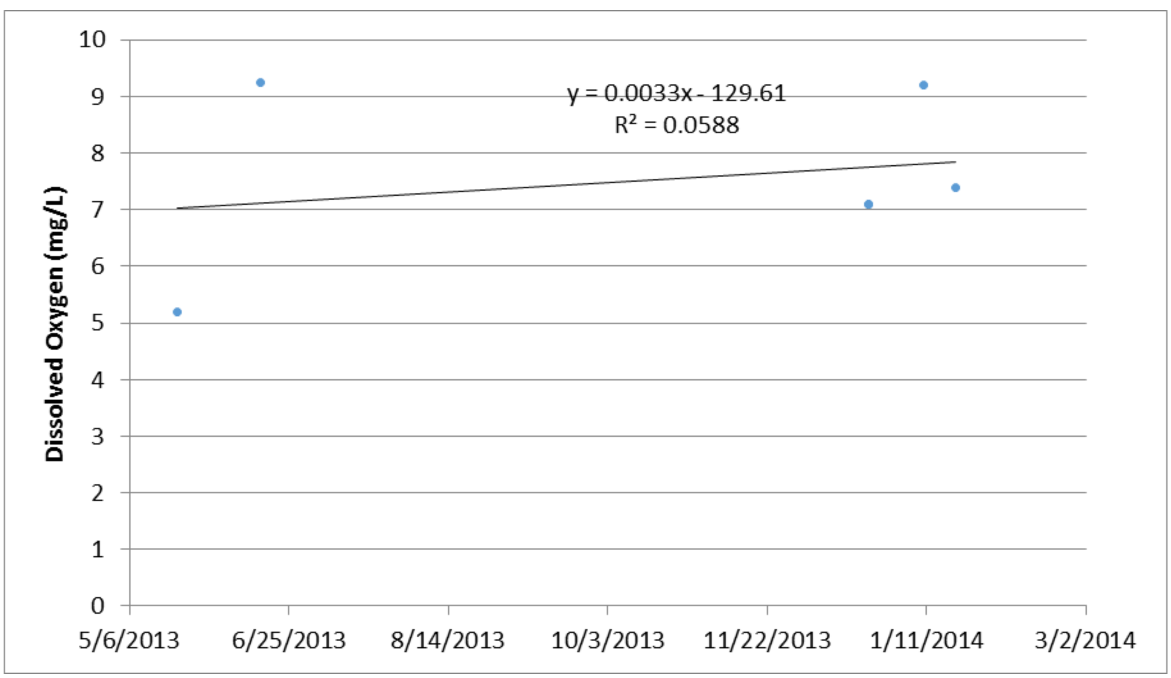

Figure 25: Dissolved Oxygen at Site 80933

pH

A total of 4 pH samples were taken at this site. The pH ranged from 7.0 in January, 2014 to 7.5 in December, 2013.

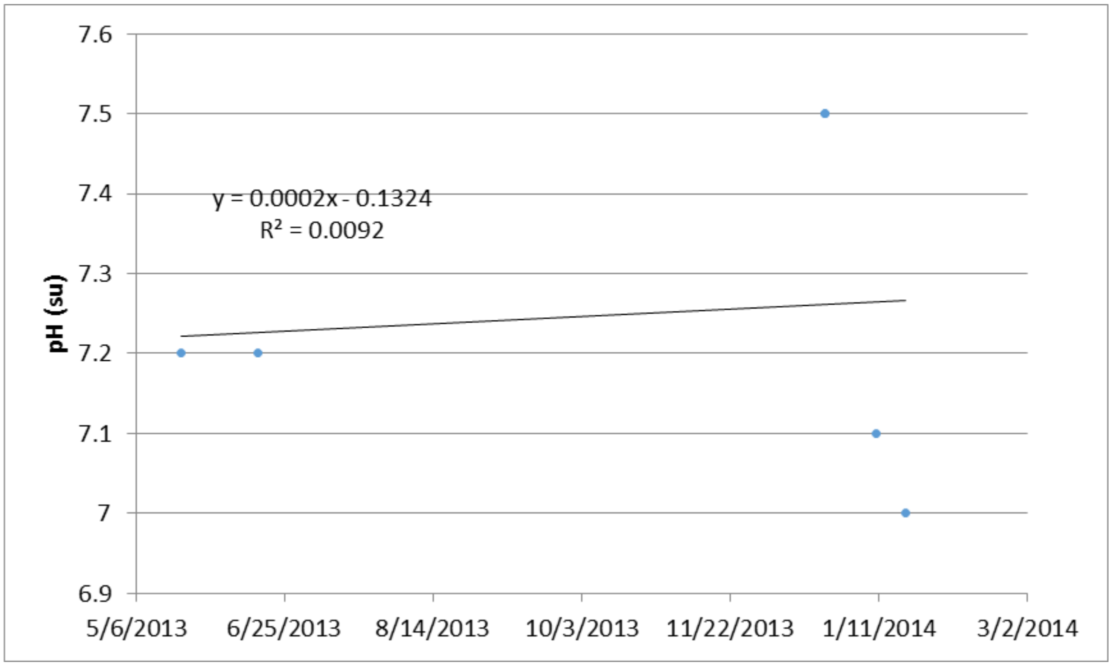

Figure 26: pH at Site 80933

Secchi disk and total depth

Mean Secchi disk depth and mean total depth were both 1.20 m for this site. The ratio of Secchi disk depth to total depth was 1.0 indicating that the water clarity was clear all the way to the creek bottom for all samples at this site.

Field Observations

Flow was recorded as normal for this site. The water clarity was always reported to be clear. Water color was recorded as tan, and the water had no distinguishable odor.

Site 80415 – Cypress Creek at Blue Hole

Site Description

This site is located at The Blue Hole, a popular local swimming hole. The monitoring location is off of a dock along the creek bank. The water at this site is deep and clear. Cypress trees on both banks shade most of the creek. One side of the creek is a park that receives many visitors, especially during the summer. The other side of the creek is private property, and is undeveloped ranch land.

Sampling Information

This site was sampled 5 times between February, 2007, and August, 2013. The site is currently being monitored.

Table 9: Descriptive parameters for Site 80415

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	5	404 ± 19	377	429
Water Temperature (°C)	5	19.64 ± 6.41	8.50	26.70
Dissolved Oxygen (mg/L)	5	5.6 ± 2.7	3.1	10
pH	5	7.2 ± 0.3	6.9	7.5
Secchi Disk Transparency (m)	5	1.28 ± 0.93	0.25	2.70
Depth (m)	5	1.28 ± 0.93	0.25	2.70

Site was sampled 5 times between 2/25/2007 and 8/31/2013.

Air and water temperature

The minimum air temperature recorded at this site was 0°C. The maximum air temperature was 29°C and was recorded in August of 2010. The minimum water temperature was 8.5°C recorded in January, 2010, and the maximum water temperature was 26.7, and was recorded in August, 2010.

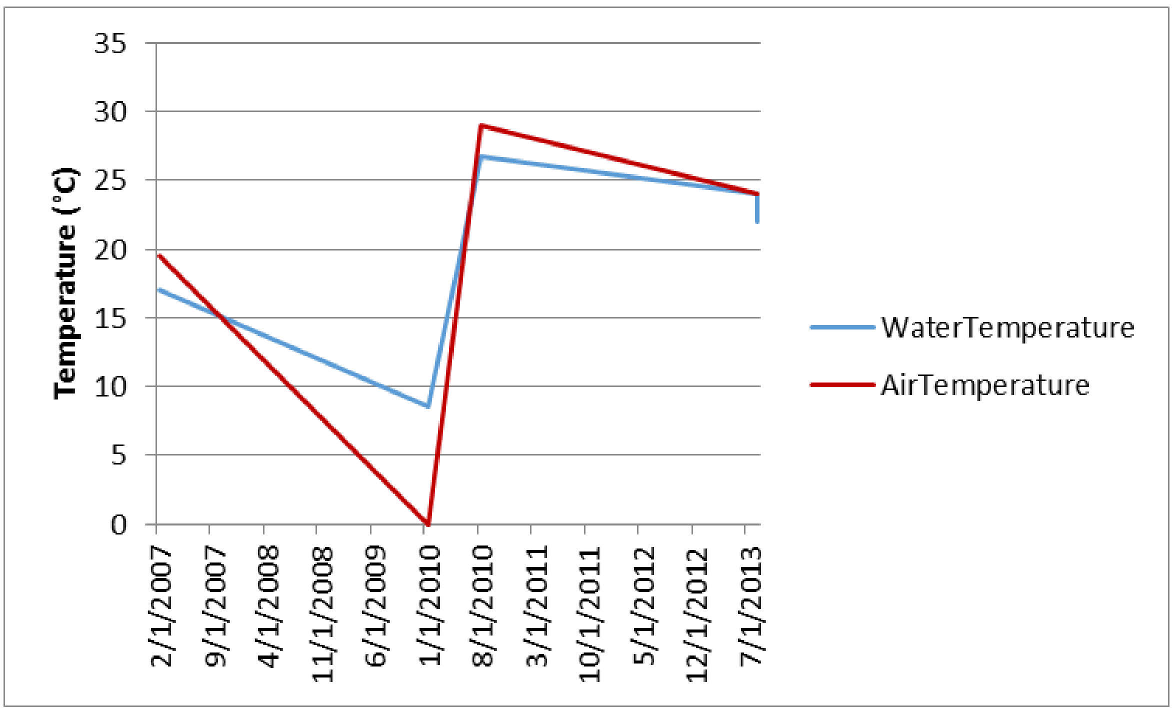

Figure 27: Air and water temperature at Site 80415

Total Dissolved Solids

The mean TDS concentration for this site was 404 mg/L and was the highest mean TDS of all the sites. The minimum TDS value was 377 mg/L recorded in August of 2010, and the maximum TDS value was 429, and was recorded in February, 2007.

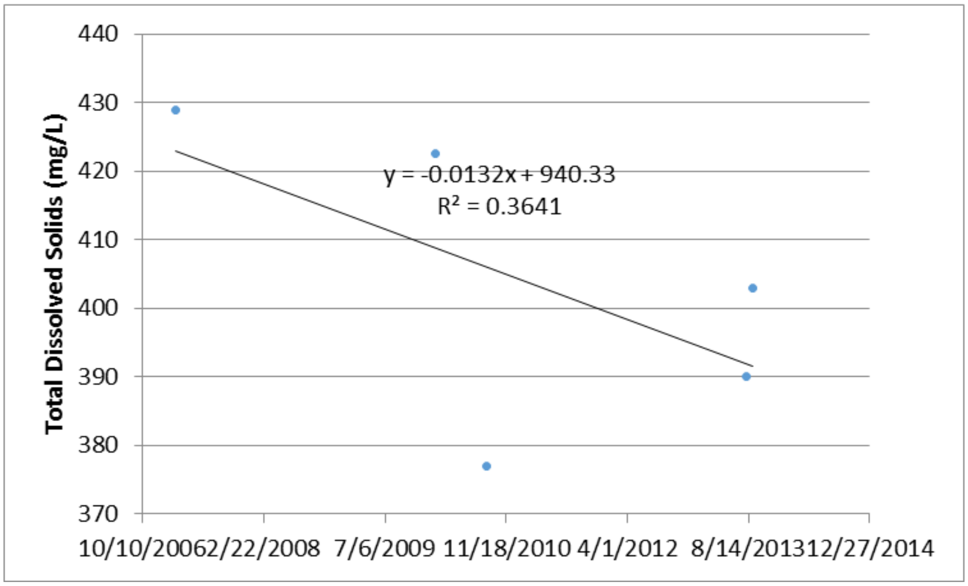

Figure 28: Total Dissolved Solids at Site 80415

Dissolved Oxygen

The mean dissolved oxygen concentration for this site was 5.6 mg/L and was the lowest mean DO concentration recorded in this watershed. The minimum DO concentration was recorded in August of 2013, and was 3.1 mg/L. The maximum DO concentration was recorded in January 2010, and was 10.0 mg/L.

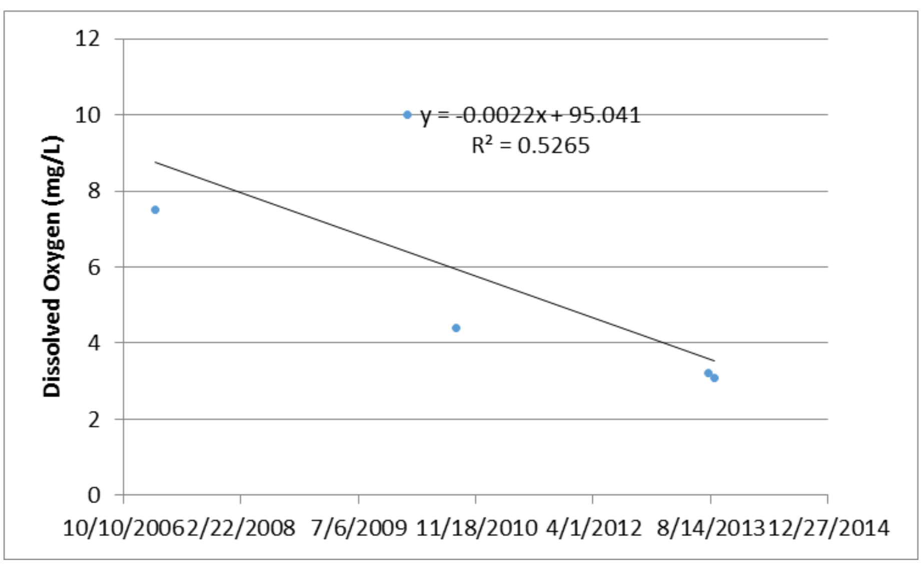

Figure 29: Dissolved Oxygen at Site 80415

pH

The mean pH was 7.2 and ranged from a low of 6.9, recorded in August, 2013, to a high of 7.5 recorded in January, 2010.

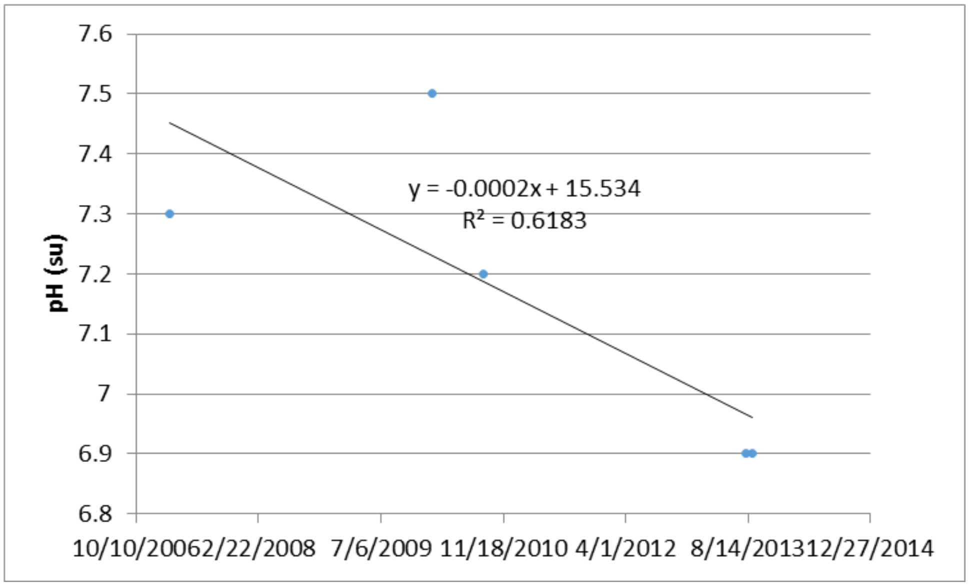

Figure 30: pH at Site 80415

Secchi disk and total depth

The mean Secchi disk depth and total depth for this site were both 1.28 m. The ratio of Secchi disk depth to total depth was 1.0 indicating that the water clarity was clear all the way to the creek bottom at all sampling events.

Field Observations

Flow at this site was recorded as low. The water color ranged from clear to light green with one instance of a dark green color. The water clarity was noted to be clear for 3 events, and cloudy for 2 events. Algae was rare or absent all together, and there was no distinguishable water odor detected.

Site 80443– Cypress Creek at Old Kyle Road

Site Description

This site is located behind several shops and restaurants off of Old Kyle Road in downtown Wimberley. The site is slightly upstream of the Ranch Road 12 Bridge in Wimberley. The location has several cypress trees along the creek banks. The surrounding land is a well-manicured lawn that receives a lot of foot traffic from patrons of the local restaurants and stores.

Sampling Information

This site was sampled 50 times between September, 2007, and August, 2012. The site is no longer being monitored.

Table 10: Descriptive parameters for Site 80443

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	48	374 ± 20	345	442
Water Temperature (°C)	49	18.16 ± 6.13	0.0	27.0
Dissolved Oxygen (mg/L)	44	6.8 ± 1.8	3.5	11.8
pH	48	7.6 ± 0.3	7.0	8.5
Secchi Disk Transparency (m)	48	1.00 ± 0.44	0.2	2.8
Depth (m)	48	1.00 ± 0.44	0.2	2.8

Site was sampled 50 times between 9/7/2007 and 8/5/2012.

Air and water temperature

There were 50 air temperature, and 48 water temperature measurements taken at this site during this period. The air temperatures fluctuated from a low of 0°C in February of 2008, to a high of 30.8°C in June of 2011. The water temperature ranged from a minimum of 0°C in February of 2008 to a high of 27.0°C in September, 2010.

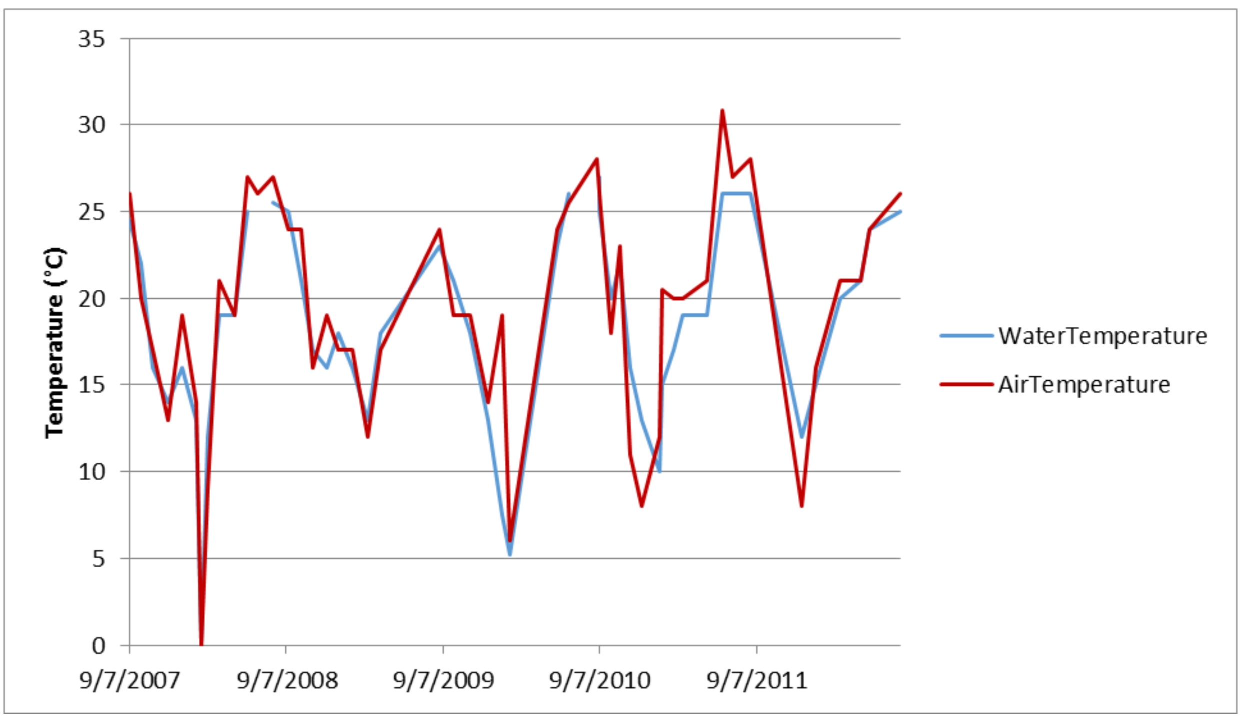

Figure 31: Air and water temperature at Site 80443

Total Dissolved Solids

Citizen scientists collected 48 TDS samples at this site. The maximum value was 442 mg/L and was taken in November, 2009. The minimum value was 345 mg/L and was taken in September, 2010. There was a significant increase in TDS concentrations over time detected at this site ($p = 0.02$); however, the R^2 value was relatively low for this correlation ($R^2 = 0.112$)

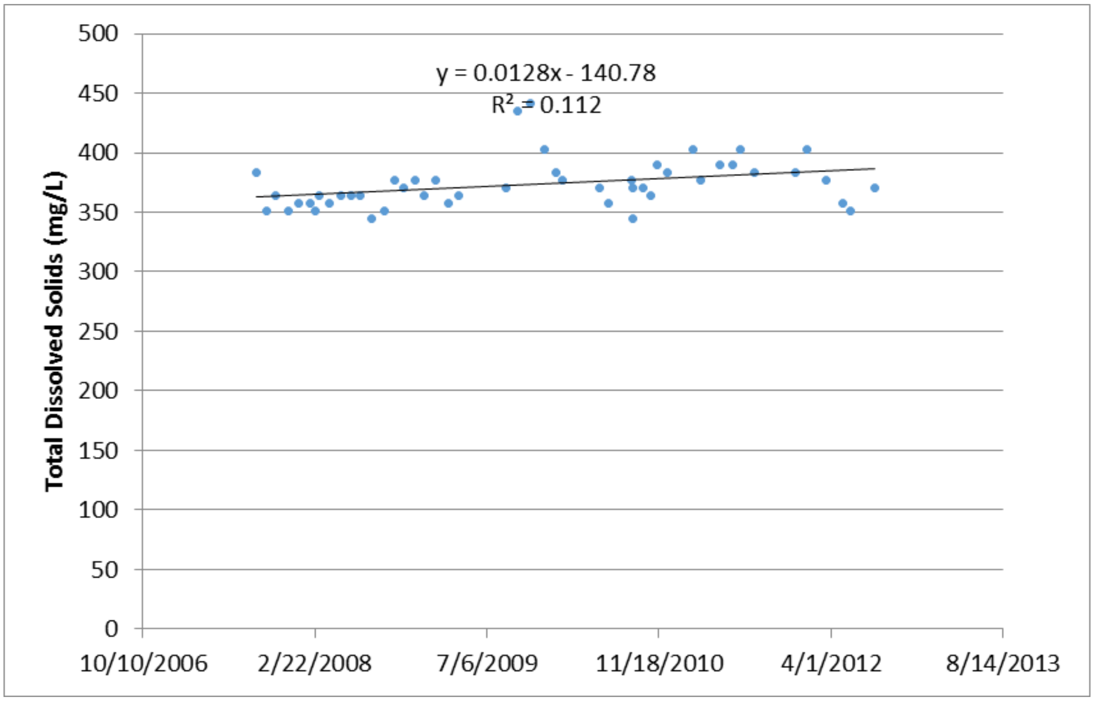

Figure 32: Total Dissolved Solids at Site 80443

Dissolved Oxygen

A total of 44 dissolved oxygen samples were taken at this site. The minimum DO concentration was 3.5 mg/L in August, 2009. The maximum DO concentration was 11.8 mg/L, and was taken in February of 2010. There was no statistically significant increase or decrease in DO concentrations over time observed for this site.

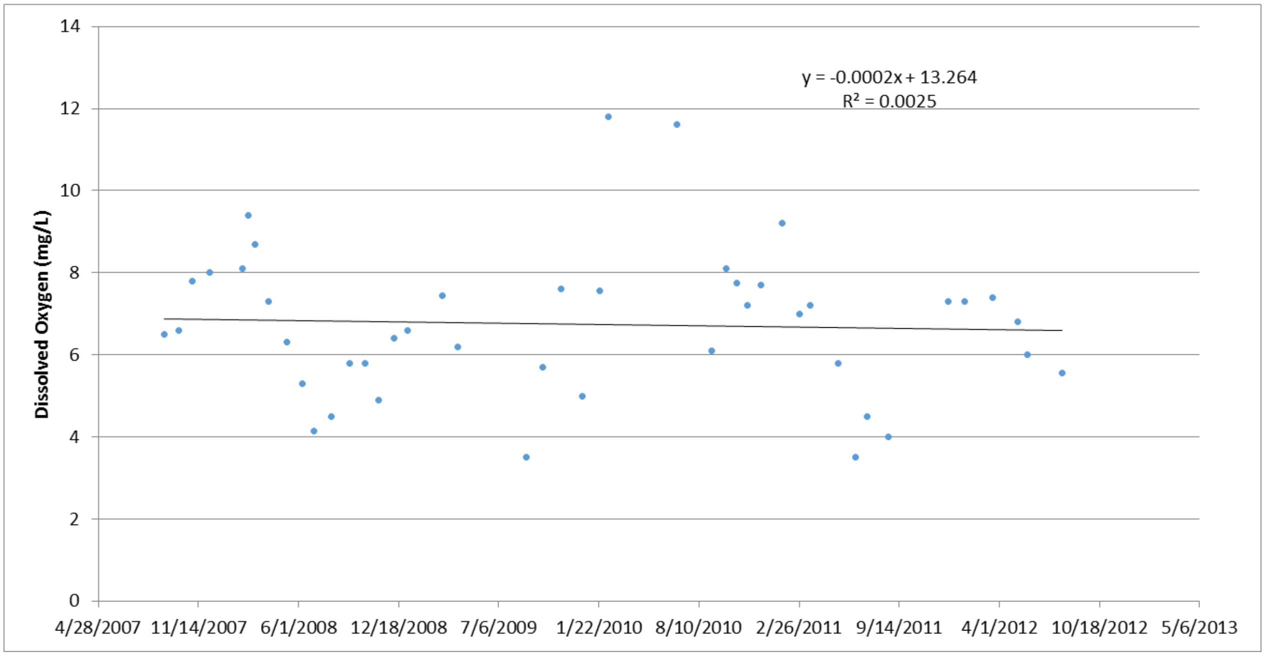

Figure 33: Dissolved Oxygen at Site 80443

pH

The mean pH for this site was 7.6 and was tied for the highest mean pH of all the sites in the watershed. The minimum pH of 7.0 was recorded in March, 2008. The maximum pH was 8.5, and was recorded in September of 2010. There was no significant increase or decrease in pH over time observed at this site.

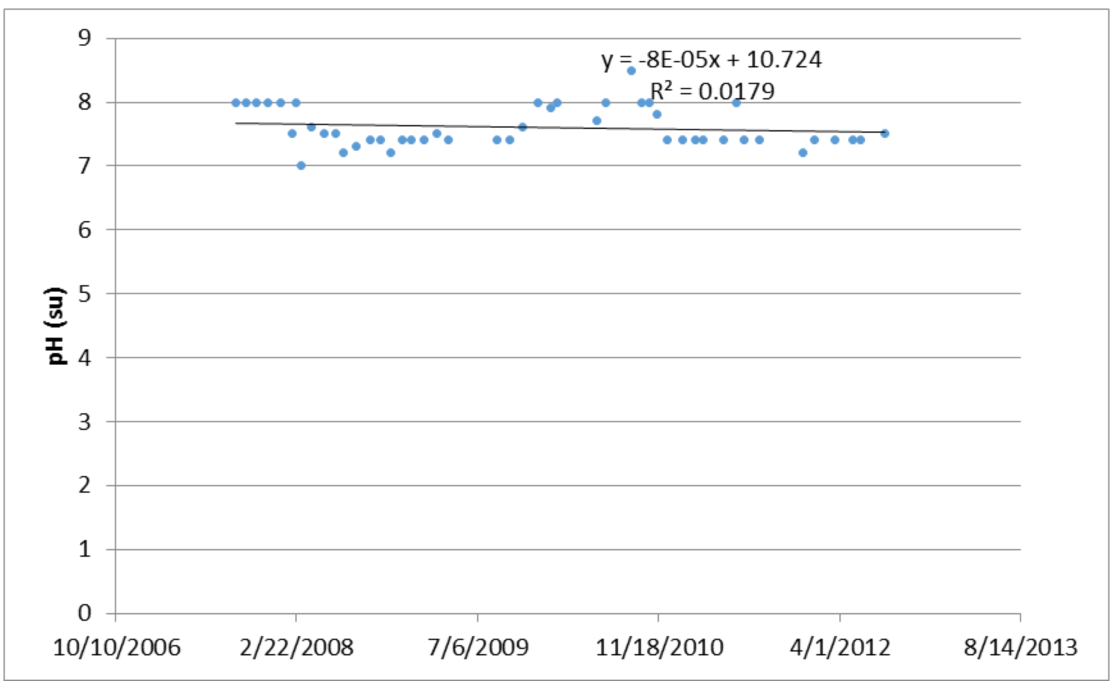

Figure 34: pH at Site 80443

Secchi disk and total depth

The mean Secchi disk depth and total depth were both 1.00 ± 0.44 m. The ratio of Secchi disk depth to total depth was 1.0 indicating that the water clarity was visible all the way to the bottom during all sampling events.

Field Observations

Water flow was mostly low, with a few events recording a normal flow. Algae was always absent or rare. The water color was usually clear with a few instances where it was recorded as dark green. Water clarity was clear for all events except for 4 where it was recorded as cloudy. There was no distinguishable water odor detected at this site.

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.

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Appendix A- List of Maps, Tables, and Figures

Tables

Figures