Blanco River Watershed Data Report

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THE MEADOWS CENTER
FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

TEXAS STATE UNIVERSITY
SAN MARCOS
The rising STAR of Texas

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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 Blanco River originates from several springs in northeastern Kendall County (Jasinski). It then flows 87 miles through Kendall, Blanco, and Hays Counties until its convergence with the San Marcos River in San Marcos, Texas (Jasinski). The Blanco River is a part of the Guadalupe River basin in the Edwards Plateau ecoregion (Jasinski). This ecoregion is known for stony clays and clay loams with limestone outcroppings and receives 15 – 33 inches of rain annually, with precipitation increasing for west to east (Jasinski; Native Prairies Association of Texas; Texas Parks & Wildlife "An Analysis of Texas Waterways"). This region is also prone to frequent and prolonged droughts, which affect flow rates of rivers and streams located in the Edwards Plateau (TPWD "An Analysis of Texas Waterways").

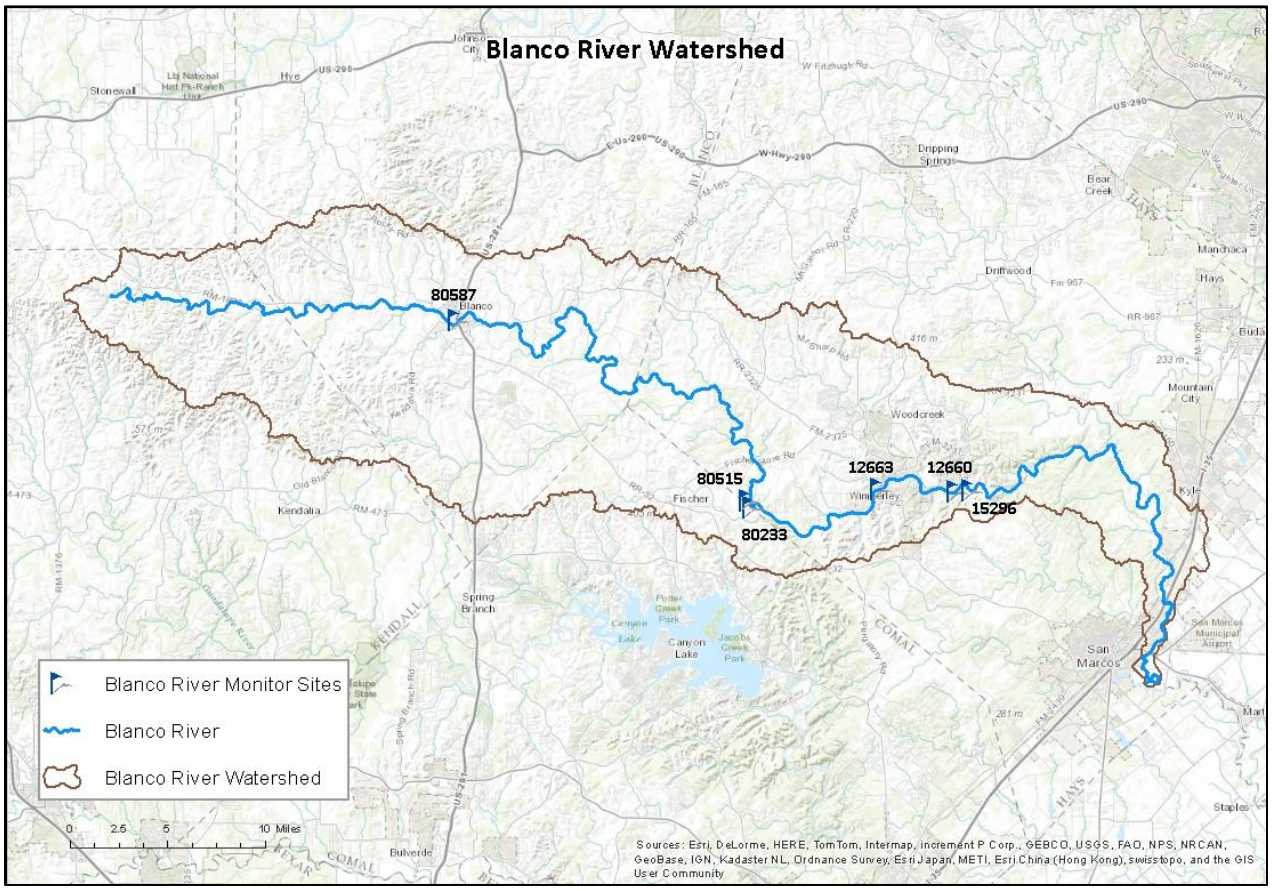

Figure 1: Map of the Blanco River Watershed with Texas Stream Team Monitor Sites

Physical Description and Land Use

The river is mostly shallow; however some recreational use is possible in areas where water is retained behind low water dams (TPWD "Ecoregion 7 – Edwards Plateau"). The Blanco River has a drainage area of over 1036 km² and is recharged by several springs throughout its 87 mile course (Hill Country Water Resources). The land that the Blanco River flows through is primarily scattered ranches, farms, with some residential and industrial uses occurring in larger cities such as Wimberley and San Marcos (Jasinski; TPWD "Ecoregion 7 – Edwards Plateau"). Ashe juniper, oak, and honey mesquite trees dominate the area (TPWD "An Analysis of Texas Waterways). This watershed is in the top 5 expanding populations in the United States, making conservation and characterization efforts extremely important (HCWR). Most of the river is located on privately owned property, therefore conservation and water quality efforts rely on voluntary collaboration among private landowners, communities, government and non-government organizations (Jasinski; The Nature Conservancy; TPWD "An Analysis of Texas Waterways).

History

The Blanco River was named for its white limestone banks and streambed by members of the Aguayo expedition in 1721 (Jasinski). Several American Indian tribes, including Comanches and Apaches, inhabited the region around the Blanco River until the 1850s (Jasinski). More permanent settlements were established in the mid-1840s and Blanco County was founded in 1858 (Jasinski). There are also dinosaur tracks imprinted in the limestone riverbed in Blanco Texas (Jasinski).

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 Blanco River is 126 CFU/100 mL. A water body is considered impaired if the geometric mean is higher than this standard.

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 2014 Texas Surface Water Quality Standards report was used to calculate the exceedances for the Blanco River Watershed, as seen below in Table 2.

Table 2: Summary of Surface Water Quality Standards for Blanco River Watershed

Parameter	Texas Surface Water Quality Standard 2014
Water Temperature (°C)	33.3
Total Dissolved Solids (mg/L)	400
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 the Blanco River 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.

Blanco River Watershed Data Analysis

Blanco River 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 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.

Blanco River Watershed Trends over Time

Sampling Trends over Time

Sampling along the Blanco River began in October of 1995 and continues to this day. A total of 388 individual monitoring events from 6 sites were analyzed. The sampling increased in number of events up

until 2011and then decreased slightly. Monthly monitoring occurred on a consistent basis throughout the years. The time of sampling ranged from 07:00 to 17:00 with a bimodal distribution in the time of sampling. The most common time of day for sampling occurred at 10:00 and 16:00.

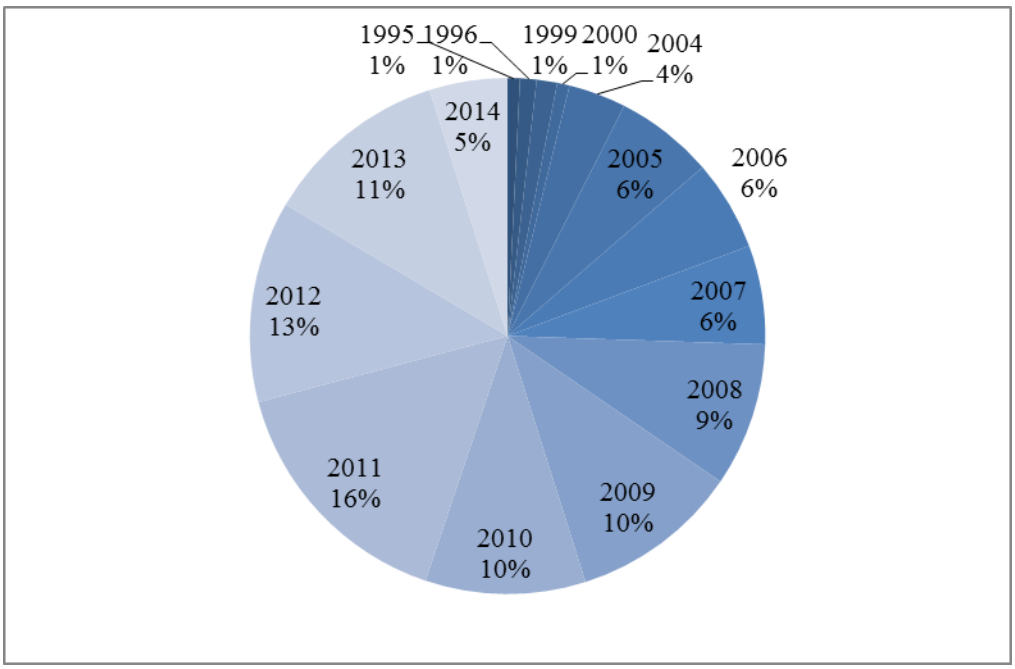

Figure 2: Breakdown of monitoring events by year.

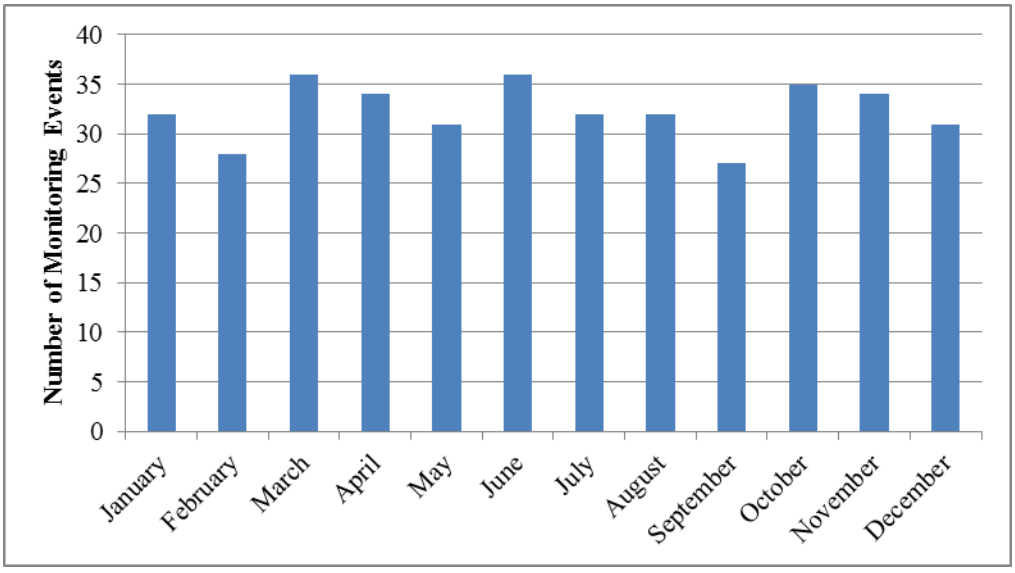

Figure 3: Breakdown of monitoring events by month in the Blanco River Watershed

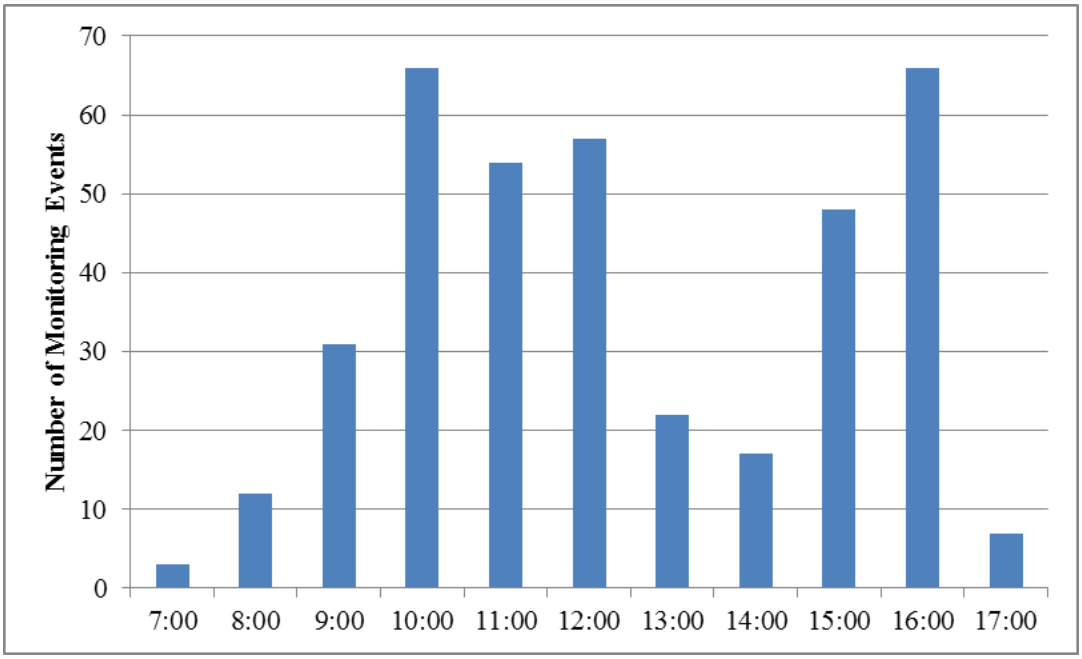

Figure 4: Breakdown of time of monitoring in the Blanco River Watershed

Table 3: Descriptive parameters for all sites in the Blanco River Watershed

Blanco River Watershed October 1995 – July 2014				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	366	312 ± 38	117	468
Water Temperature (°C)	381	21.0 ± 6.1	7.0	34.0
Dissolved Oxygen (mg/L)	373	8.0 ± 1.7	2.8	12.6
pH	379	7.8 ± 0.3	7.0	9.7
E. coli	74	27	0	1600

There were a total of 388 sampling events between 10/1995 and 07/2014. 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 381 water and air temperature values were collected within the Blanco River Watershed between 1995 and 2014. Water temperature exceeded the TCEQ optimal temperature of 33.3 only on one occasion. Air temperature varied between 2°C and 38°C.

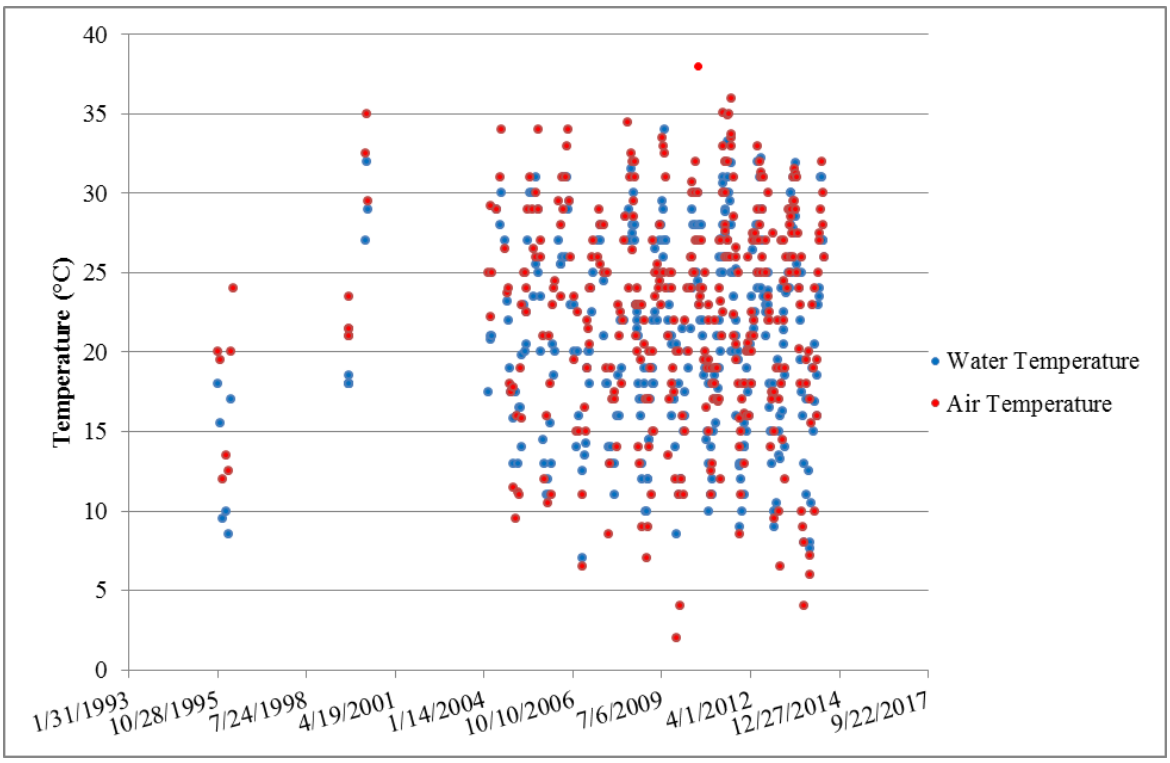

Figure 5: Air and water temperature over time at all sites within the Blanco River Watershed

Total Dissolved Solids

Citizen scientists collected 366 TDS samples within the watershed. The TDS measurement was completed for 94% of all monitoring events. The average TDS measurement for all sites was 312 mg/L. There was no significant trend in TDS over time detected.

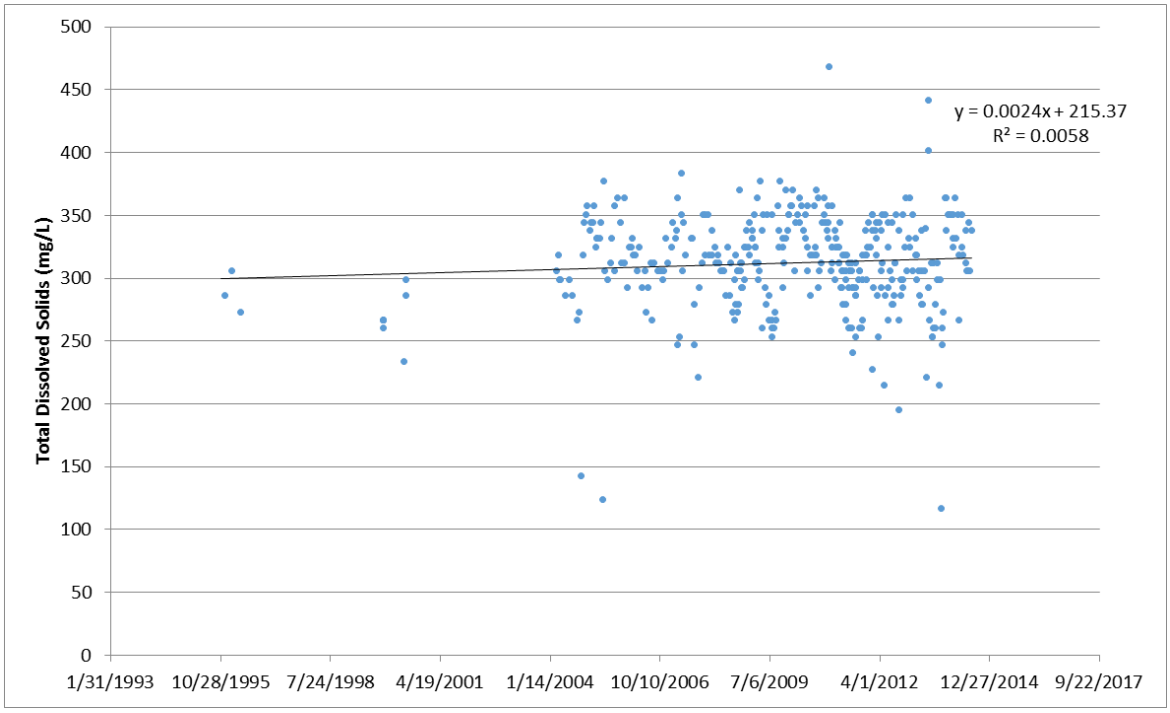

Figure 6: Total Dissolved Solids over time at all sites within the Blanco River Watershed

Dissolved Oxygen

Citizen scientists collected a total of 373 DO samples within the Blanco River 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 8.0 mg/L and it ranged from a low of 2.8 mg/L in July, 2013, to a high of 12.6 mg/L in January of 2014. 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.

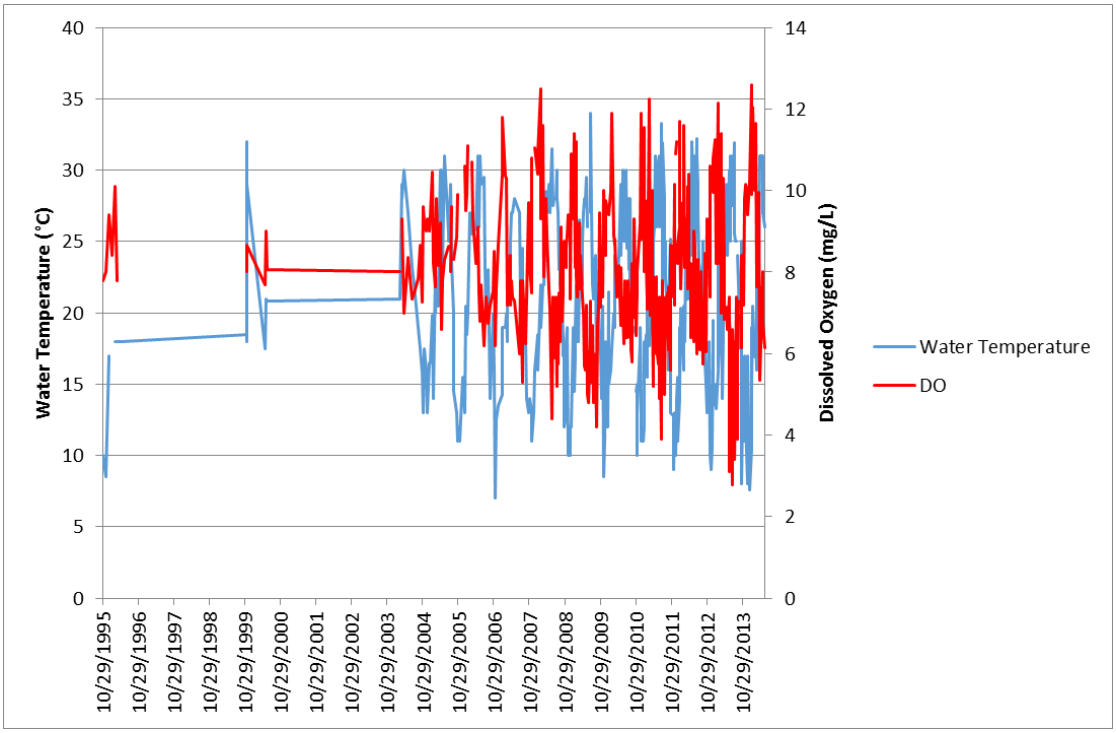

Figure 7: Dissolved Oxygen over time at all sites within the Blanco River Watershed

Table 4: Average Dissolved Oxygen values by Sampling Time within the Blanco River Watershed

Time	Average DO (mg/L)	Standard Deviation
07:00 – 08:00	7.7	0.3
08:00 – 09:00	7.2	1.2
09:00 – 10:00	7.3	1.5
10:00 – 11:00	7.5	1.3
11:00 – 12:00	7.9	1.9
12:00 – 13:00	8.1	2.3
13:00 – 14:00	8.4	2.0
14:00 – 15:00	8.3	1.7
15:00 – 16:00	8.4	1.6
16:00 – 17:00	8.5	1.3
17:00 – 18:00	8.1	0.7

pH

The pH was measured for 97.6% of all sampling events in the watershed. The mean pH was 7.8 and it ranged from 7.0 to 8.7 for all sites. There was a significant trend detected with pH decreasing over time ($p = 0.000$, R^2 0.1154).

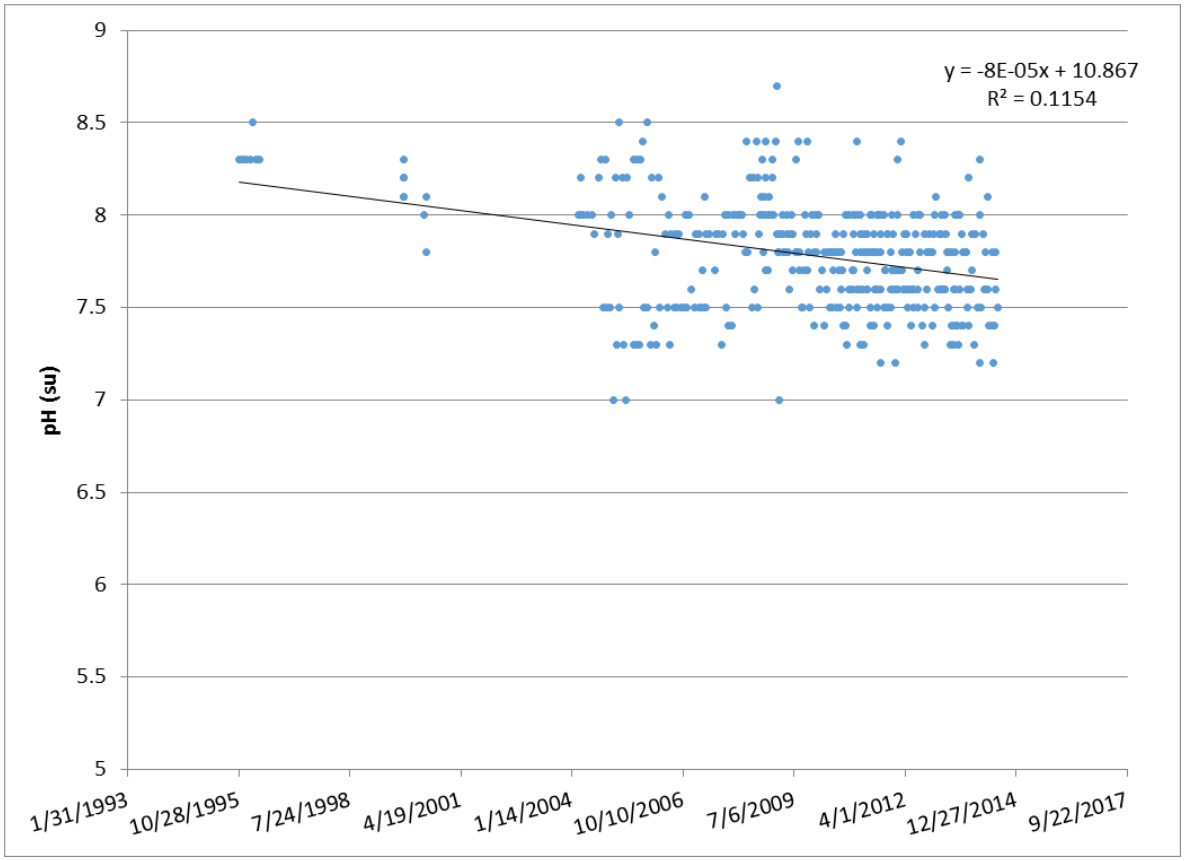

Figure 8: pH over time at all sites within the Blanco River Watershed

E. coli Bacteria

E. coli samples were taken at 4 of the 6 sites. A total of 74 E. coli samples were taken. The geomean for E. coli was 27 CFU/100 mL. The E. coli counts ranged from 0 CFU/100 mL to a high of 1600 CFU/100 mL collected in October, 2013. There was no significant trend in E. coli over time detected.

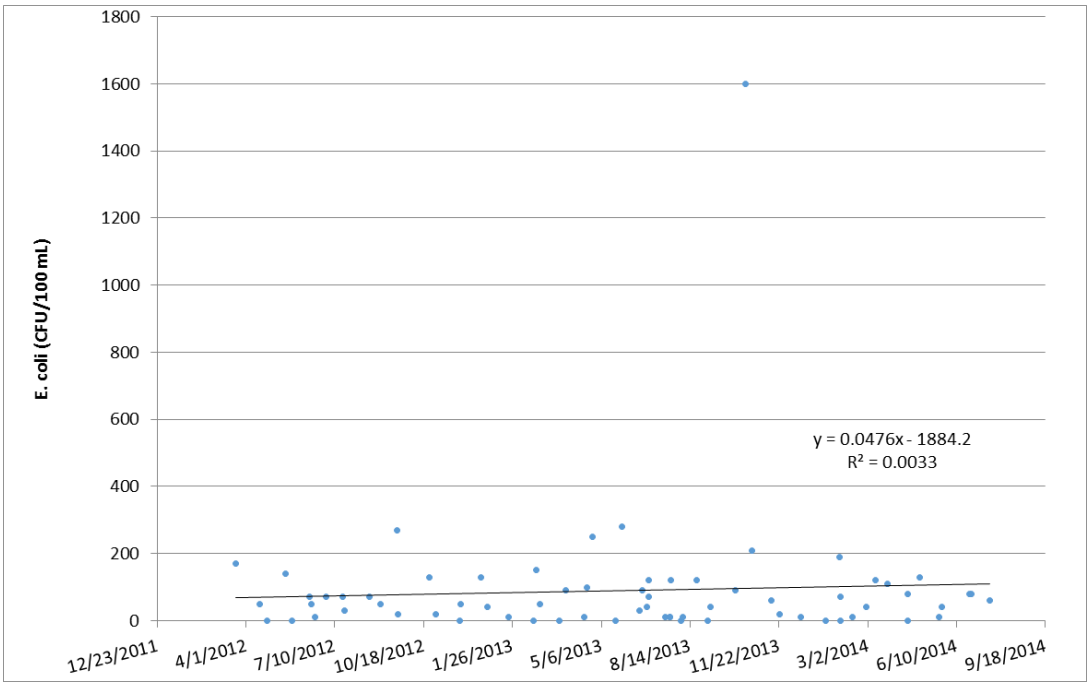

Figure 9: E. coli over time at all sites within the Blanco River Watershed

Blanco River Watershed Upstream to Downstream Trends

Total Dissolved Solids

There was no significant increasing or decreasing trend in TDS between the sites upstream and downstream.

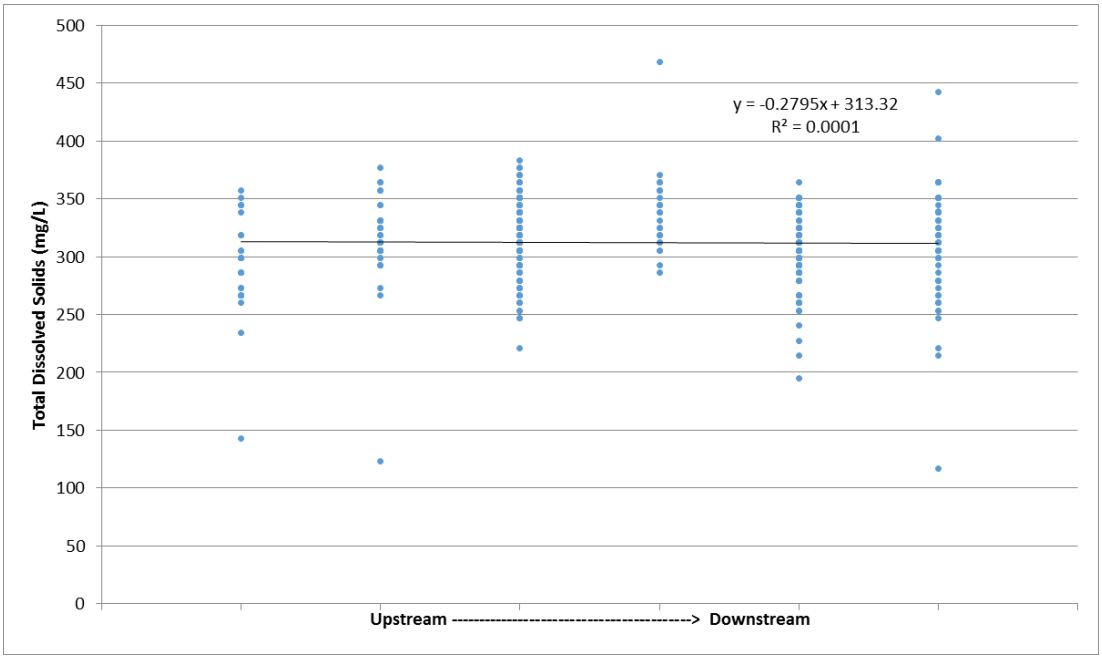

Figure 10: Upstream vs. downstream trends in Total Dissolved Solids in the Blanco River Watershed

Dissolved Oxygen

There was a significant increasing trend in dissolved oxygen as one moves downstream on the Blanco River ($p = 0.003$). The low R^2 value of 0.0243 indicated that distance only explained about 2% of the variability among the sites.

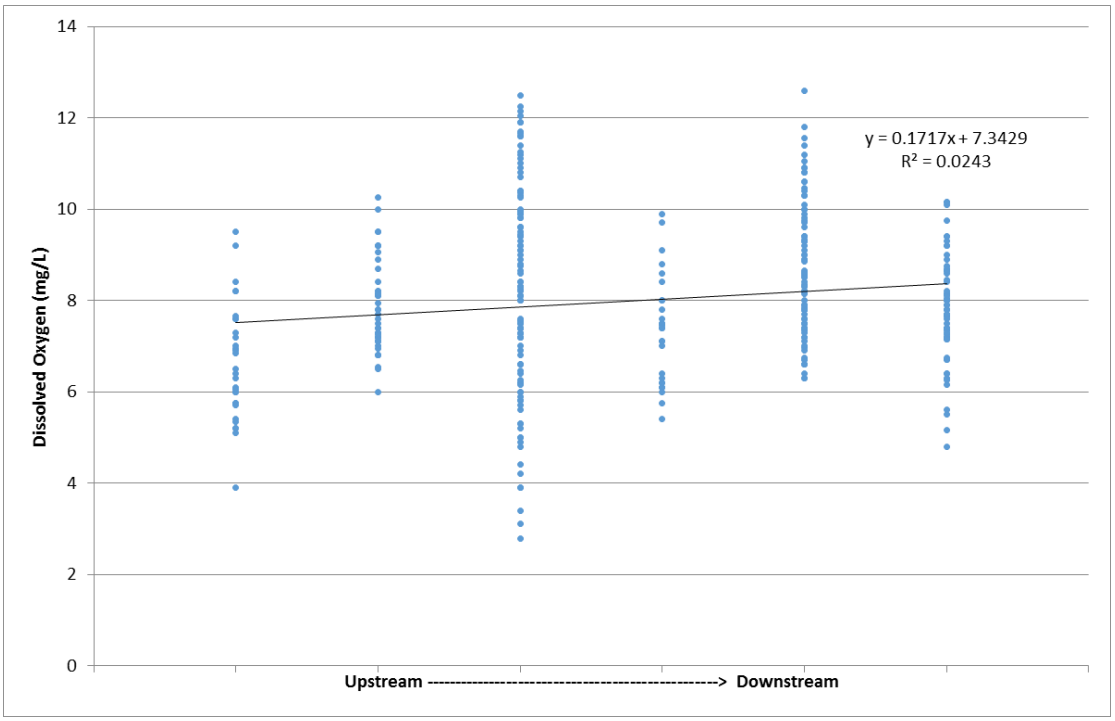

Figure 11: Upstream vs. downstream trends in Dissolved Oxygen in the Blanco River Watershed

pH

The regression analysis indicated a significant trend in pH with the pH decreasing as one moves downstream on the Blanco River ($p = 0.000$). The R^2 value of 0.088 indicates that this relationship between pH and distance downstream explains 8.8% of the variability in the data.

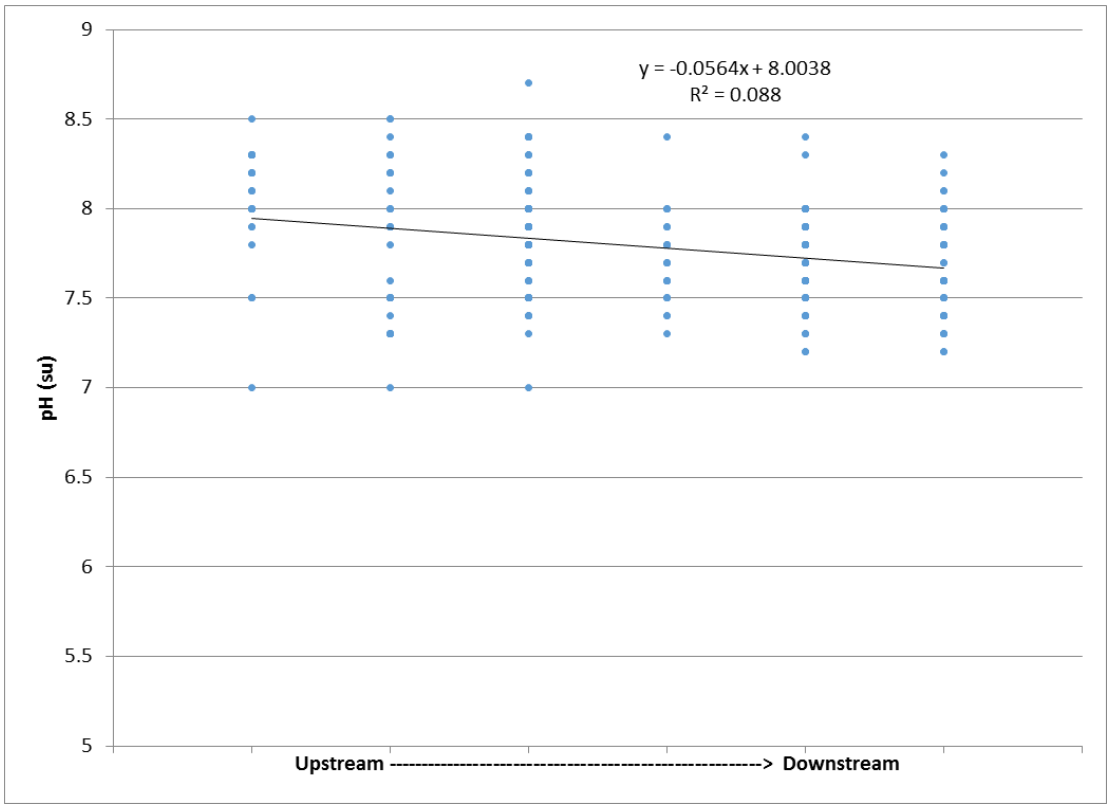

Figure 12: Upstream vs. downstream trends in pH in the Blanco River Watershed

Blanco River 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 80515 had the highest overall average for TDS, with a result of 328 ± 27 mg/L. Site 15296 had the lowest average TDS, with a result of 294 ± 47 mg/L.

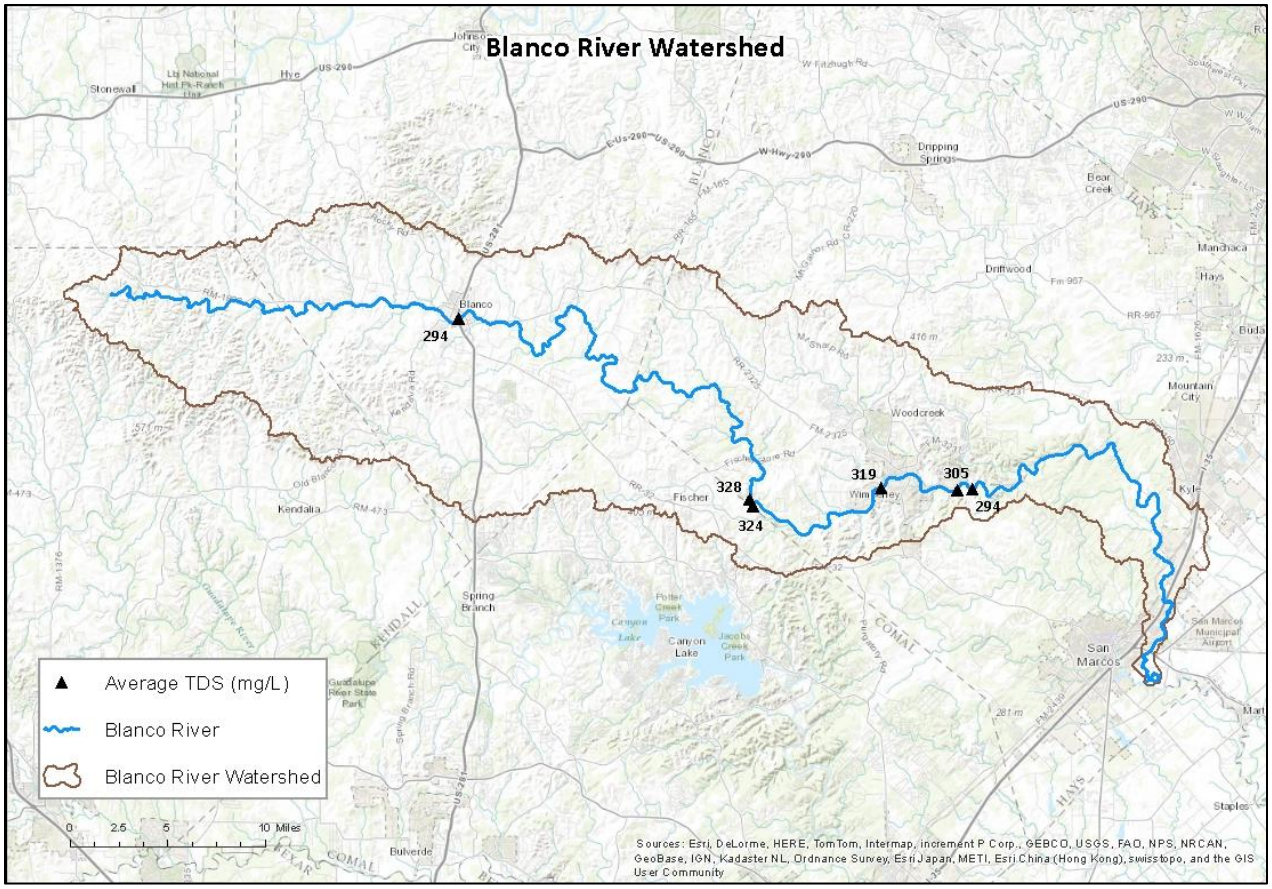

Figure 13: Map of average Total Dissolved Solids in the Blanco River Watershed

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 80587 had the lowest average DO reading, with a result of 6.3 ± 1.3 mg/L. Site 12660 had the highest average DO reading, with a result of 8.6 ± 1.5 mg/L.

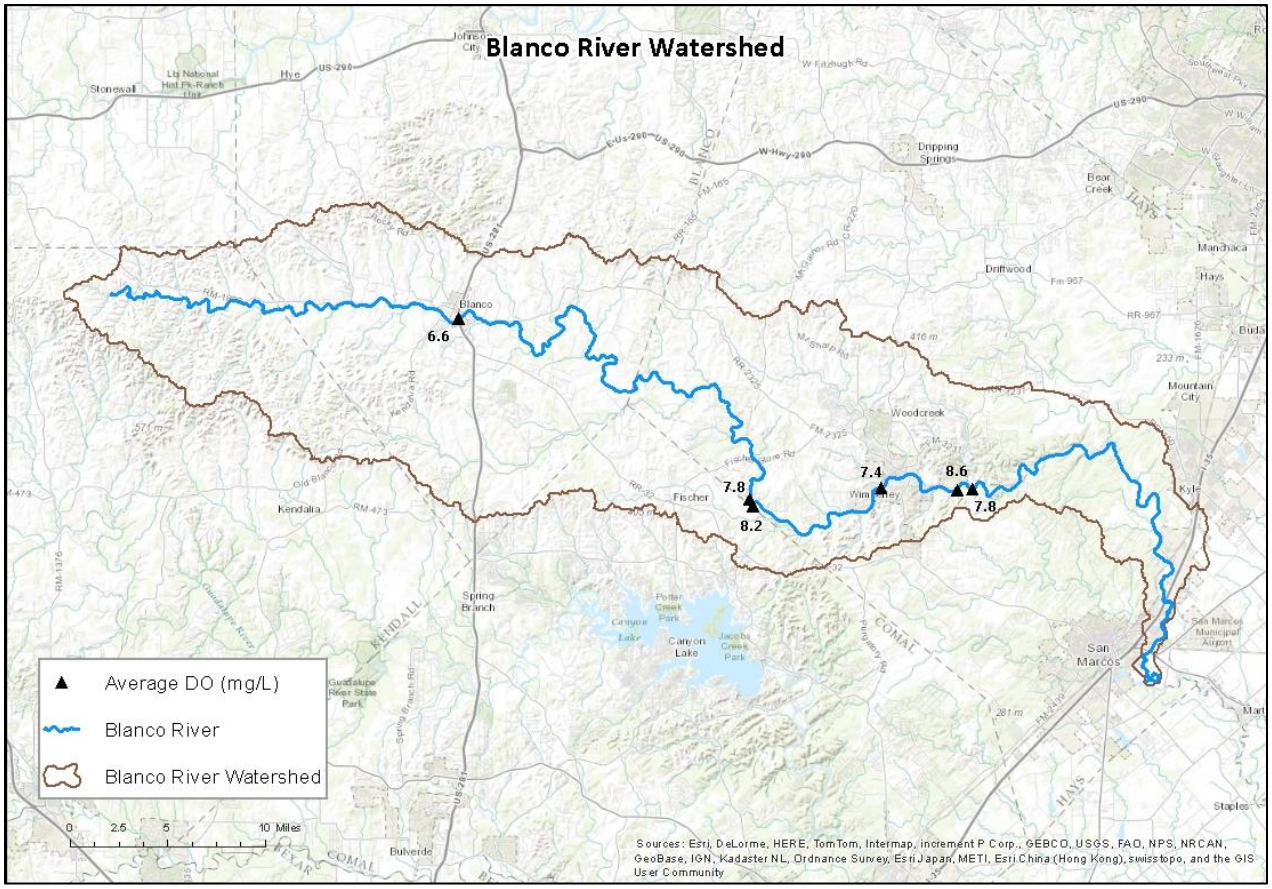

Figure 14: Map of average Dissolved Oxygen in the Blanco River Watershed

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. Sites 12663 and 12660 had the highest average pH level, with a result of 8.0 ± 1.3 and 8.0 ± 0.2, respectively. Site 80587 had the lowest average pH level, with a result of 7.5 ± 0.2.

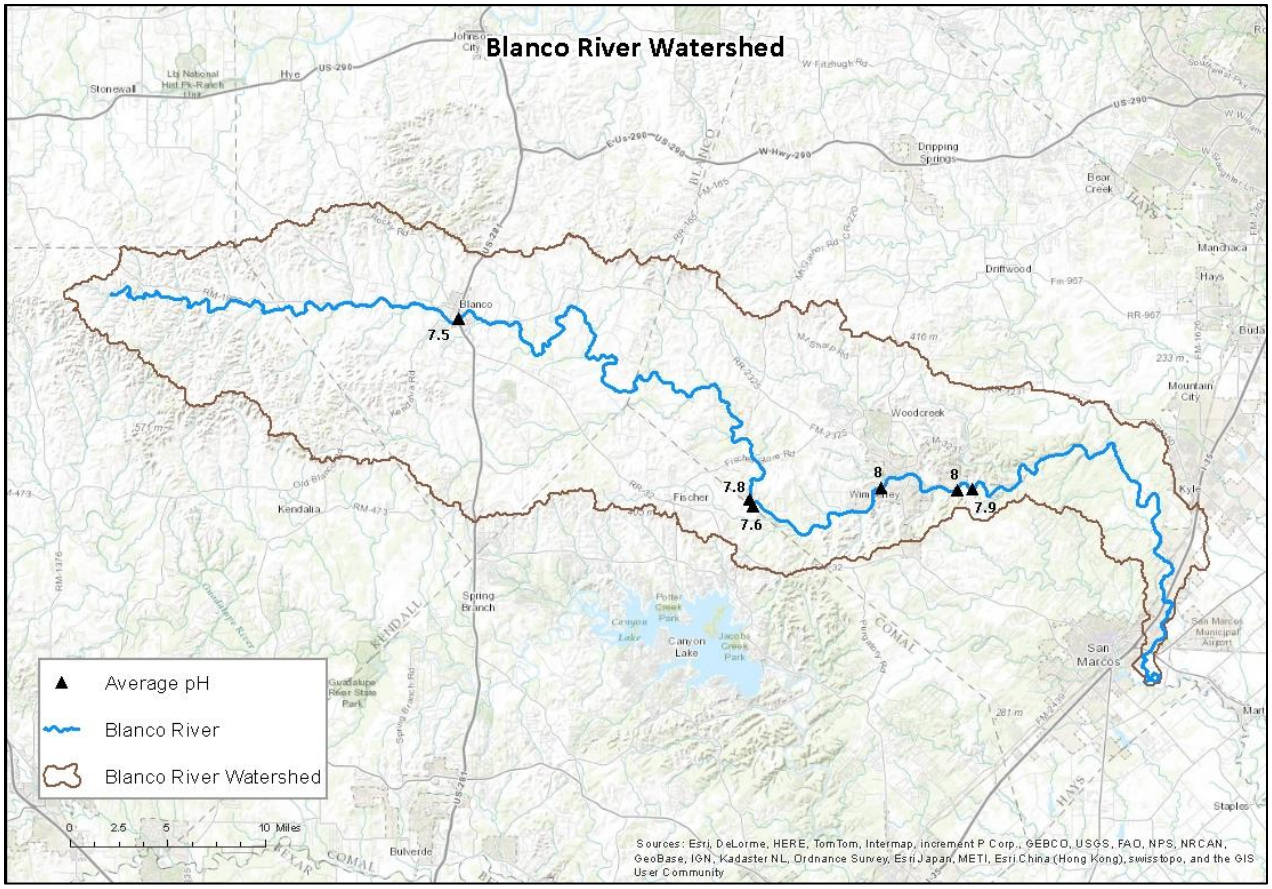

Figure 15: Map of average pH in the Blanco River Watershed

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 80587 had the highest average geomean, with a result of 112 CFU/100mL. Site 80223 had the lowest average geomean, with at result of 11 CFU/100mL.

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 sites in the Blanco River Watershed

Site Number	TDS (mg/L)	DO (mg/L)	pH	E.coli (CFU/100 mL)
80587	294 ± 27	6.6 ± 1.3 (min)	7.5 ± 0.2 (min)	112 (max)
80515	328 ± 27 (max)	7.8 ± 1.0	7.8 ± 0.1	79
80223	324 ± 40	8.2 ± 2.3	7.6 ± 0.3	11 (min)
12663	319 ± 34	7.4 ± 1.2	8.0 ± 1.3 (max)	N/A
12660	305 ± 31	8.6 ± 1.5 (max)	8.0 ± 0.2 (max)	26
15296	294 ± 47 (min)	7.8 ± 1.5	7.9 ± 0.3	N/A

Site 80587 – Blanco River @ Blanco State Park

Site Description

This site is located in Blanco State Park near Blanco, TX. It is about 200 meters downstream of the Highway 281 Bridge over the Blanco River. The north bank of the river, where the site is located, is cleared for camping sites. The river is wide and deep in this section due to a low water dam downstream of the site. This is a popular location for camping, swimming, and fishing.

Sampling Information

This site has been sampled 32 times between 9/14/2010 and 4/29/2014. It is most commonly sampled in the morning between 08:00 and 10:00.

Table 6: Descriptive parameters for Site 80587

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	27	294 ± 27	195	345
Water Temperature (°C)	32	21.0 ± 6.7	7.6	30.0
Dissolved Oxygen (mg/L)	31	6.6 ± 1.3	3.9	9.5
pH	32	7.5 ± 0.2	7.2	7.8
E. coli (CFU/100 mL)	16	113	50	270

Site was sampled 32 times between 9/14/2010 and 4/29/2014.

Air and water temperature

Air and water temperatures were taken 32 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 30.0°C recorded in June, 2011, and a low temperature of 6.5°C recorded in February, 2013. The mean water temperature was 21.0°C and water temperature ranged from 7.6°C in January, 2014 to 30.0°C in June of 2013.

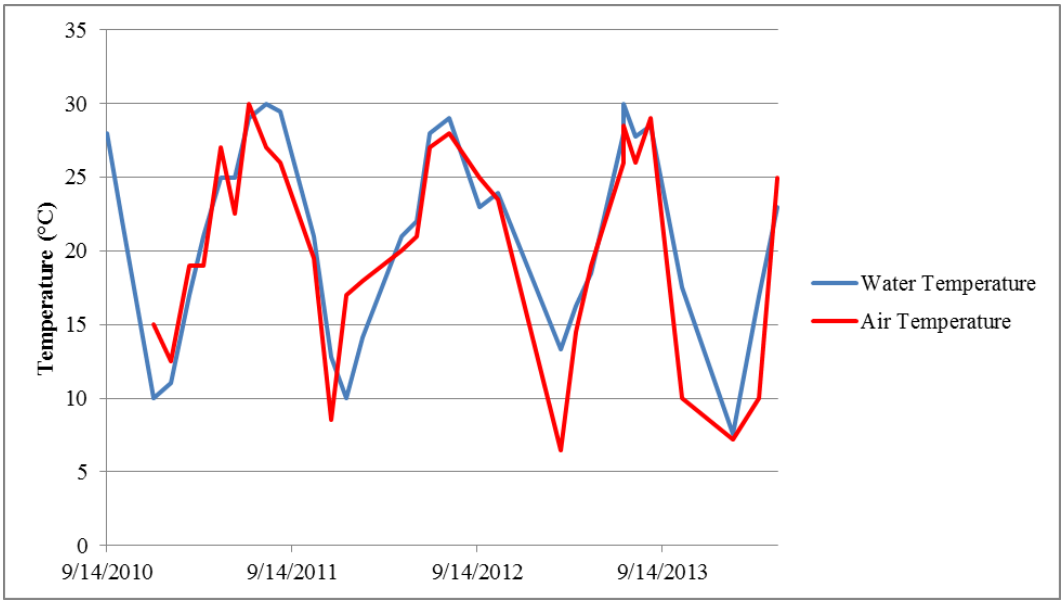

Figure 16: Air and Water Temperature at site 80587

Total Dissolved Solids

Citizen scientists sampled TDS at this site 27 times during the time period. The mean TDS concentration was 294 mg/L. The concentration of TDS ranged from a minimum of 195 mg/L in September, 2012 to a maximum of 345 mg/L in December of 2010. There was no significant trend in TDS concentrations over time observed at this site.

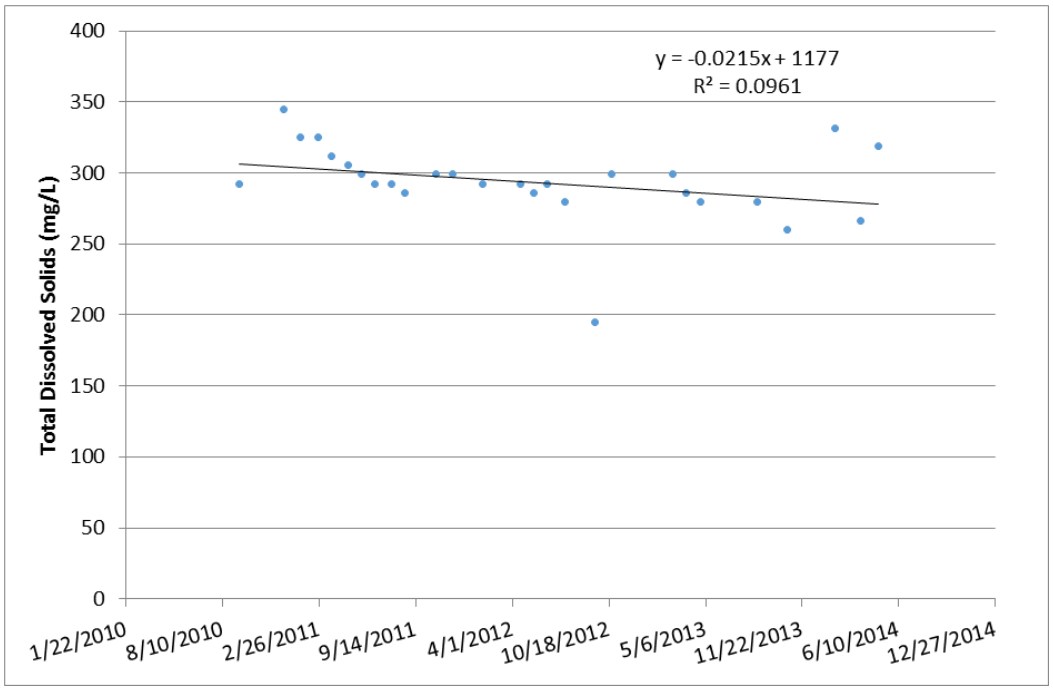

Figure 17: Total Dissolved Solids at site 80587

Dissolved Oxygen

Citizen scientists took 31 dissolved oxygen samples at this site. The mean DO concentration was 6.6 mg/L. Dissolved oxygen varied from a low of 3.9 mg/L in June of 2013, to a high of 9.5 mg/L in January, 2011. There was no significant trend in DO values over time observed for this site.

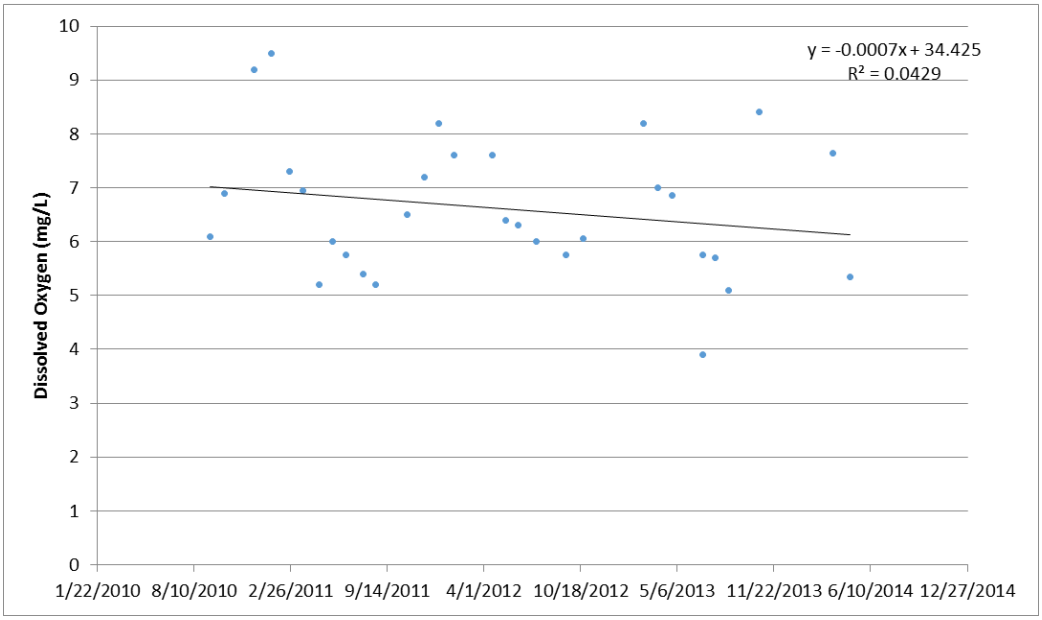

Figure 18: Dissolved Oxygen at site 80587

pH

There were 32 pH measurements taken at this site during this time period. The mean pH was 7.5 and it varied from a minimum of 7.2 in December of 2011, to a maximum of 7.8 in March, 2014. There was no significant trend in pH over time observed at this site.

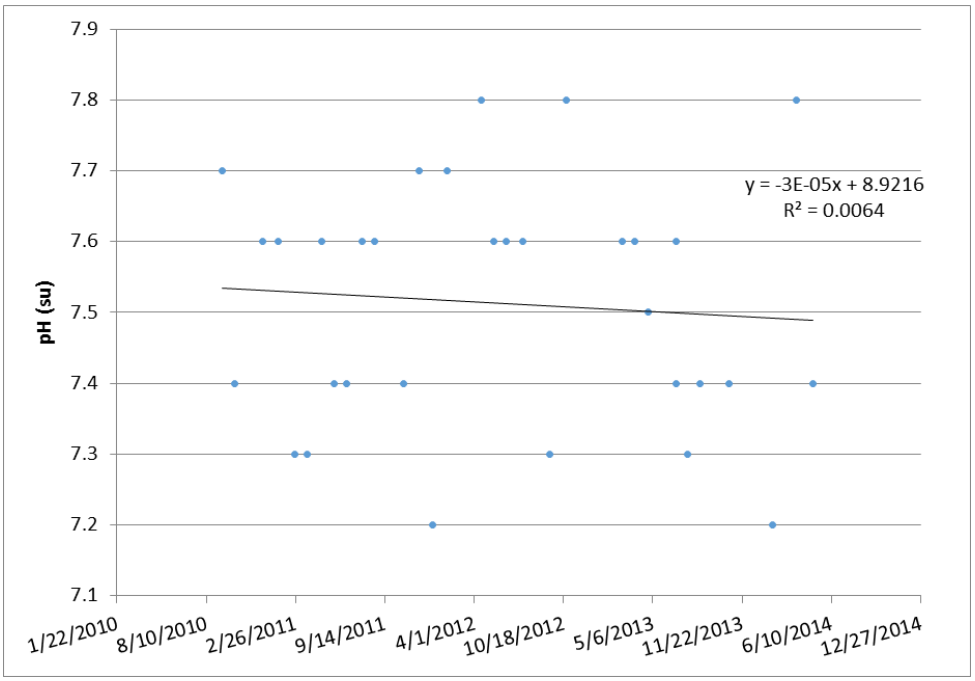

Figure 19: pH at site 80587

Secchi disk and total depth

There were 23 monitoring events where Secchi disk depth and total depth were recorded. In 11 instances, the Secchi disk depth was greater than the total depth indicating that the water was clear all the way to the bottom. In 12 instances, the Secchi disk depth was less than the total depth. The average Secchi disk depth at those times was 0.45 m. The water at this location had varying degrees of water clarity during the sampling events.

Field Observations

The water flow was recorded as low or normal for all of the monitoring events. There was no algae cover present at this site. The water color carried from no color, to light green, to dark green, to brown. Water clarity was clear 60% of the time, cloudy 28% of the time, and turbid 12% of the time. The water had no detectable odor.

E. coli Bacteria

E. coli samples were taken 16 times at this site. The geomean for E. coli was 113 CFU/100 mL. The E. coli counts ranged from a low of 50 CFU/100 mL in February of 2013, to a high of 270 CFU/100 mL in September of 2012. There was no significant trend in E. coli observed for this site during this time.

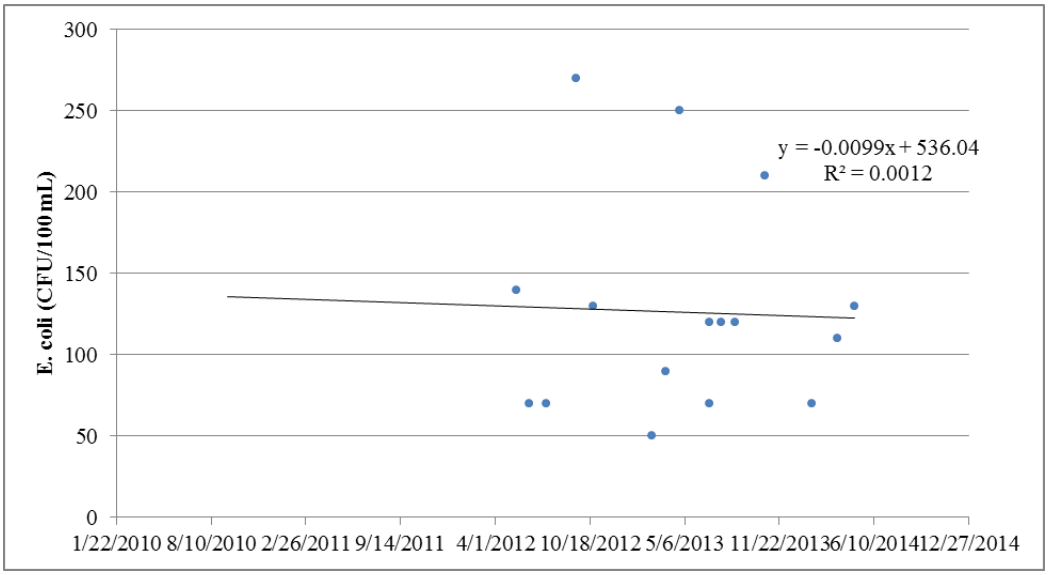

Figure 20: E. coli at site 80587

Site 80515 – Blanco River @ 500 River Rapids Rd.

Site Description

This site is located on private property in a riverfront neighborhood along the Blanco River. The location contains many cypress trees along the bank and although it is in a neighborhood, the opposite bank is undeveloped ranchland.

Sampling Information

This site was sampled 43 times between 10/6/2008 and 10/4/2013. It is no longer being monitored. The most common time of sampling was between 10:00 and 11:00.

Table 7: Descriptive parameters for Site 80515

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	43	328 ± 27	267	377
Water Temperature (°C)	43	20.0 ± 4.8	10.0	27.0
Dissolved Oxygen (mg/L)	43	7.8 ± 1.0	6.0	10.3
pH	43	7.8 ± 0.1	7.5	8.0
E. coli (CFU/100 mL)	8	79	40	150

Site was sampled 43 times between 10/6/2008 and 10/4/2013.

Air and water temperature

Air and water temperatures were taken 43 times at this site. Both temperatures followed a seasonal pattern with the low air temperature recorded as 10°C in February of 2013 and a high temperature of 33°C recorded in August, 2011. The mean water temperature was 20°C and varied from a low of 10°C in December, 2012 to a high of 27 °C in June, 2009.

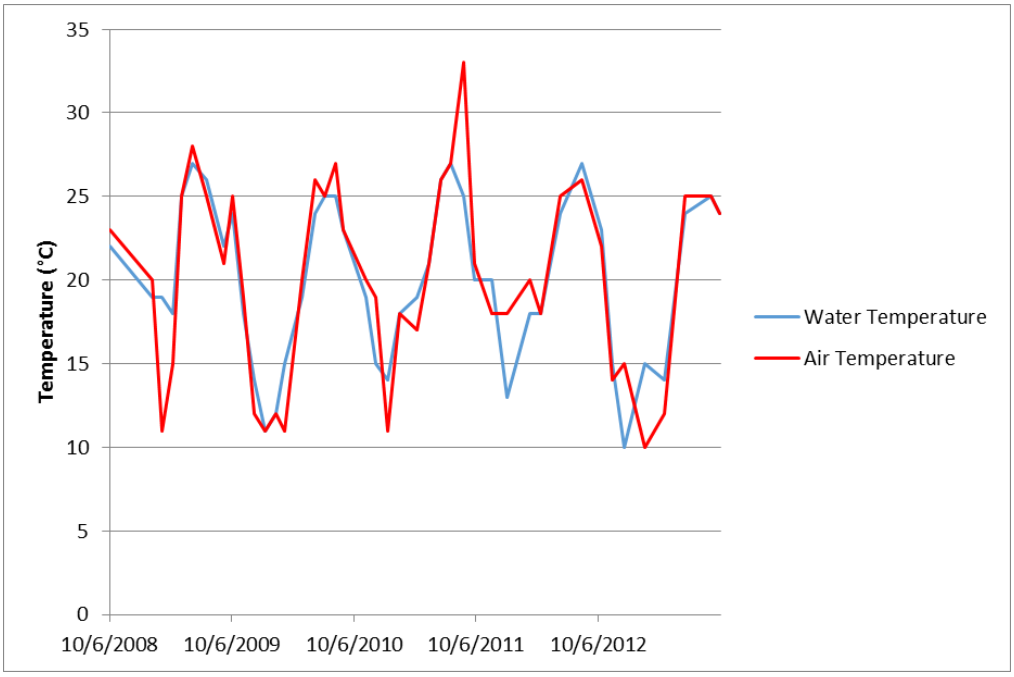

Figure 21: Air and water temperature at site 80515

Total Dissolved Solids

A total of 43 TDS measurements were taken at this site. The mean TDS value was 328 mg/L and ranged from a high of 377 mg/L in October of 2009 to a low of 267 mg/L in June, 2012. There was a significant trend in TDS concentrations over time observed at this site with TDS values decreasing over time ($p = 0.000$). The high R^2 value of 0.443 indicates that this relationship explains a large percentage of the variability.

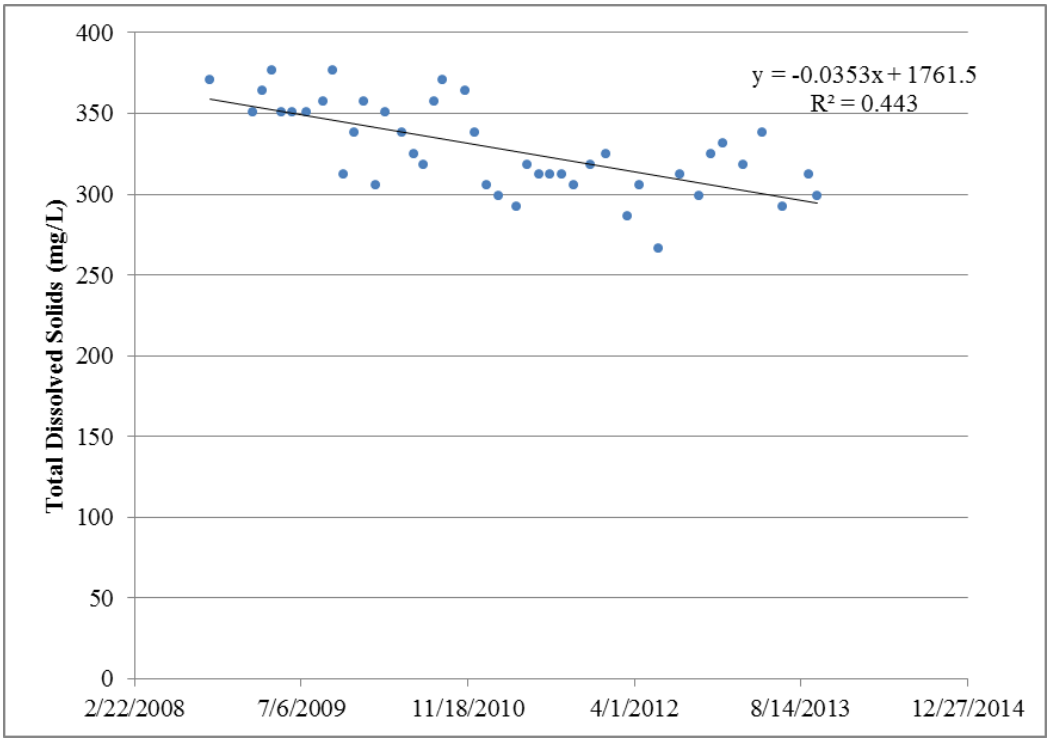

Figure 22: Total Dissolved Solids at site 80515

Dissolved Oxygen

There were 43 DO samples taken at this site during this time. The mean DO was 7.8 mg/L. The minimum DO concentration was 6.0 mg/L in September of 2009, and the maximum DO concentration was 10.3 mg/L taken in December of 2012. There was no significant trend between DO concentrations and time observed at this site.

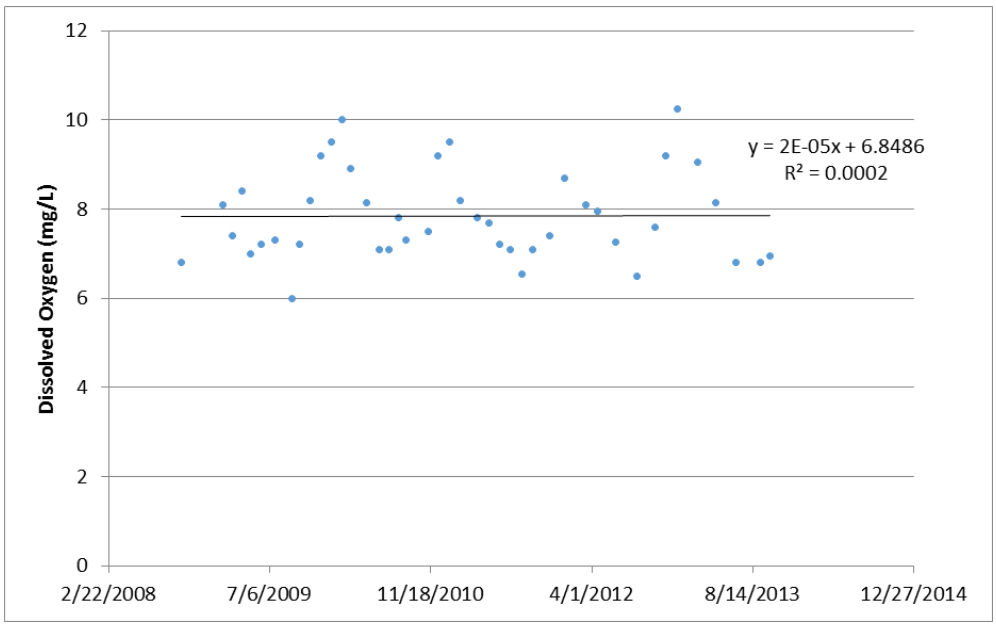

Figure 23: Dissolved Oxygen at site 80515

pH

Citizen scientists took 43 pH samples at this site. The mean pH was 7.8. The minimum pH was 7.5 and was recorded in September of 2009. The maximum pH was 8.0 and was recorded on multiple occasions. There was no significant trend in pH observed at this site.

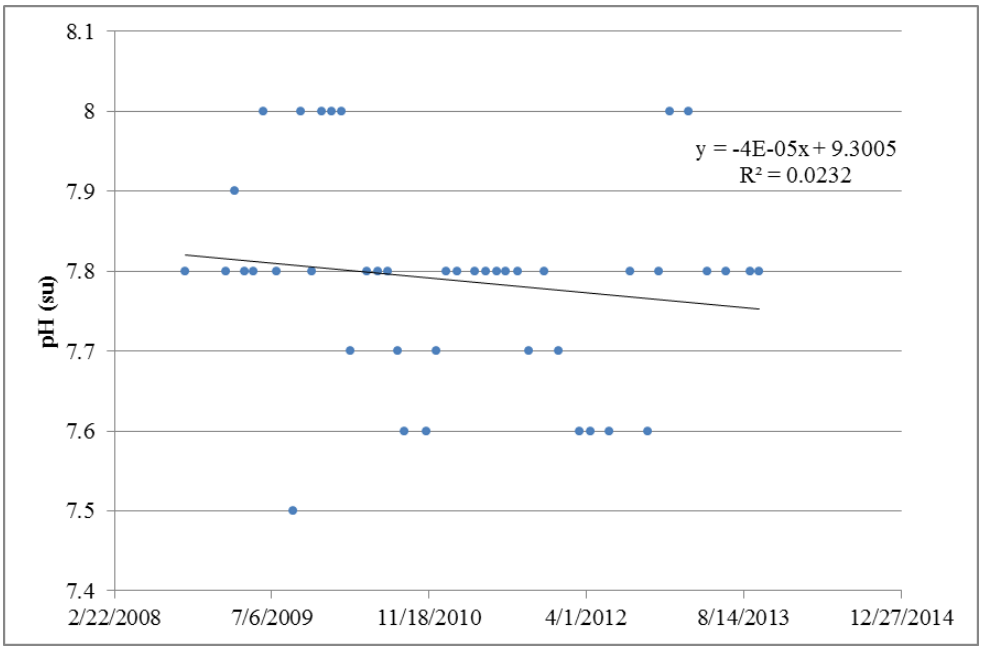

Figure 24: pH at site 80515

Secchi disk and total depth

The mean total depth for this site was 0.51m. The Secchi disk depth was greater than total depth for all recordings, indicating that the water was clear all the way to the bottom.

Field Observations

The flow was recorded as low or normal for all events. There was no algae cover present at this site. The water color was recoded as no color or dark green. Water clarity was recorded as clear for 88% of the monitoring events, and cloudy for 12% of the monitoring events.

E. coli Bacteria

There were 8 E. coli samples taken at this site. The geomean for E. coli was 79 CFU/100 mL. The minimum E. coli count was 40 CFU/100 mL and was taken in September of 2013. The maximum E. coli count was 150 CFU/100 mL and was recorded in February, 2013. There was no significant trend in E. coli over time observed at this site.

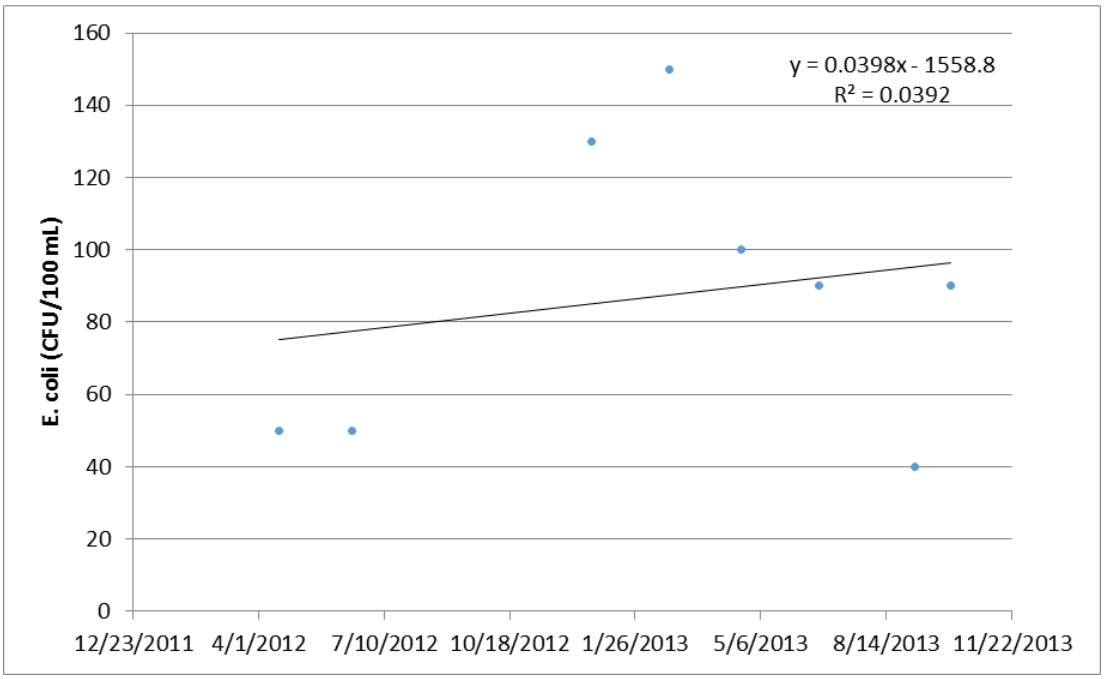

Figure 25: E. coli at site 80515

Site 80233 – Carpers Creek Tributary to Blanco River

Site Description

This site is located slightly downstream of Site 80515 – Blanco River at 500 Rapids Rd. Site 80233 is also located on private property and is at the confluence with Carpers Creek. This site is on the south bank of the river. It is located in a wooded area of cypress and live oak trees. There are a few houses on this side of the river, but it is mostly undeveloped land.

Sampling Information

This site is an actively monitored site that was sampled 116 times from 10/24/2004 to 7/17/2014. This site was typically sampled in the late morning to early afternoon from 11:00 to 13:00.

Table 8: Descriptive parameters for Site 80233

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	114	324 ± 39	117	402
Water Temperature (°C)	116	19.3 ± 5.4	7.0	29.0
Dissolved Oxygen (mg/L)	110	8.2 ± 2.3	2.8	12.5
pH	115	7.6 ± 0.3	7.0	9.5
E. coli (CFU/100 mL)	33	11	0	1600

Site was sampled 116 times between 10/24/2004 and 7/17/2014.

Air and water temperature

There were 116 air and water temperatures taken at this site during this time. Temperatures fluctuated in a seasonal pattern with the lowest air temperature of 6.5°C taken in January, 2007 to a high of 34.5°C in June, 2008. The mean water temperature was 19.3°C. The lowest water temperature was 7.0°C and was taken in January, 2007. The highest water temperature was 29°C in August of 2006.

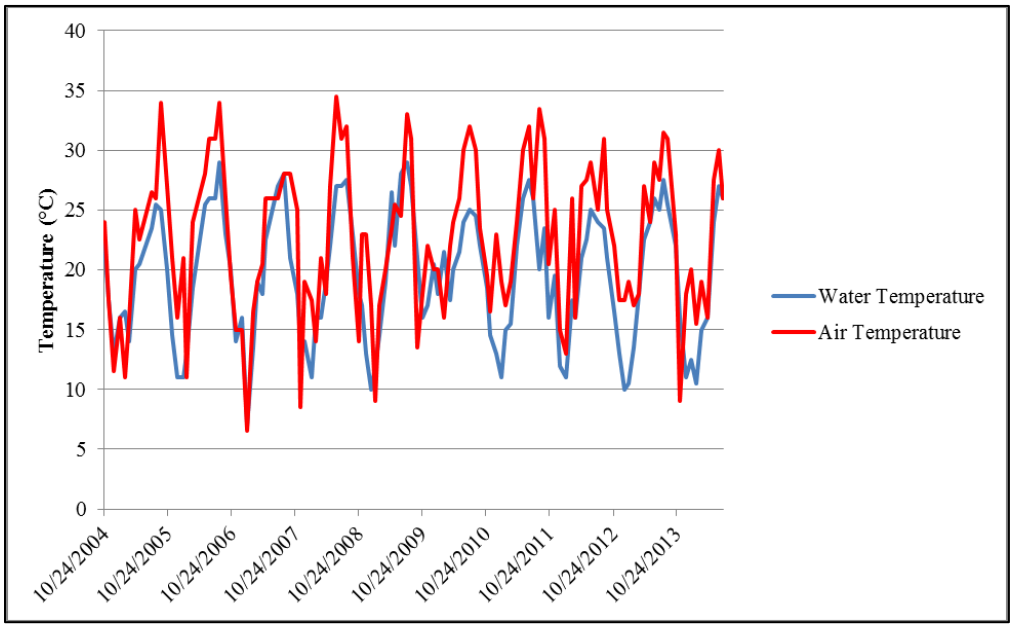

Figure 26: Air and water temperature at site 80233

Total Dissolved Solids

Citizen scientists took 114 TDS samples from this site. The mean TDS concentration was 324 mg/L and varied from a low of 117 mg/L in October, 2013 to a high of 402 mg/L in June, 2013. There was no significant trend in TDS concentrations over time observed at this site.

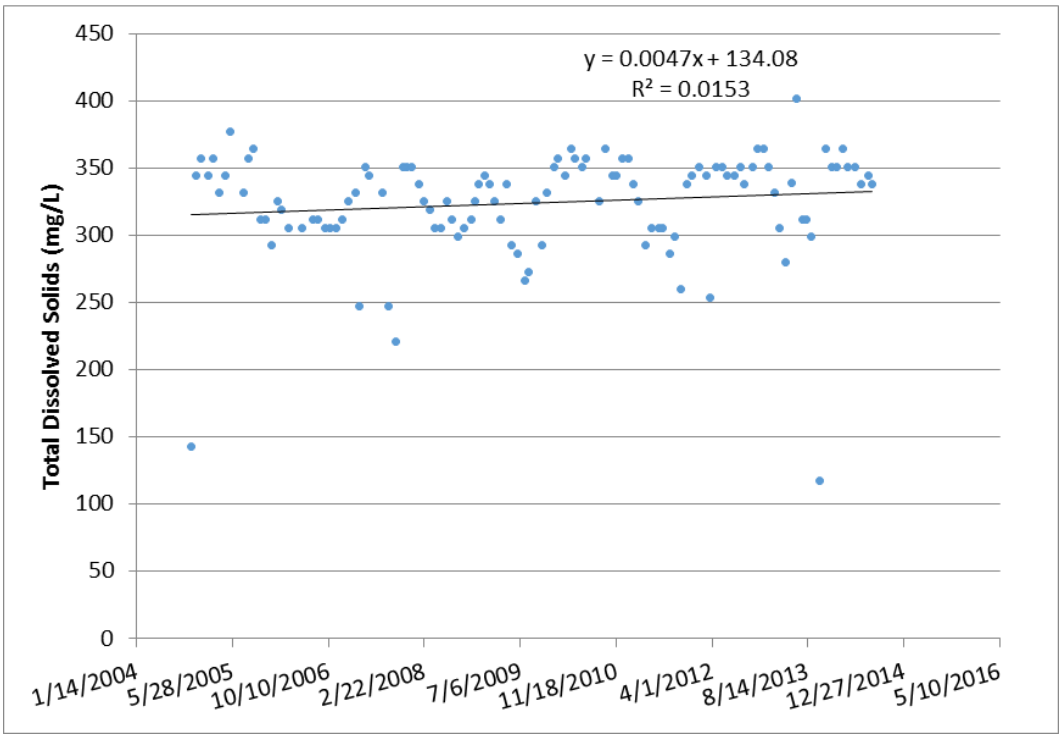

Figure 27: Total Dissolved Solids at site 80233

Dissolved Oxygen

Citizen scientists took 110 dissolved oxygen samples at this site during this time. The mean DO concentration was 8.2 mg/L. The lowest DO concentration measured was 2.8 mg/L in July of 2013. The highest DO concentration was 12.5 mg/L and was taken in February of 2008. There was no significant trend in DO over time observed for this site during this time.

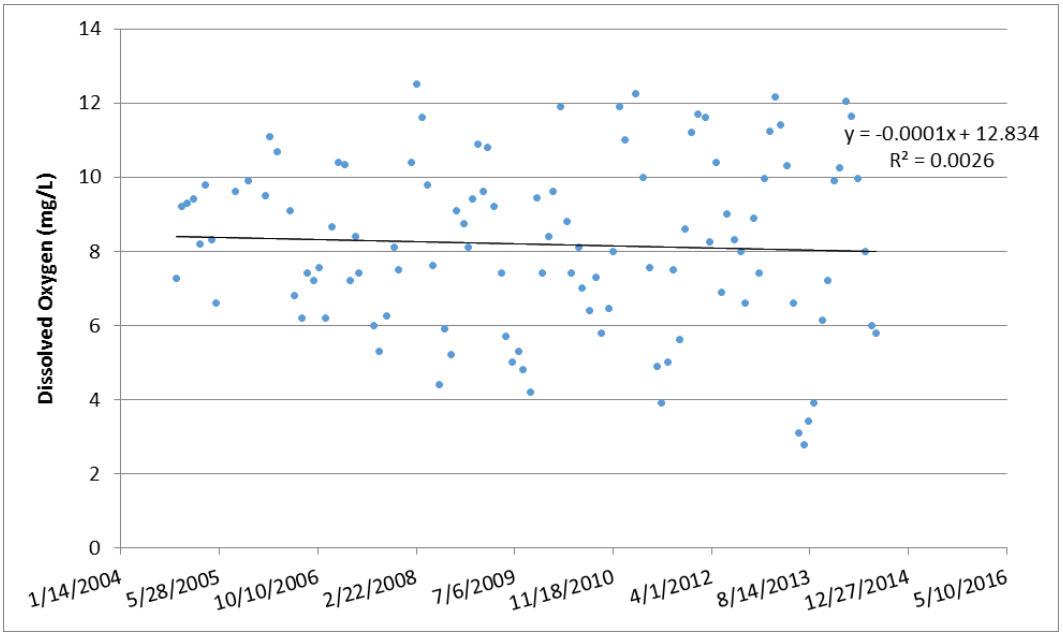

Figure 28: Dissolved Oxygen at site 80233

pH

Citizen scientists took 115 pH measurements at this site during this period. The mean pH was 7.6. The minimum pH was 7.0 and was recorded in January of 2005. The maximum pH was 9.5 and was recorded in November, 2012. There was no significant trend in pH over time observed for this site at this site.

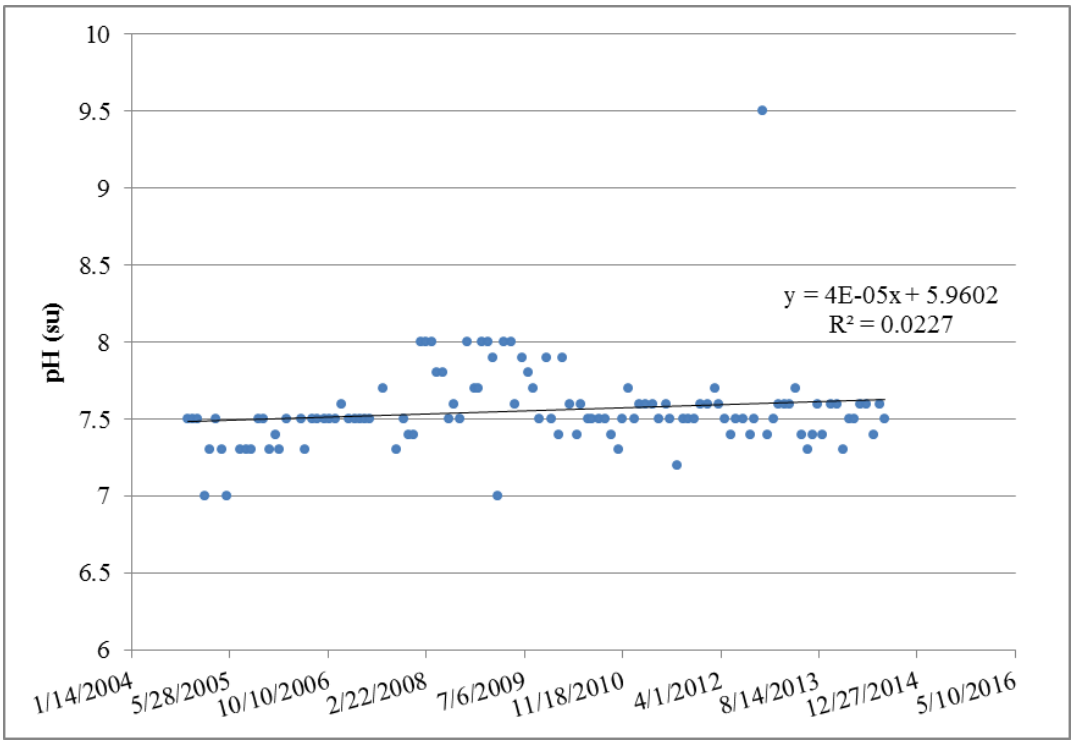

Figure 29: pH at site 80233

Secchi disk and total depth

There were 99 Secchi disk depths and total depths taken for this site. The mean total depth was 0.71 m at this location. Secchi disk depth was greater than total depth for 92% of the sampling events indicating that the water was clear all the way to the bottom for a majority of the time. The average Secchi disk depth when it was less than total depth was 0.46 m.

Field Observations

Flow was recorded as low or normal. The algae cover was absent or rare 95% of the time. The rest of the time, the algae cover was recorded as common (26 – 50%). The water was described as having no color. The clarity described as clear, and there was no describable odor at this site.

E. coli Bacteria

There were 33 E. coli samples taken at this site. The geomean for E. coli was 11 CFU/100 mL. The minimum E. coli count was 0 and the highest E. coli count was 1600 CFU/100 mL and was taken in October of 2013.

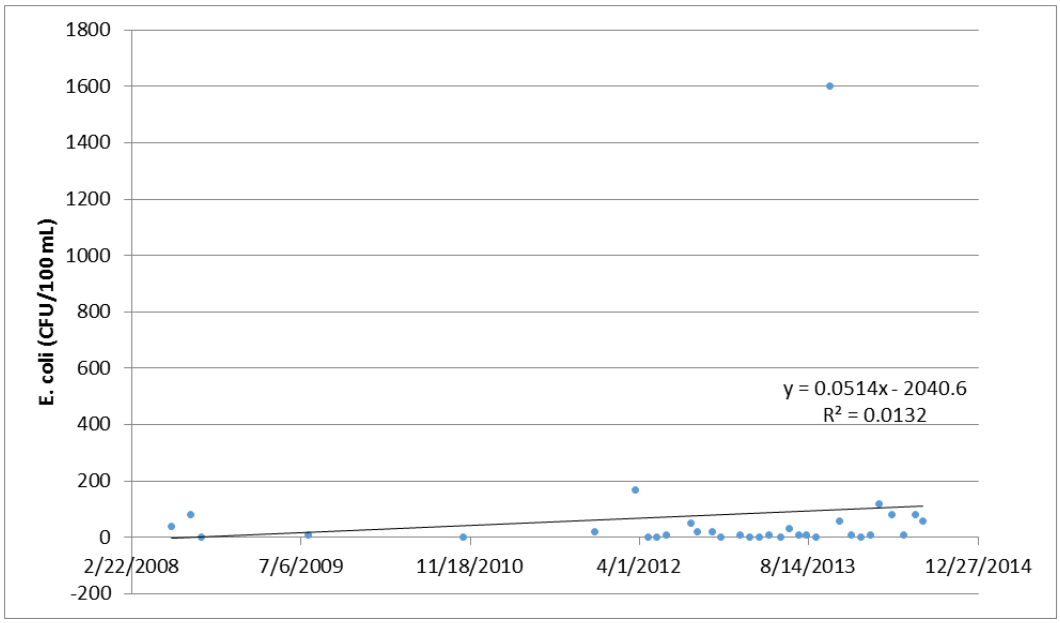

Figure 30: E. coli at site 80233

Site 12663 – Blanco River @ Lower Water Crossing at Pioneer Town

Site Description

This site is located downstream of a Low Water Crossing at Pioneer Town in Wimberley, TX. Pioneer Town is private property, but it is a popular swimming area for people who pay a fee. There are several houses along the riverfront at this location. The river downstream of the low water crossing is shallow, rocky, and swift. There are several cypress trees along the river bank at this site.

Sampling Information

This site was sampled 29 times between 3/7/2004 and 1/30/2014. The time of sampling varied between 07:00 and 23:00.

Table 9: Descriptive parameters for Site 12663

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	27	319 ± 34	267	34
Water Temperature (°C)	28	22.0 ± 6.2	9	32
Dissolved Oxygen (mg/L)	27	7.4 ± 1.2	5.4	9.9
pH	27	8.0 ± 0.3	7.8	9.7

Site was sampled 29 times between 3/7/2004 and 1/30/2014.

Air and water temperature

There were 28 air and water temperatures taken at this site. The temperatures fluctuated in a seasonal pattern. The highest air temperature recorded at this site was 38°C and was taken in August, 2010. The

lowest air temperature recorded was 12 °C, and was taken in May of 2011. The mean water temperature was 22.0°C. Water temperature varied from a low of 9°C in December, 2011, to a high of 32°C in June of 2012.

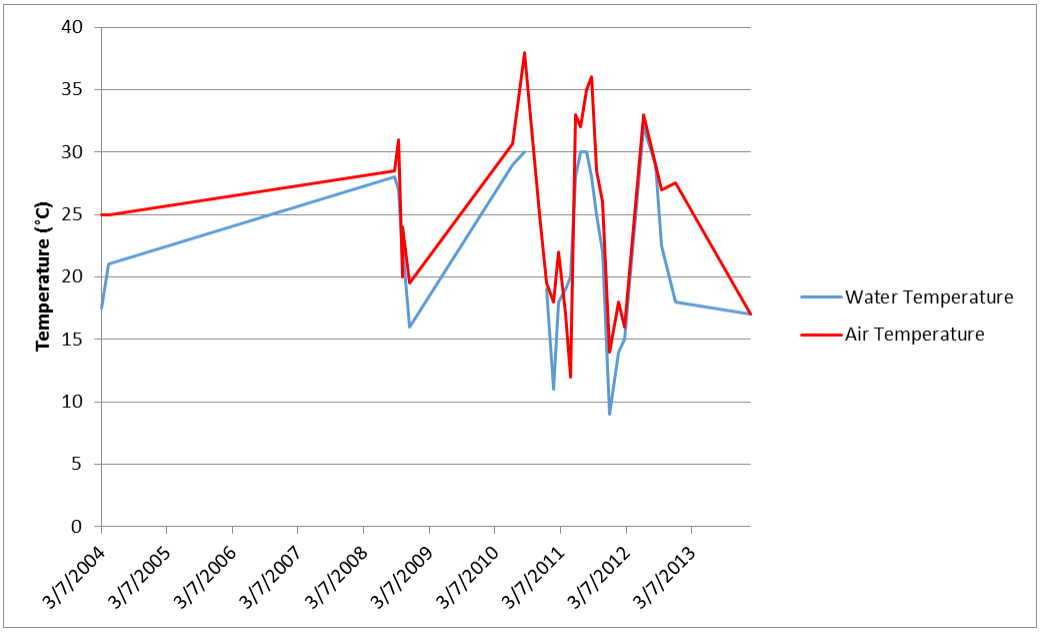

Figure 31: Air and water temperature at site 12663

Total Dissolved Solids

Citizen scientists took 27 TDS samples at this site. The mean TDS concentration was 319 mg/L. The minimum TDS concentration was taken in September of 2012 and was 267 mg/L. The maximum TDS concentration was 468 mg/L and was taken in December of 2010. There was no significant trend in TDS concentrations over time observed at this site.

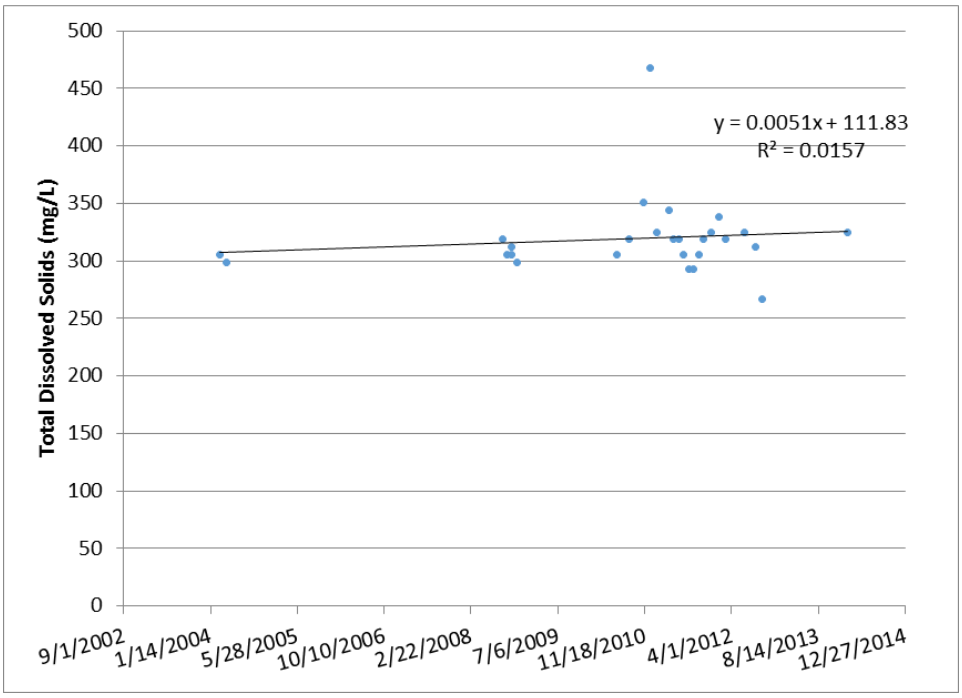

Figure 32: Total Dissolved Solids at site 12663

Dissolved Oxygen

There were 27 dissolved oxygen samples taken at this site. The mean DO concentration was 7.4 mg/L. The lowest DO concentration was 5.4 mg/L and was taken in June, 2011. The highest DO concentration was 9.9 mg/L and was recorded in January of 2014. There was no significant trend in DO concentration over time observed at this site.

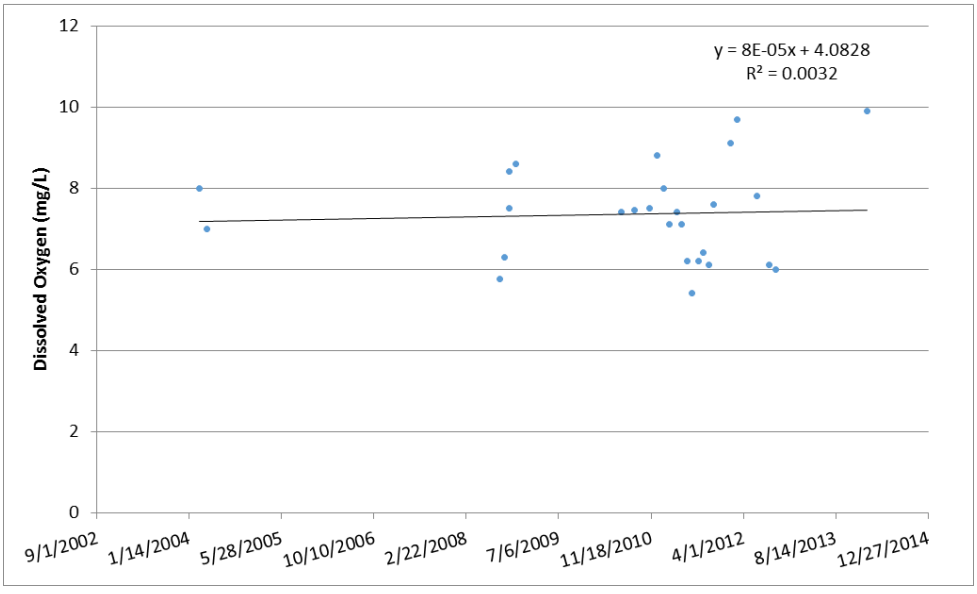

Figure 33: Dissolved Oxygen at site 12663

pH

There were 27 pH measurements taken at this site. The mean pH was 8.0. The minimum pH was 7.8 and was recorded in June of 2011. The maximum pH was 9.7 and was recorded in February of 2012. There was no significant trend in pH over time observed at this site.

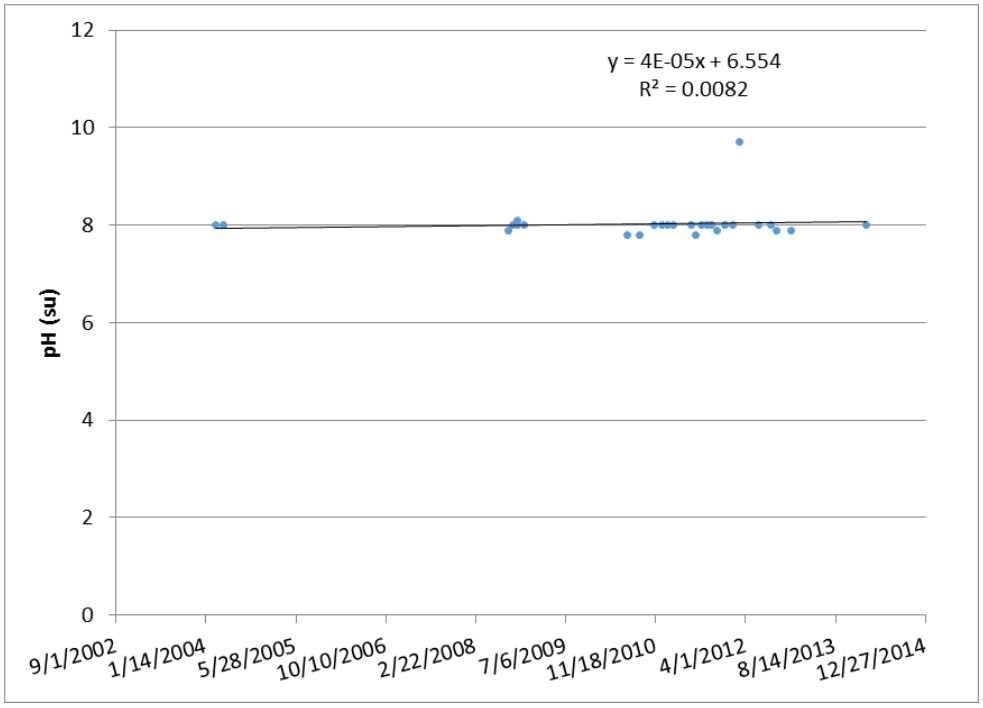

Figure 34: pH at site 12663

Secchi disk and total depth

The average depth of this site was 1.0 m. The Secchi disk depth was greater than the total depth in all samples indicating that the water was clear all the way to the bottom.

Field Observations

The flow was described as low in almost all events. There was no algae cover present at this location. The water was described as having no color, or a light green color. Water clarity was described as clear in all events, and the water had no describable odor.

Site 12660 – Blanco River @ CR 174 (Hidden Valley Crossing)

Site Description

This site is located at a county road low water crossing. It is in a valley on the south bank of the Blanco River. There is some farmland and ranchland in this valley. On the north bank are several houses. Both banks are lined with cypress trees.

Sampling Information

This is an actively monitored sites that was sampled 102 times between 3/31/2014 and 6/27/2014. It was typically sampled in the afternoon, between 15:00 and 17:00.

Table 10: Descriptive parameters for Site 12660

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	96	305 ± 31	215	371
Water Temperature (°C)	99	22.3 ± 6.4	8.0	34.0
Dissolved Oxygen (mg/L)	99	8.6 ± 1.4	6.3	12.6
pH	101	8.0 ± 0.2	7.7	8.7
E. coli (CFU/100 mL)	15	27	0	280

Site was sampled 102 times between 3/31/2004 and 6/27/2014.

Air and water temperature

Air and water temperatures were taken 99 times at this site. The temperatures fluctuated on a seasonal basis. The minimum air temperature was 4°C and was recorded in November, 2013. The maximum air temperature was 34°C and was recorded in August, 2004. The mean water temperature was 22.3°C. Water temperature varied from a minimum of 8°C in November, 2013 to a maximum of 34°C in August, 2009.

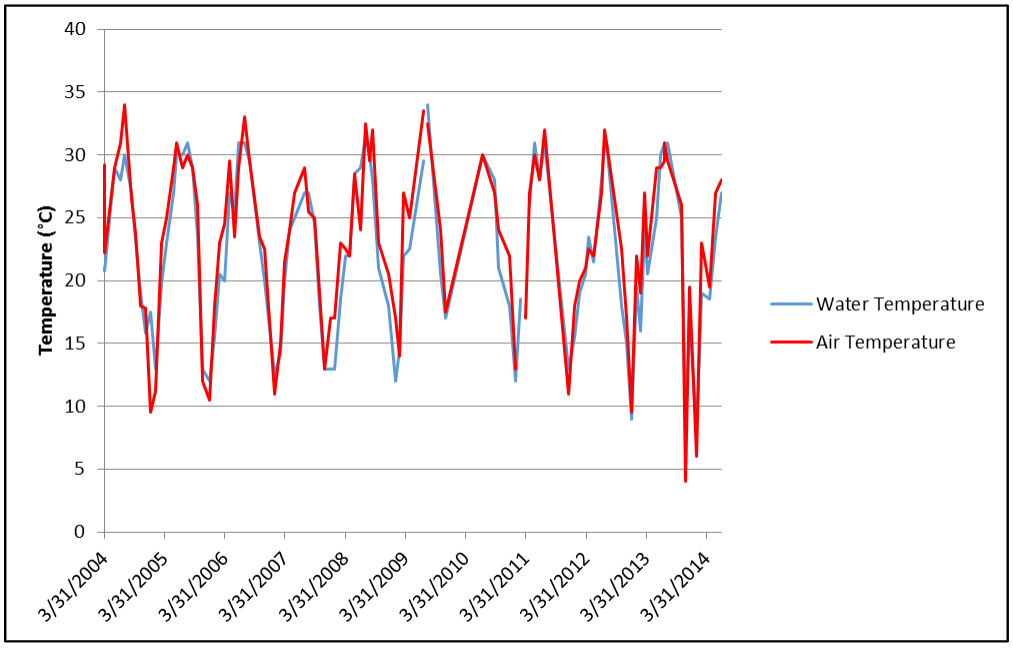

Figure 35: Air and water temperatures at site 12660

Total Dissolved Solids

Citizen scientists took 96 TDS samples at this site. The mean TDS concentration was 305 mg/L. The minimum TDS measurement was 215 mg/L and was taken in May of 2012. The maximum TDS concentration was 371 mg/L and was recorded in November of 2009. There was no significant trend in TDS over time observed at this site.

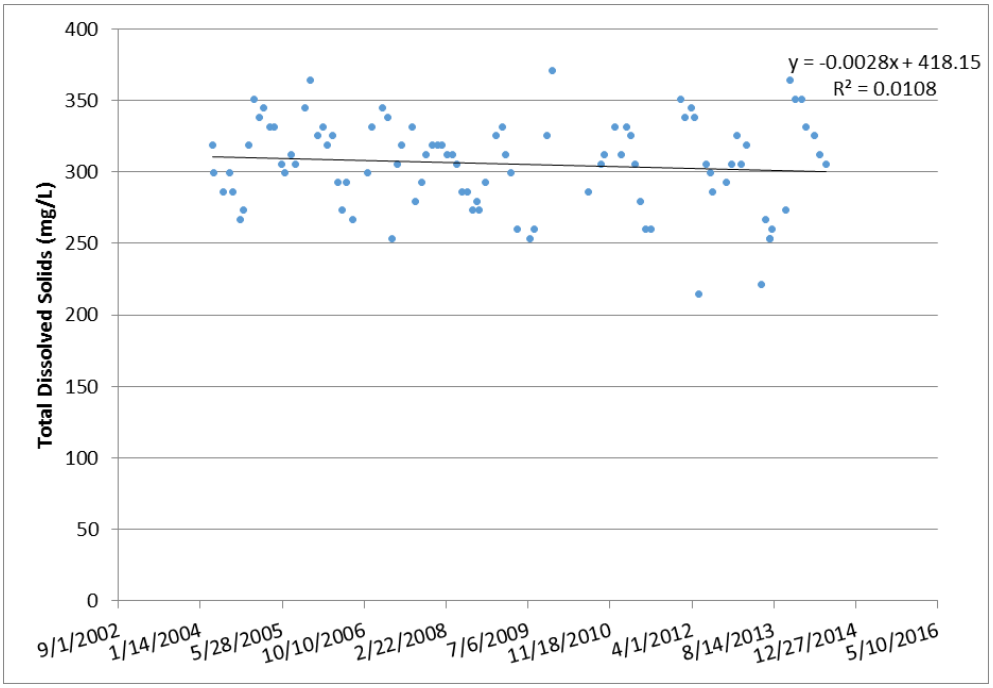

Figure 36: Total Dissolved Solids at site 12660

Dissolved Oxygen

There were 99 DO samples taken at this site. The mean DO concentration was 8.6 mg/L. The minimum DO concentration was 6.3 mg/L and was taken in June, 2013. The maximum DO concentration was 12.6 mg/L and was taken in January of 2014. There was no significant trend in DO concentration over time observed at this site.

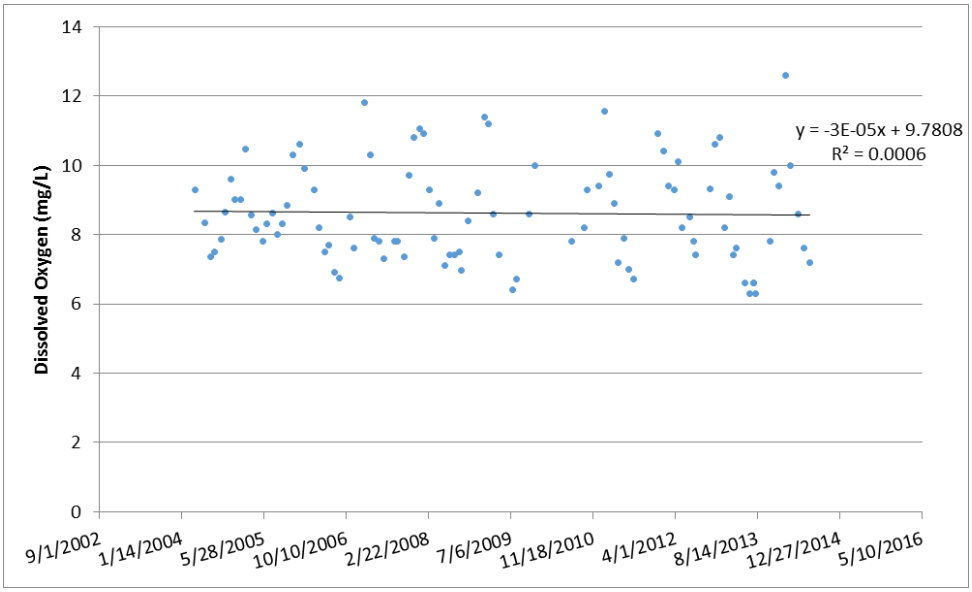

Figure 37: Dissolved Oxygen at site 12660

pH

There were 101 pH measurements taken at this site. The mean pH was 8.0. The minimum pH was 7.7 and was taken in March of 2007. The maximum pH was 8.7 and was taken in January, 2009. There was a significant decrease in pH observed over time at this site ($p = 0.007$). The low R^2 value of 0.0714 indicates that this relationship only explains about 7% of the variation of the data.

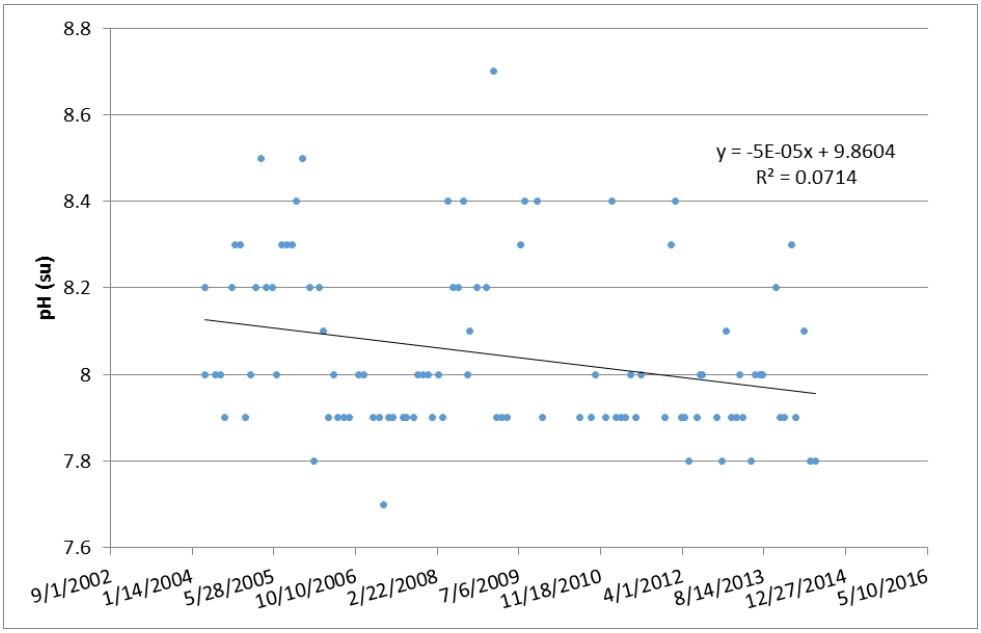

Figure 38: pH at site 12660

Secchi disk and total depth

The mean total depth at this site was 0.78 m. The Secchi disk depth was never greater than the total depth indicating that the water at this site was not visible to the bottom of the river. The mean Secchi disk depth was 0.66 m.

Field Observations

The flow was recorded as low or normal. There was no algae cover present at this site. The water had no color. Water clarity was recorded as clear, and the water had no describable odor.

E. coli Bacteria

There were 15 E. coli samples taken at this site. The geomean was 27 CFU/100 mL. E. coli ranged from no bacteria detected to 280 CFU/100 mL in May of 2013. There was no significant trend in E. coli over time observed at this site.

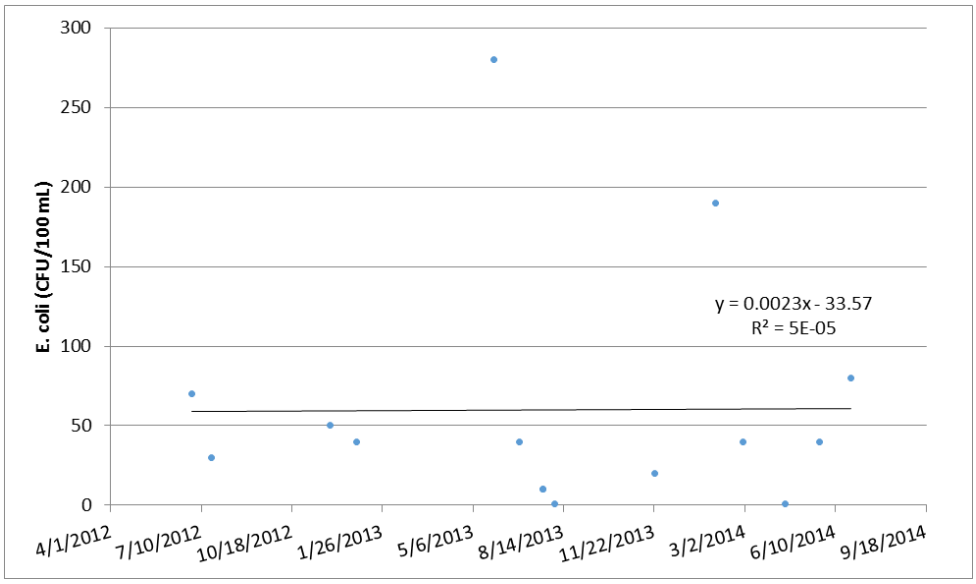

Figure 39: E. coli at site 12660

Site 15296 – Blanco River @ TSU Camp

Site Description

This site is located at the Texas State University Camp which is a large property for camping, hiking, swimming, and fishing. The surrounding land is mostly undeveloped. The monitoring location is in a pool downstream of a small rapid. The banks are lined with cypress trees.

Sampling Information

This site is an actively monitored site that was monitored 66 times between 10/29/1995 and 6/15/2014. The time of sampling varied from 07:00 to 18:00.

Table 11: Descriptive parameters for Site 15296

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	59	294 ± 46	124	442
Water Temperature (°C)	63	21.7 ± 6.7	8.5	33.3
Dissolved Oxygen (mg/L)	64	7.8 ± 1.2	4.8	10.2
pH	61	7.9 ± 0.3	7.2	8.5

Site was sampled 66 times between 10/29/1995 and 6/15/2014.

Air and water temperature

There were 63 air and water temperatures taken at this site. The temperatures fluctuated in a seasonal pattern. The minimum air temperature was 2°C and was recorded in December of 2009. The maximum temperature was 35.1°C and was taken in May of 2011. The mean water temperature was 21.7°C. Water temperature fluctuated from a low of 8.5°C in December of 2009, to a high of 33.3°C in July, 2011.

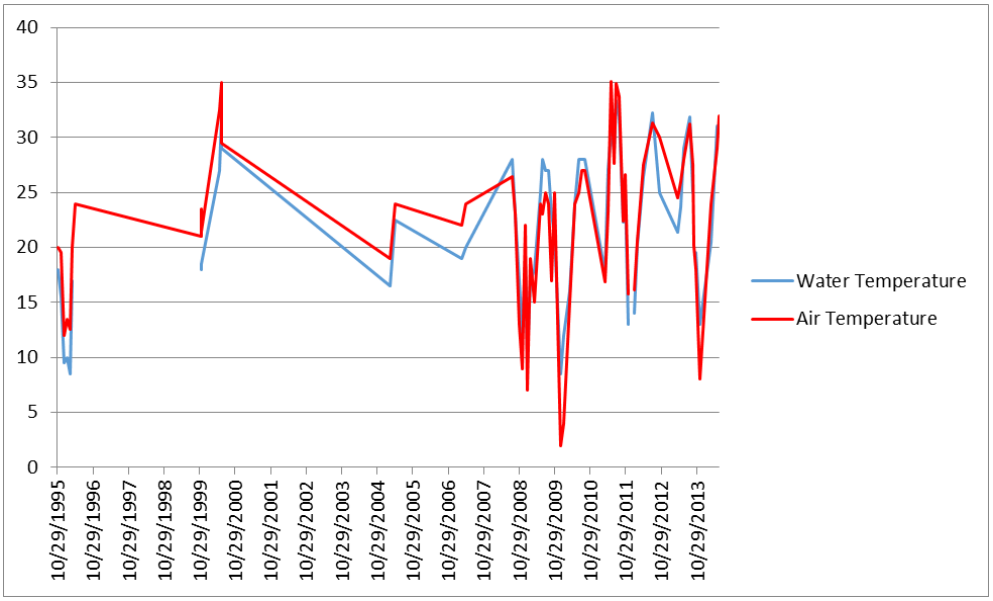

Figure 40: Air and water temperatures at Site 15296

Total Dissolved Solids

There were 59 TDS samples taken at this site. The mean TDS concentration was 294 mg/L. The minimum TDS concentration was 124 mg/L and was taken in May, 2005. The maximum TDS concentration was 442 mg/L and was recorded in June, 2013. There was no significant trend in TDS concentrations over time observed at this site.

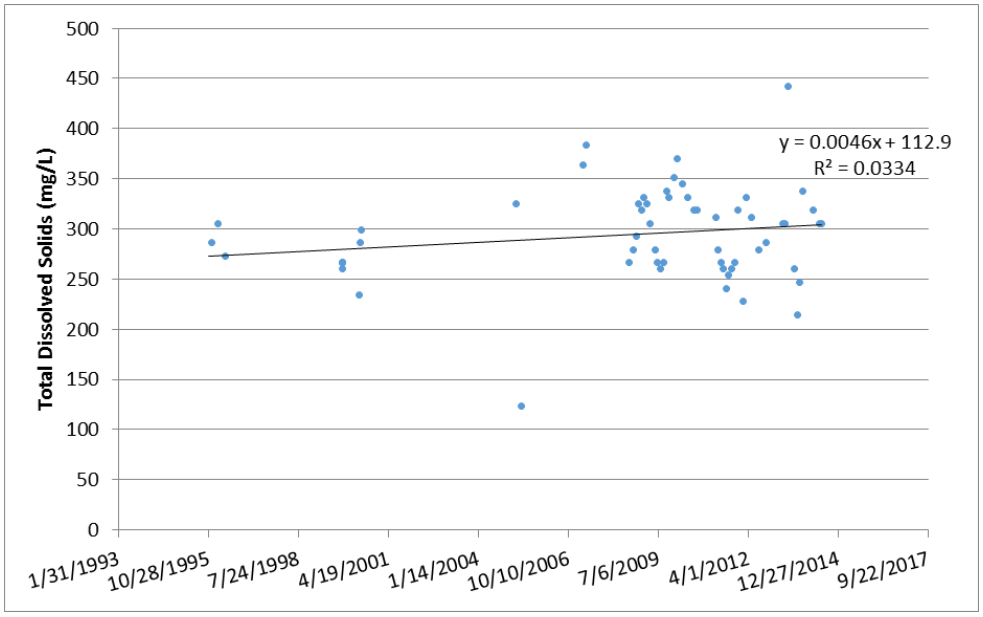

Figure 41: Total Dissolved Solids at Site 15296

Dissolved Oxygen

There were 64 DO samples taken at this site during this time. The mean DO concentration was 7.8 mg/L. The minimum DO concentration was taken in June of 2009 and was 4.8 mg/L. The maximum DO concentration was 10.2 mg/L and was taken in November, 2013.

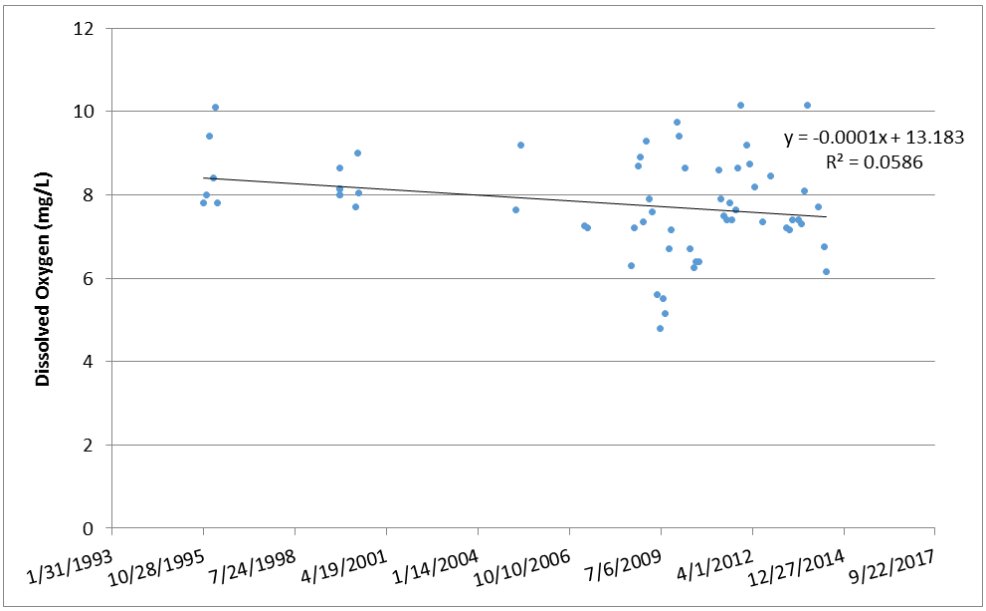

Figure 42: Dissolved Oxygen Site 15296

pH

There were 61 pH measurements taken at this site. The mean pH was 7.9 and pH ranged from a low of 7.2 in May, 2014, to a high of 8.5 in March, 1996. There was a significant decrease in pH over time observed at this site. The high R^2 value of 0.5685 indicates a strong relationship between pH and time for this site.

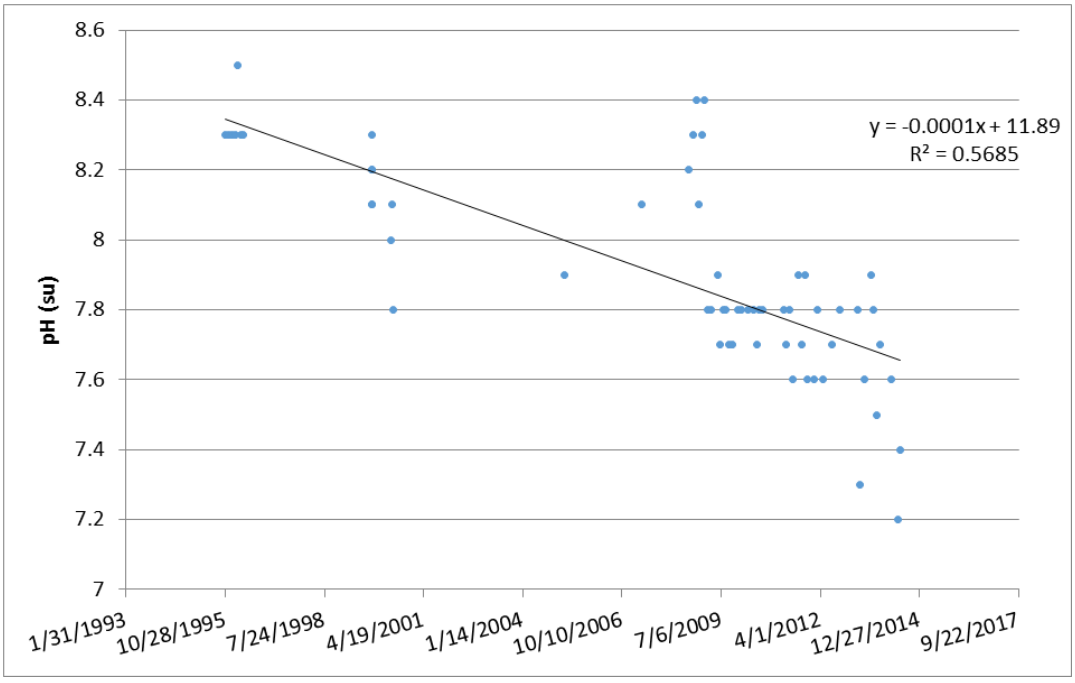

Figure 43: pH Site 15296

Secchi disk and total depth

The mean total depth at this site was 0.68 m. The Secchi disk depth was recorded as greater than total depth for all monitoring events indicating that the water at this site was clear all the way to the bottom.

Field Observations

The flow at this site was recorded as low or normal for all events. Algae cover was mostly absent, but there were a few instances where it was recorded as common (26-50%). The water clarity was described as clear for all events except for three where it was described as cloudy, and one event where it was described as turbid. The water odor was mostly described as no odor. The first 7 months of monitoring at this site has a recording of musky for water odor, and there were 3 instances where the odor was described as fishy.

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