

# Pedernales River Watershed Data Report

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June 2013



**THE MEADOWS CENTER**  
FOR WATER AND THE ENVIRONMENT  

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TEXAS STATE UNIVERSITY



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*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**

The Pedernales River rises up in the southeast portion of Kimble County, runs 106 miles southeast through Gillespie, Blanco, Hays, and Travis counties and empties into Lake Travis, just before the confluence with the Colorado River. The Pedernales River Watershed has a drainage area of approximately 815,000 acres (1,273 square miles) within the Colorado River Basin, which drains from the rugged Texas Hill Country to the Gulf of Mexico. This report covers data collected from 2008 to 2013. The data utilized for this study includes Stream Team citizen scientist data, in addition to data from LCRA CRWN. Monitoring sites include 14 sites in the Pedernales River Watershed including several tributaries: Heinz Creek, Williams Creek, Live Oak Creek, Town Creek, Barons Creek, Hamilton Pool, and Cypress Creek.

The Pedernales River originates in limestone along the central portion of the Edwards Plateau and then flows eastward through the Edwards Plateau. The Edwards Plateau ecoregion is primarily characterized by a limestone plateau and the geomorphology typically has more hills in the southern portion. Additionally, the area contains a small network of spring-fed, perennial streams. Those streams are often cool and clear owing to the underlying karst aquifer, which produces high water quality and is ideal for contact recreation activities (The Nature Conservancy).

For the most part, the area is characterized by juniper-oak savanna and mesquite-oak savanna, housing soils that are mostly mollisols (Griffith, Bryce, Omernik, & Rogers, 2007). The fine, sandy to clay loams of the surrounding watershed also supports the ashe juniper, bald cypress, mesquite, and grasses characteristic of the Hill Country. The watershed supports a variety of fish and wildlife as well. According to Texas Parks and Wildlife, fish commonly caught in Pedernales River includes catfish, perch, carp, and bass. Common wildlife inhabitants include coyotes, armadillos, white-tailed deer, skunks, opossums, rabbits, and raccoons. Common birds sighted in the area include herons, ravens, doves, quail, roadrunners, western scrub jays, wild turkeys, owls, and the endemic rufous-crowned sparrow (Texas Parks and Wildlife Department).

The major geologic structure to make note of is the Llano Uplift. Perhaps the most well-known portion of the Llano Uplift is the Pedernales Falls, located in the Pedernales Falls State Park, where the river drops 15.24 meters over a 914.4 meter stretch of layered, step-down limestone formations (Texas Parks and Wildlife Department). The climate in this area is subtropical, which consists of hot summers and dry winters. The Pedernales River area flows through rocky, rugged terrain where the ground typically rises far above the river valley. Owing to this geomorphology, the Pedernales River is well-known for rapid flash flooding because of the steep sloping drainage. The upper reaches of the Pedernales River are often dry, with the majority of the water located in the lower reaches (Lower Colorado River Authority, 2000).

## 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 ( $\mu\text{S}/\text{cm}^3$ ). 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 result from sediment washing away from construction sites, erosion of farms, or mining operations. Average Secchi disk transparency (a.k.a. Secchi depth) readings that are less than the total depth readings indicate turbid water. Readings that are equal to total depth indicate clear water. Low total depth observations have a potential to concentrate contaminants.

For this specific report, Transparency tubes were utilized in place of a Secchi disk to measure turbidity. Transparency tubes consist of two main pieces: the tube with measurement markings in increments of every two millimeters and the release spout with a valve at the base of the tube. The utilization of the Transparency tube is allowed by the EPA as described in the “Volunteer Stream Monitoring: A Methods Manual” and is also allowed by the TCEQ Surface Water Quality Monitoring Department as described in the “Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods.” The EPA method involves collecting the sample in a bucket, and the TCEQ procedure involves collecting the sample directly in the tube. The Texas Stream Team method incorporates both methods depending on the safety of the water body. The bucket is used when a water body is not safe enough for the monitor to sample while standing in the stream.

## *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 Pedernales 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.

### **Lower Colorado River Authority (LCRA): Colorado River Watch Network (CRWN)**

The LCRA Colorado River Watch Network (CRWN) is a partner program of Texas Stream Team. As such, CRWN has their own set of procedures and quality system for their citizen monitoring program. For more information on CRWNs data collection procedures please visit the LCRA website. As an independent entity which does not receive funding from the TCEQ or Texas State University, CRWN manages volunteers, conducts trainings, manages data, and supplies equipment for volunteers within the Colorado River Watershed. However Texas Stream Team has chosen to include CRWN data information in this Data Report based on the following points: CRWN is considered as a part of the Texas Stream Team monitoring network, CRWN data is included in the Texas Stream Team database, and CRWN volunteers and state-funded staff are counted as match for the Texas Stream Team grant project. Other ways in which Texas Stream Team partners exclusively with CRWN is through the sharing of water quality data and joint event planning.

## 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 |
|--------------------------------|--------|--------------------------|---------------|--------------------|--------------|
| <i>E. coli</i>                 | water  | SPS                      | 100           | Refrigerate @ 4°C* | 6 Hours      |
| Nitrate/Nitrogen               | water  | Plastic Test Tube        | 10 mL         | Refrigerate @ 4°C* | 48 Hours     |
| Orthophosphate/<br>Phosphorous | water  | Glass Mixing Bottle      | 25 mL         | Refrigerate @ 4°C* | 48 Hours     |
| Chemical Turbidity             | water  | Plastic Turbidity Column | 50 mL         | Refrigerate @ 4°C* | 48 Hours     |

\*Preservation performed within 15 minutes of collection.

Container Key: SPS = Sterile Polystyrene

### Processes to Prevent Contamination

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

### Documentation of Field Sampling Activities

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

For all *E. coli* sampling events, station ID, location, sampling time, date, depth, sample collector's name/signature, group identification number, incubation temperature, incubation duration, *E. coli* colony

counts, dilution aliquot, field blanks, and media expiration dates are checked and recorded if expired. Values for all measured parameters are recorded. If reagents or media are expired, it is noted and communicated to Texas Stream Team.

Sampling is still encouraged with expired reagents and bacteria media; however, the corresponding values will be flagged in the database. Detailed observational data are recorded, including water appearance, weather, field observations (biological activity and stream uses), algae cover, unusual odors, days since last significant rainfall, and flow severity.

Comments related to field measurements, number of participants, total time spent sampling, and total round-trip distance traveled to the sampling site are also recorded for grant and administrative purposes.

## Data Entry and Quality Assurance

### Data Entry

The citizen monitors collect field data and report the measurement results on Texas Stream Team approved physical or electronic datasheet. The physical data sheet is submitted to the Texas Stream Team and local partner, if applicable. The electronic datasheet is accessible in the online DataViewer and, upon submission and verification, is uploaded directly to the Texas Stream Team Database.

### Quality Assurance & Quality Control

All data are reviewed to ensure that they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to specified monitoring procedures and project specifications. The respective field, data management, and Quality Assurance Officer (QAO) data verification responsibilities are listed by task in the Section D1 of the QAPP, available on the Texas Stream Team website.

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

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

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

## Data Analysis Methods

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

## Standards & Exceedances

The TCEQ determines a water body to be impaired if more than 10% of samples, provided by professional monitoring, from the last seven years, exceed the standard for each parameter, except for *E. coli* bacteria. When the observed sample value does not meet the standard, it is referred to as an exceedance. At least ten samples from the last seven years must be collected over at least two years with the same reasonable amount of time between samples for a data set to be considered adequate. The 2010 Texas Surface Water Quality Standards report was used to calculate the exceedances for the Pedernales River Watershed, as seen below in Table 2.

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

| Parameter                     | 2010 Texas Surface Water Quality Standards for Pedernales River |                |
|-------------------------------|-----------------------------------------------------------------|----------------|
| Water Temperature (°C)        | 32.7° C (Maximum)                                               |                |
| Total Dissolved Solids (mg/L) | 525 mg/L (Maximum)                                              |                |
| Dissolved Oxygen (mg/L)       | 5 mg/L (Minimum)                                                |                |
| pH                            | 6.5-9.0 (Range)                                                 |                |
| <i>E. coli</i> (CFU)          | 399 CFU/100mL                                                   | Single Sample  |
|                               | 126 CFU/100mL                                                   | Geometric Mean |

## Methods of Analysis

All data collected from Pedernales River Watershed and its tributaries were exported from the Texas Stream Team database and the CRWN 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  $\leq 0.05$ . A p-value of  $\leq 0.05$  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.

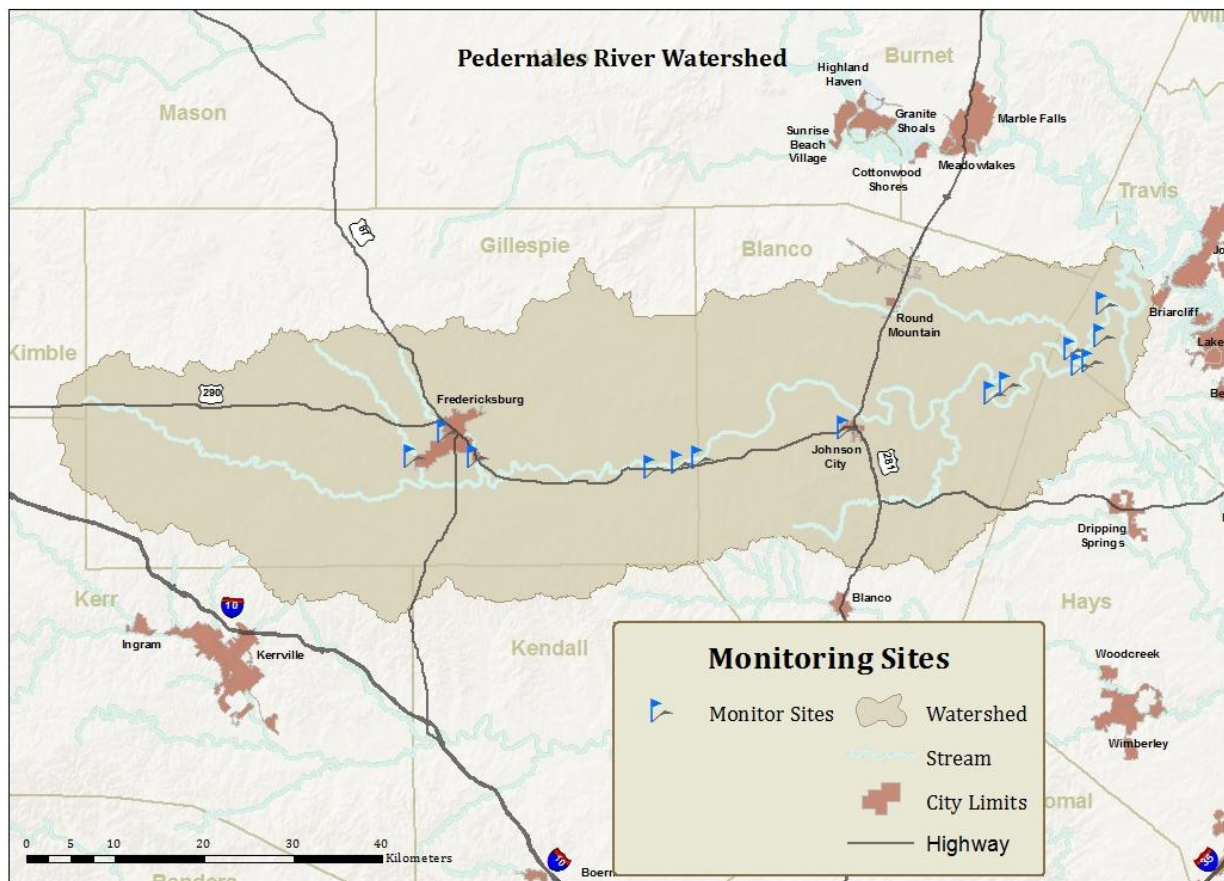
For this report, specific conductivity measurements, gathered by volunteers, were converted to TDS using the TCEQ-recommended conversion formula of specific conductivity 0.65. This conversion was made so that volunteer gathered data could be more readily compared to state gathered data. Geomeans were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



## Pedernales River Watershed Data Analysis

### Pedernales 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.



Map 1: Water Quality Monitoring Sites in the Pedernales River Watershed



## Pedernales River Watershed Trends over Time

### Sampling Trends over Time

Sampling along the Pedernales River began in January 2008 and sampling events increased each year over time. Sampling in 2013 appears to be the lowest, but at the time of writing, only two full months of sampling had been reported. Sampling was evenly distributed across all months, with April seeing the lowest number of sampling events. A majority of the sampling events took place mid-morning, with few, to no samplings occurring in the dark hours.

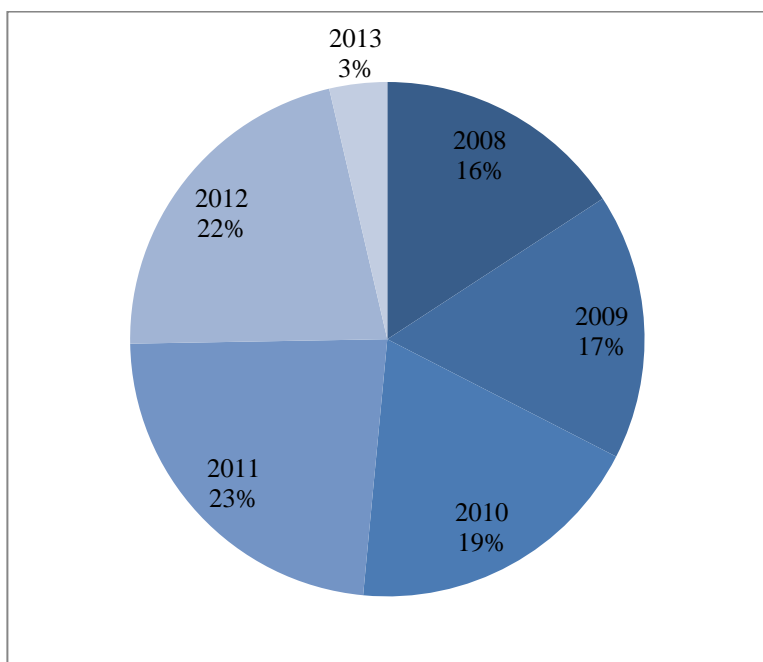


Figure 1: Samples by Year along the Pedernales River

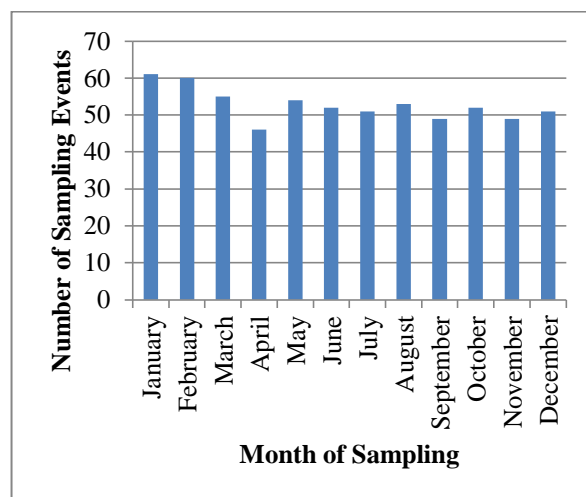


Figure 2: Breakdown of Sampling by Month for the Pedernales River Watershed

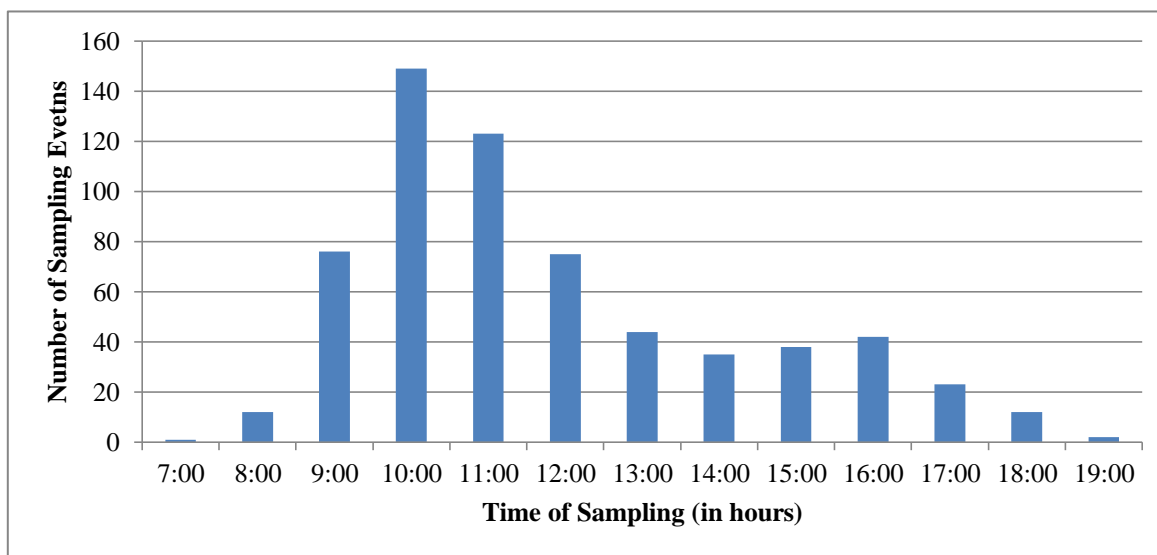


Figure 3: Breakdown of Time of Sampling on the Pedernales River

## Descriptive Parameters over time

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

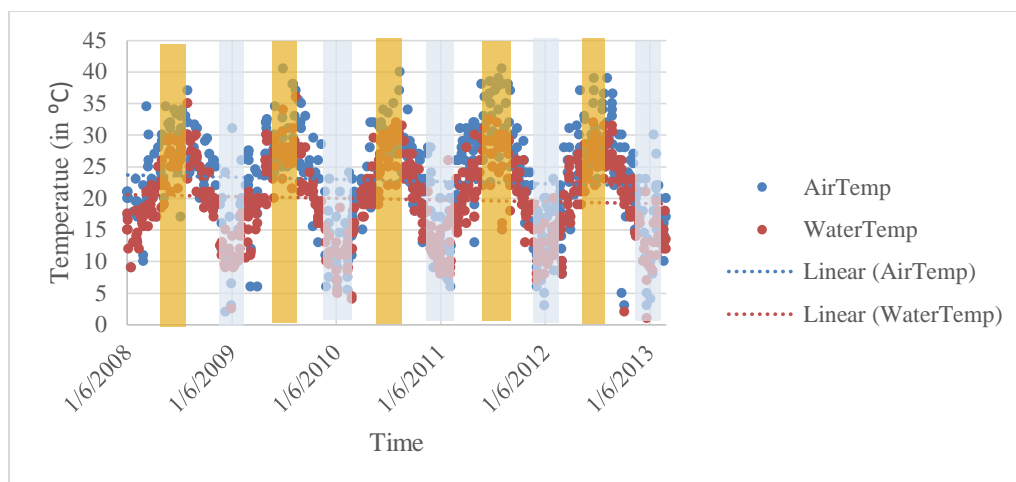
| <b>Pedernales River Watershed<br/>01/2008 to 03/2012</b> |                   |                                                     |            |            |
|----------------------------------------------------------|-------------------|-----------------------------------------------------|------------|------------|
| <b>Parameter</b>                                         | <b>% Complete</b> | <b>Mean <math>\pm</math> Standard<br/>Deviation</b> | <b>Max</b> | <b>Min</b> |
| Total Dissolved Solids (mg/L)                            | 96.5%             | 417.59 $\pm$ 98.3                                   | 936        | 175.5      |
| Water Temperature ( $^{\circ}$ C)                        | %                 | 19.83 $\pm$ 6.58                                    | 36         | 1          |
| Dissolved Oxygen (mg/L)                                  | 95%               | 7.12 $\pm$ 1.8                                      | 11.65      | 0.9        |
| pH                                                       | 94.94%            | 7.85 $\pm$ 0.48                                     | 9.7        | 6.5        |
| Transparency tube (m)                                    | 81.83%            | 0.89 $\pm$ 0.38                                     | 1.5        | 0.018      |
| Depth (m)                                                | 99.4%             | 1.7 $\pm$ 2.1                                       | 33         | 0          |
| <i>E. coli</i> Bacteria Geomean<br>(CFU/100 mL)          | 80.1%             | 19.13 $\pm$ 8.9                                     | 8000       | 1          |

\*There were a total of 633 sampling events from 01/2008 to 03/2013. Mean, calculated in Microsoft Excel, is listed for all parameters except *E. coli*, where a geomean was used.

## Trend Analysis over Time

### Air and water temperature

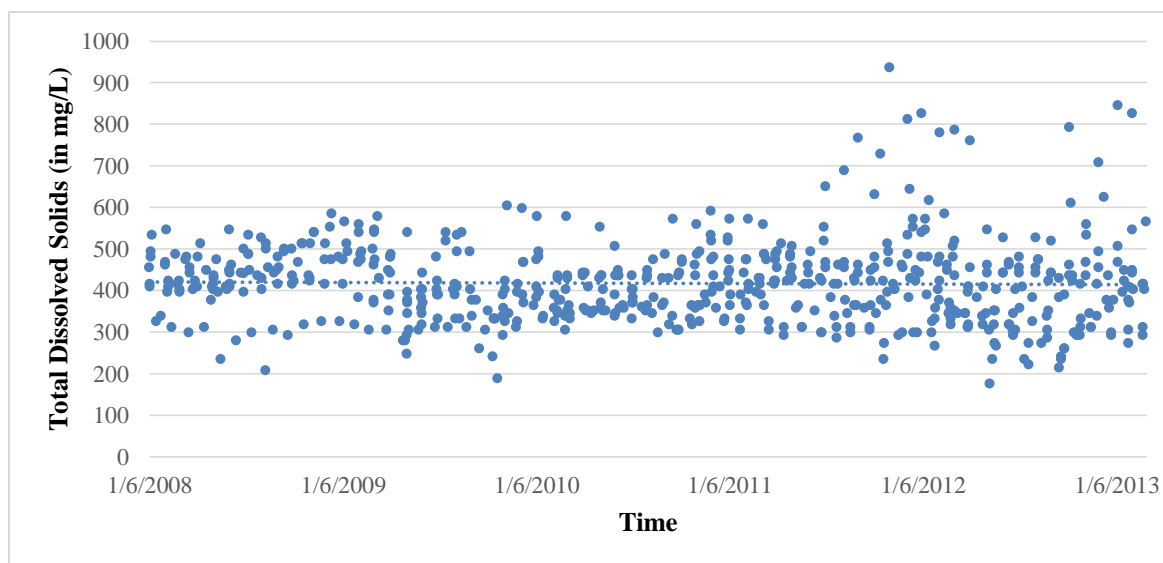
A total of 619 air temperature values and 614 water temperature values were collected within the Pedernales River Watershed from 2008 to 2013. Water temperature reached a high of 36 $^{\circ}$ C in August of 2009, at Site 80364, and had an average temperature of 19.8 $^{\circ}$ C. Air temperature reached a high of 40.5 $^{\circ}$ C in 07/2009 at Site 80310. Regression analysis ( $p=0.130$ ) shows that variation in water temperature was not significantly affected by time, with water temperature showing no statistically significant trends over time. However, the water temperature values were highly variable due to seasonal influences and did not fit to a basic linear model well ( $R^2=0.004$ ).



**Figure 4: Air and Water Temperature over time at all sites**

### Total Dissolved Solids

Citizen scientists collected 611 TDS measurements within the watershed. The TDS did not significantly correlate to time, indicated with a regression analysis p-value of 0.475. However, the TDS values were variable and did not fit a basic linear model well ( $R^2=0.001$ ). The average of TDS samples collected from 2008 to 2013 did not differ from the average of the samples collected from 1998 to 2007, which were only used as an historical average for comparison in this study.

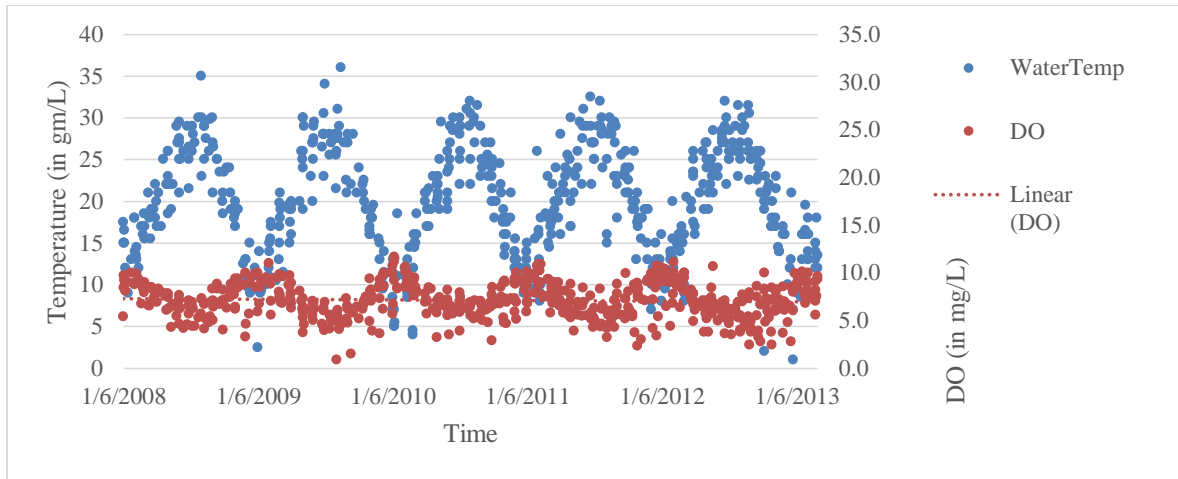


**Figure 5: Total Dissolved Solids at all sites from 01/2008 to 03/2013**

### Dissolved Oxygen

Citizen scientist monitors collected a total of 611 DO samples within the Pedernales River Watershed. The DO values were not related to time ( $p=0.223$ ), with DO showing no trend over time during this sampling period. However, DO values were highly variable due to seasonal influences and did not fit to a

basic linear model well ( $R^2=0.002$ ). Additionally, DO was affected by water temperature, season, and time of day that sampling occurred. The DO was also affected by water temperature, as shown in Figure 6. Cold water holds more oxygen than warm water; thus, DO was highest in the winter months. Additionally, plants and algae add a substantial amount of DO via photosynthesis, resulting in the pattern 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. The average of DO values collected from 2008 to 2013 did not differ from the average of the values collected from 1998 to 2007, which were only used as an historical average for comparison in this study.



**Figure 6: Water Temperature and Dissolved Oxygen at all sites from 01/2008 and 03/2013**

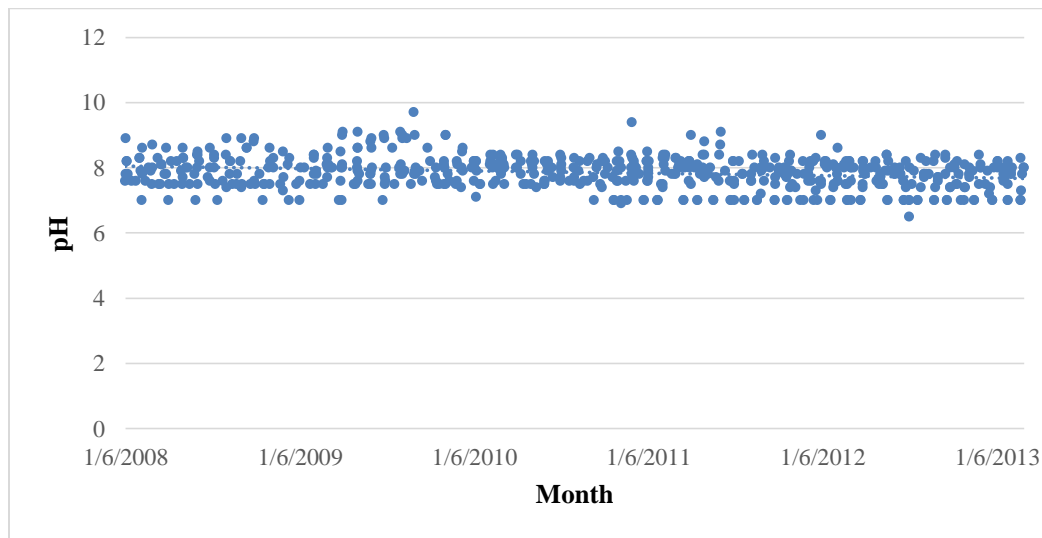
**Table 4: Average Dissolved Oxygen values by Sampling Time within the Pedernales River Watershed**

| Time        | Average Dissolved Oxygen (mg/L) | Standard Deviation |
|-------------|---------------------------------|--------------------|
| 7:00        | 5.9                             | 0.0                |
| 8:00        | 7.1                             | 1.41               |
| 9:00        | 7.3                             | 1.91               |
| 10:00       | 6.9                             | 1.8                |
| 11:00       | 7.3                             | 1.81               |
| 12:00       | 7.7                             | 1.46               |
| 13:00       | 7.4                             | 1.67               |
| 14:00       | 7.1                             | 1.94               |
| 15:00       | 6.4                             | 2.21               |
| 16:00       | 6.9                             | 1.92               |
| 17:00-22:00 | 6.7                             | 1.95               |

## pH

The pH mean was 7.85 and was sampled 601 times, with 5 individual values outside the optimal range for aquatic life pH (6.5 to 9). Regression analysis showed that time could be a statistically valid predictor of pH ( $p=0.000$ ;  $F=32.90$ ) within the watershed, with pH decreasing slightly over time; however, the low  $R^2$  value (0.052) suggests that a basic linear model is not a good fit for this relationship due to the high level of variability in the samples. The average of pH values collected from 2008 to 2013 did not differ from the

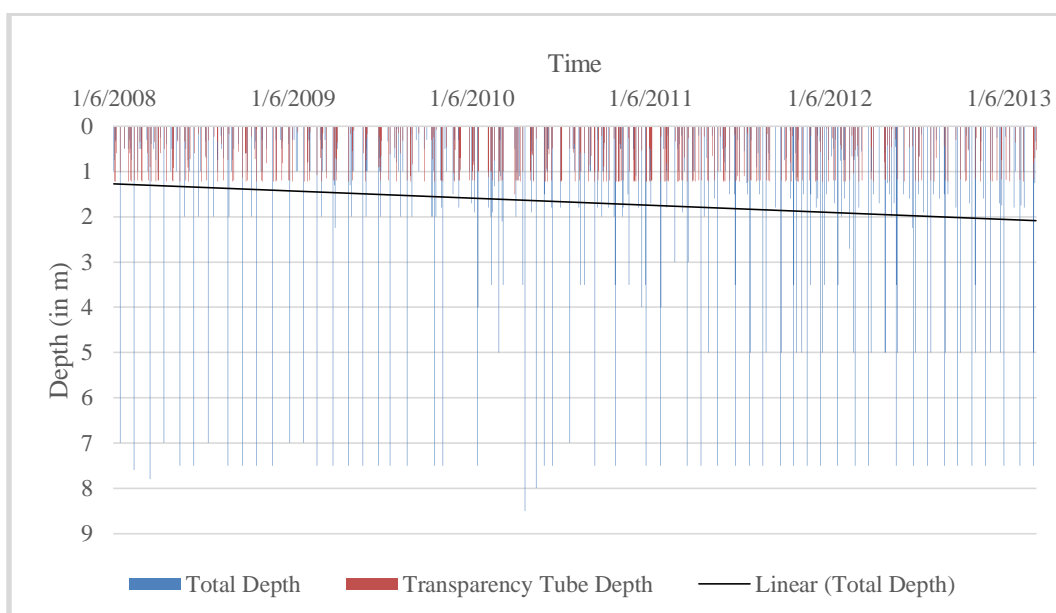
average of the values collected from 1998 to 2007, which were only used as an average for comparison in this study.



**Figure 7: pH at all sites from 01/2008 and 03/2013**

#### Transparency tube depth and total depth

Total depth was measured 629 times and transparency tube values were collected 518 times within the watershed during the sampling period. Transparency tube ( $p=0.238$ ) values were not affected by time, while total depth values ( $p=0.006$ ) were significantly affected by time. However, a low  $R^2$  ( $R^2 = 0.05$ ) values suggest a high degree of variability.



**Figure 8: Total depth and transparency tube depth at all sites from 01/2008 to 03/2013**

#### Field Observations

Field observations at all sites show that water clarity was clearer to more cloudy over time, while water surface observations were clearer over time. A majority of the sites over time were recorded as not having

algae, or having rare occurrences of algae (39% and 29% respectively), while 80% of the observers noted that the water surface was clear. Water clarity was noted to be clear during 84% of the sampling events, while water color was divided between clear (32%), light green (23%), and dark green (28%). Water was odorless during 95% of the field observations at all sites, while 62% of the observations noted that the water at all sites was calm. During the sampling events, the weather was clear 71% of the time and cloudy or clear during 29% of the sampling events.

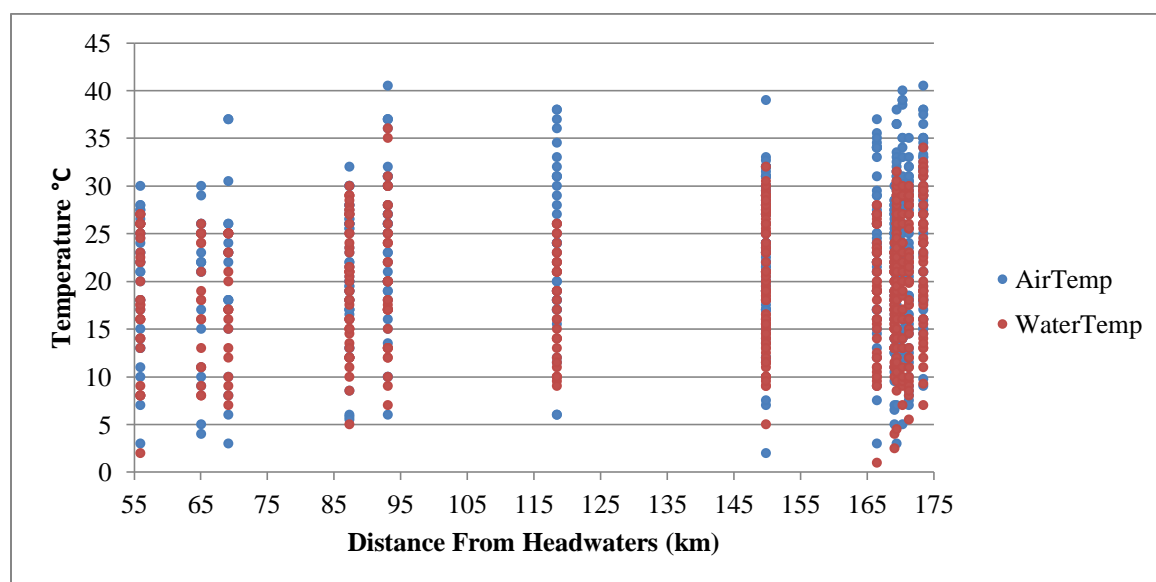
### ***E. coli* Bacteria**

Regression analysis ( $p = 0.234$ ) of volunteer data suggests no correlation between *E. coli* levels and time for the duration of this study. A total of 507 samples were collected.

## **Pedernales River Upstream and Downstream Trends**

### **Air and water temperature**

Water temperature was shown to have no significant correlation ( $p=0.096$ ) with distance along the Pedernales River in this study. Air temperature was not reviewed with a regression analysis. In Figure 9, below, air and water temperature are presented in an upstream to downstream visualization.



**Figure 9: Water and Air Temperature vs. Distance from Headwaters from 01/2008 to 03/2013**

### **Total Dissolved Solids**

The TDS concentration had a significant correlation ( $p=0.000$ ; F-value =285.30) with distance along the Pedernales River in this study, with TDS decreasing with distance from headwaters.

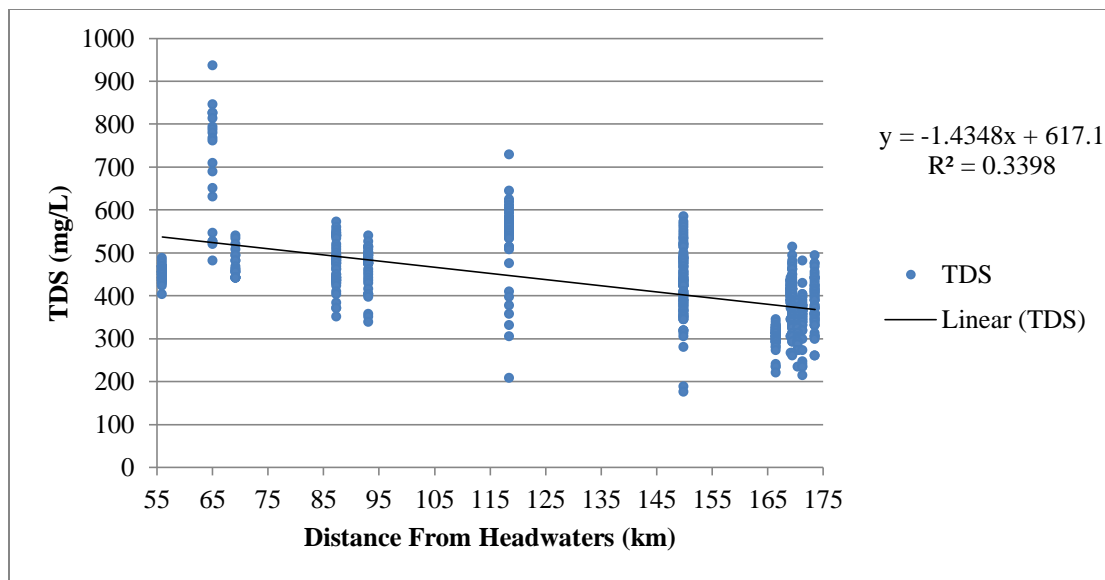
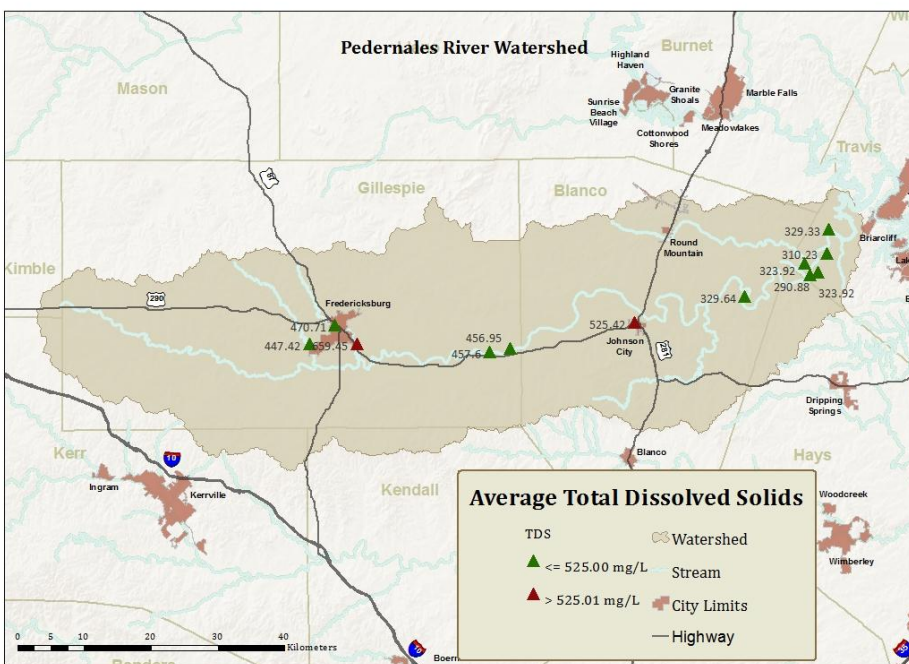


Figure 10: Total Dissolved Solids vs. Distance from Headwaters 12/2008 to 03/2013



Map 2: Average Total Dissolved Solids

### Dissolved Oxygen

Distance from headwaters was not a significant predictor ( $p=0.96$ ) of DO along the Pedernales River during this study.

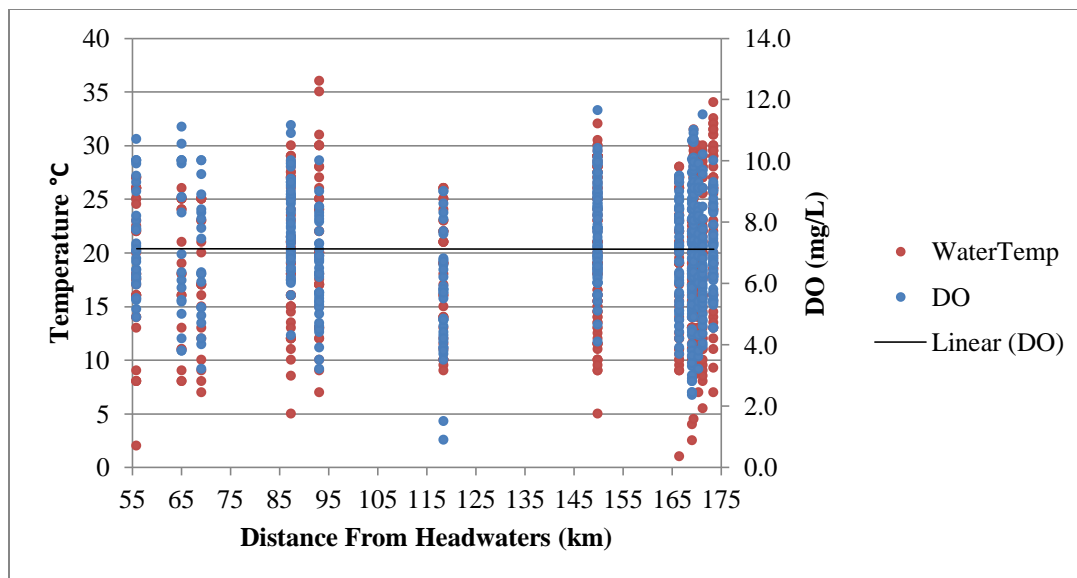
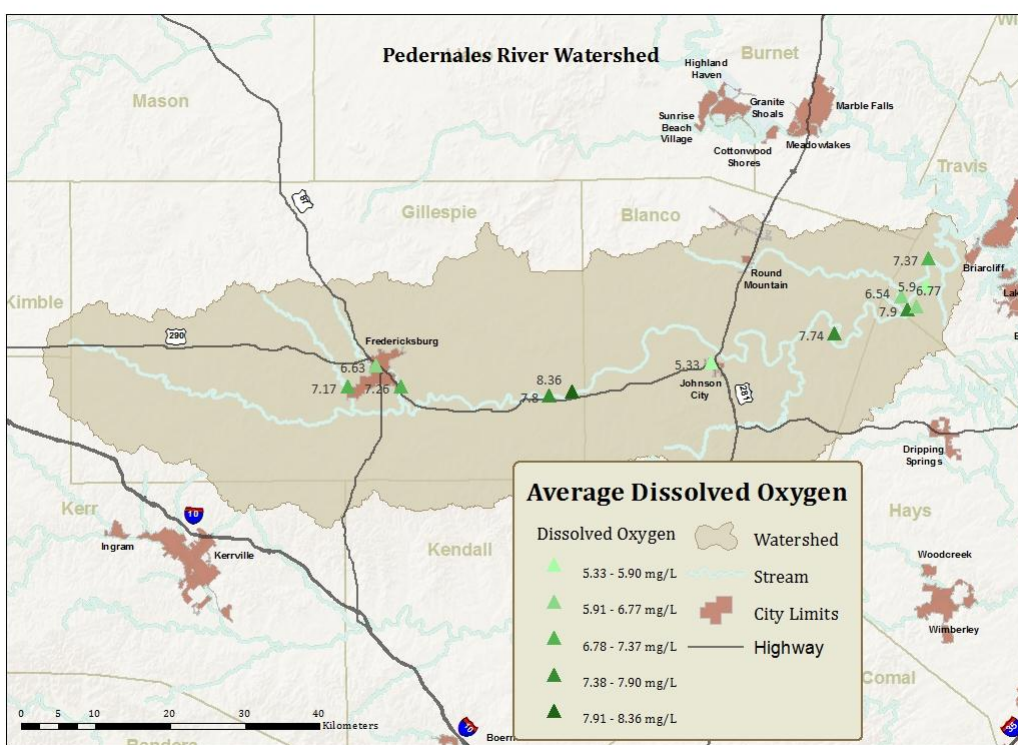


Figure 11: Dissolved Oxygen and Water Temperature vs. Distance from Headwaters from 01/2008 to 03/2013



Map 3: Average Dissolved Oxygen

## pH

Distance from headwaters was a significant predictor ( $p=0.000$ ;  $F=23.47$ ) of pH along the Pedernales River, with pH decreasing as distance from headwaters increased; however, a  $R^2$  value of 0.036 suggests that there are high levels of variability and that a basic linear model may not be the best model for the data.



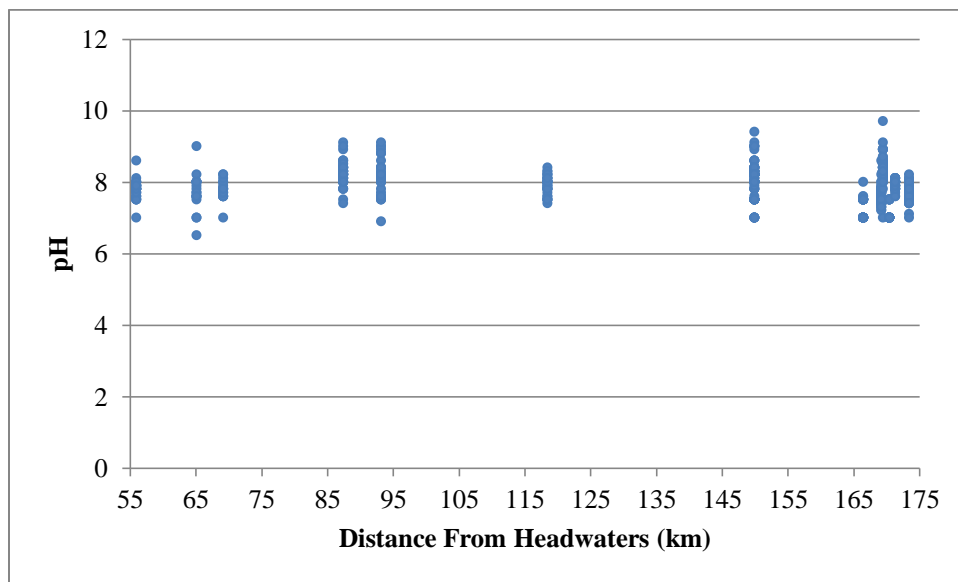
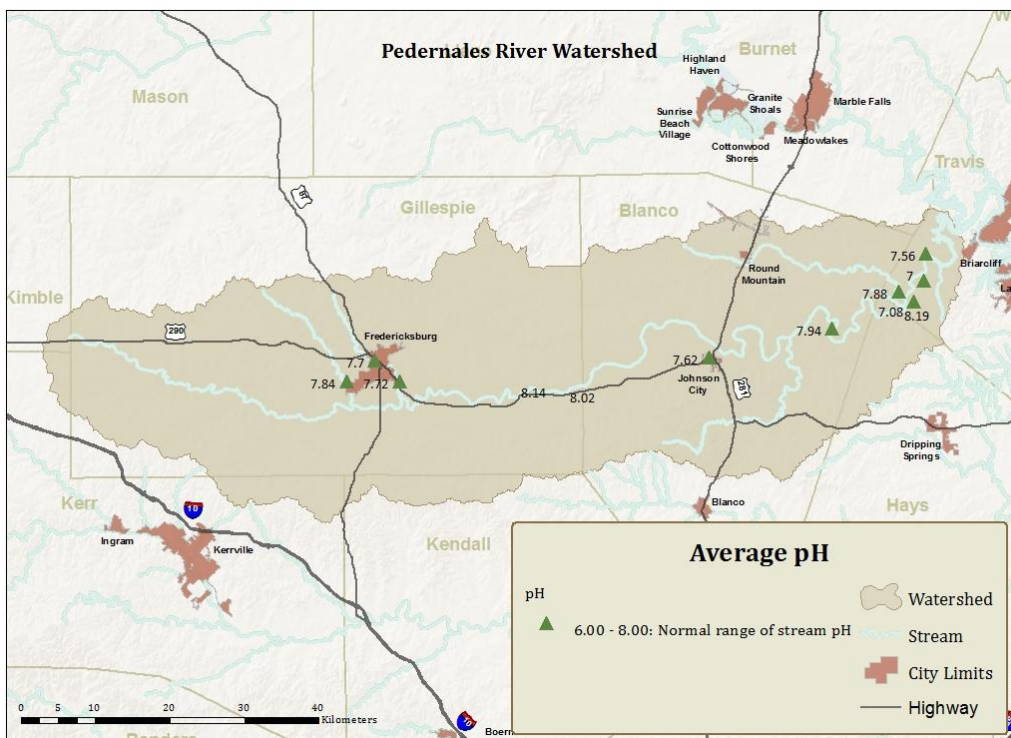


Figure 12: pH vs. Distance from Headwaters from 01/2008 to 03/2013



Map 4: Average pH

#### Transparency tube and total depth

Transparency tube values show a significant trend of decreasing visibility over distance from headwaters ( $p=0.05$ ), while total depth showed a significant trend of increasing depth over distance ( $p=0.005$ ).

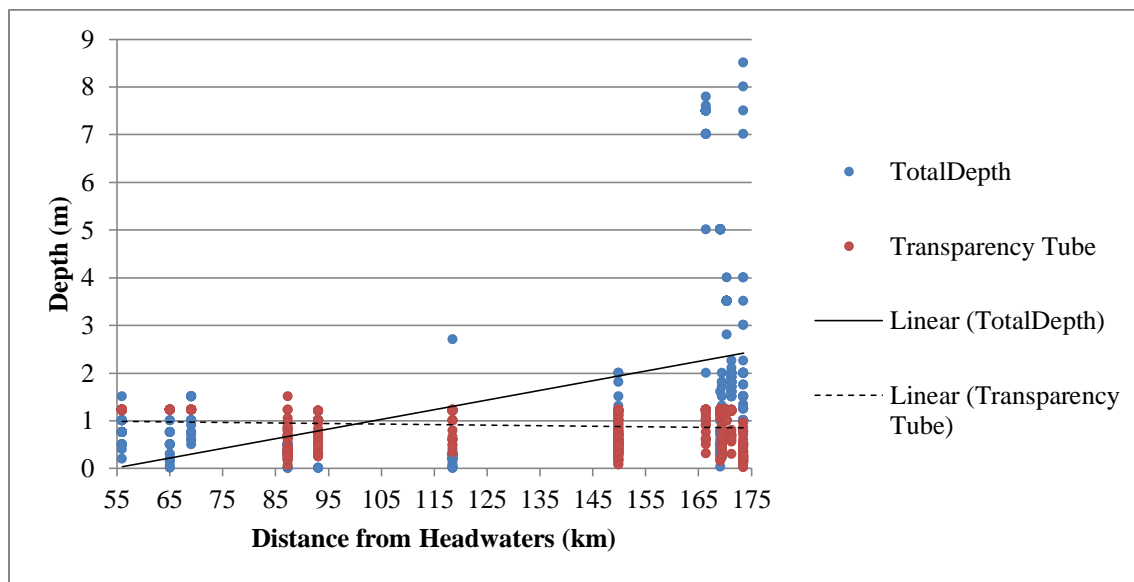


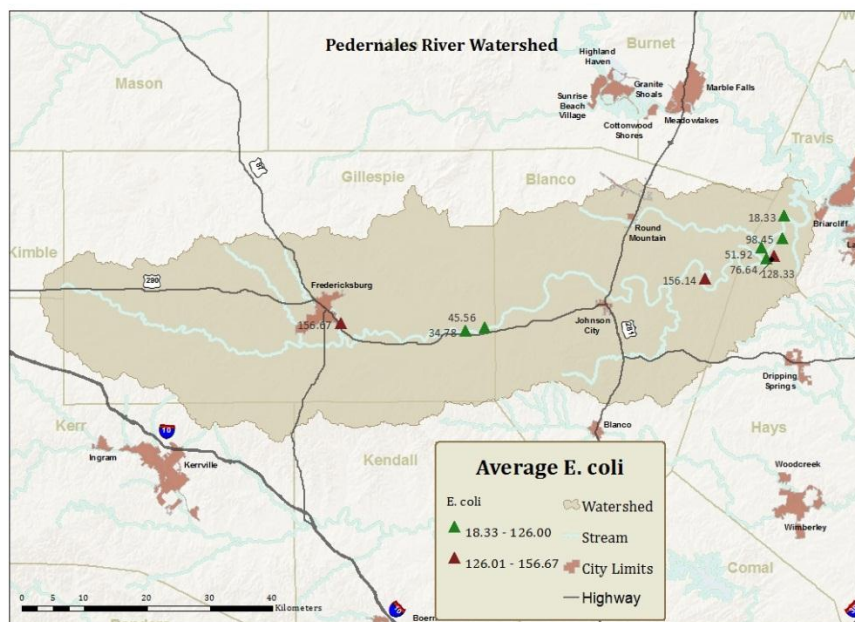
Figure 13: Total depth and transparency tube depth vs. Distance from Headwaters from 01/2008 to 03/2013

### Field Observations

Among the field observations, 'algae cover' and 'water color' both showed significant trends. More observances of algae cover were found in water farther from the headwaters.

### *E. coli* Bacteria

Regression analysis suggests decreasing trend regarding *E. coli* along the Pedernales River in this study; however, low  $R^2$  and low F-values suggest that this model cannot predict significance in the dataset due to high levels of variability in the results.



Map 5: Average *E. coli*

## Pedernales 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 7, 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 80937- Baron’s Creek at Highway 290 had the highest overall average for TDS, with a result of  $705.7 \pm 133.9$  mg/L. Site 80934- Hamilton Pool had the lowest average TDS, with a result of  $303.3 \pm 25.3$  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 80314- Town Creek at Johnson Settlement had the lowest average DO reading, with a result of  $5.56 \pm 1.91$  mg/L. Site 12369- Pedernales River at Hammett’s Crossing had the highest average DO reading, with a result of  $8.42 \pm 1.41$  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. Site 12369- Pedernales River at Hammett’s Crossing had the highest average pH level, with a result of  $8.36 \pm 0.36$ . Site 80936- Pogue Springs had the lowest average pH level, and was closest to neutral, with a result of  $7.09 \pm 0.20$ .

*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 80314- Town Creek at Johnson Settlement had the highest average geomean, with a result of 408.19 CFU/100mL. Site 80310- Pedernales River at Buffalo Crossing had the lowest average geomean, with a result of 3.45 CFU/100mL.

Please see Table 7, on the following page, 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 Pedernales Sites**

| Site Number | TDS (mg/L)           | DO (mg/L)          | pH                 | <i>E. coli</i> geomean (CFU/100mL) |
|-------------|----------------------|--------------------|--------------------|------------------------------------|
| 12369       | 386.43 ± 59.41       | 8.42 ± 1.41 (max.) | 8.36 ± 0.36 (max.) | 10.75                              |
| 12376       | 475.00 ± 550         | 8.09 ± 1.46        | 8.24 ± 0.44        | 11.29                              |
| 17335       | 403.50 ± 32.37       | 5.93 ± 2.04        | 7.61 ± 0.24        | 10.51                              |
| 80310       | 383.10 ± 53.7        | 7.12 ± 1.41        | 7.7 ± 0.23         | 3.45 (min.)                        |
| 80311       | 359.04 ± 105.11      | 7.5 ± 1.43         | 7.83 ± 0.43        | 12.13                              |
| 80364       | 464 ± 47.6           | 6.36 ± 1.53        | 8.18 ± 0.47        | 279.39                             |
| 17333       | 452.1 ± 17.7         | 7.37 ± 1.63        | 7.79 ± 0.26        | NA                                 |
| 15419       | 474.1 ± 53.9         | 7.96 ± 1.46        | 8.24 ± 0.32        | 10.64                              |
| 80314       | 525.95 ± 105.77      | 5.56 ± 1.91 (min.) | 7.9 ± 0.25         | 408.19 (max.)                      |
| 80312       | 472.88 ± 31.9        | 6.74 ± 2.08        | 7.77 ± 0.26        | NA                                 |
| 80934       | 303.3 ± 25.3 (min.)  | 6.93 ± 1.64        | 7.2 ± 0.27         | 81.53                              |
| 80935       | 348.46 ± 51.99       | 6.76 ± 1.68        | 7.93 ± 0.123       | 12.14                              |
| 80936       | 318.7 ± 33.70        | 6.58 ± 2.42        | 7.09 ± 0.20 (min.) | 32.96                              |
| 80937       | 705.7 ± 133.9 (max.) | 6.74 ± 2.08        | 7.77 ± 0.26        | NA                                 |

## Site 12369 – Pedernales River at Hammett’s Crossing

### Site Description

This site is located near where Hamilton Pool Rd/Hammett’s Crossing crosses over the Pedernales River. To the west side of the site are limestone cliffs dominated by oak and ashe juniper, with a small gravel and grass/sedge dominated bar, while the opposite bank is a large gravel and sand bar. This site features reserve/park land nearby or open farm/ranchland.

### Sampling Information

This is a currently active site sampled from 01/07/2008 to 02/25/2013 by LCRA CRWN monitors; Steven Hubbell, John Ahrns, David Bennett, and Michael Brewster. Sampling occurred, on average, 12 times a year, throughout the month and the day, although variation in date and time of sampling did occur. Since 01/2008, monitors spent a total of 78 hours and 57 minutes sampling and have traveled 88.75 miles for sample collection at this site, with an average of 76.41 minutes spent sampling and 0.43 miles spent travelling to collect samples.

**Table 6: Descriptive parameters for Site 12369 Pedernales River at Hammett's Crossing**

| Parameter                                    | % Complete | Mean $\pm$ Standard Deviation | Max    | Min    |
|----------------------------------------------|------------|-------------------------------|--------|--------|
| Total Dissolved Solids (mg/L)                | 100%       | 386.43 $\pm$ 59.41            | 513.50 | 260.00 |
| Water Temperature (°C)                       | 100%       | 20.68 $\pm$ 6.80              | 31.50  | 4.5    |
| Dissolved Oxygen (mg/L)                      | 98%        | 8.42 $\pm$ 1.41               | 11     | 4.9    |
| pH                                           | 98%        | 8.36 $\pm$ 0.36               | 9.7    | 7      |
| Transparency tube (m)                        | 100%       | 0.93 $\pm$ 0.34               | 1.22   | 0.25   |
| Depth (m)                                    | 100%       | 0.25 $\pm$ 0.08               | 0.5    | 0.02   |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 89%        | 10.75                         | 310    | 1      |

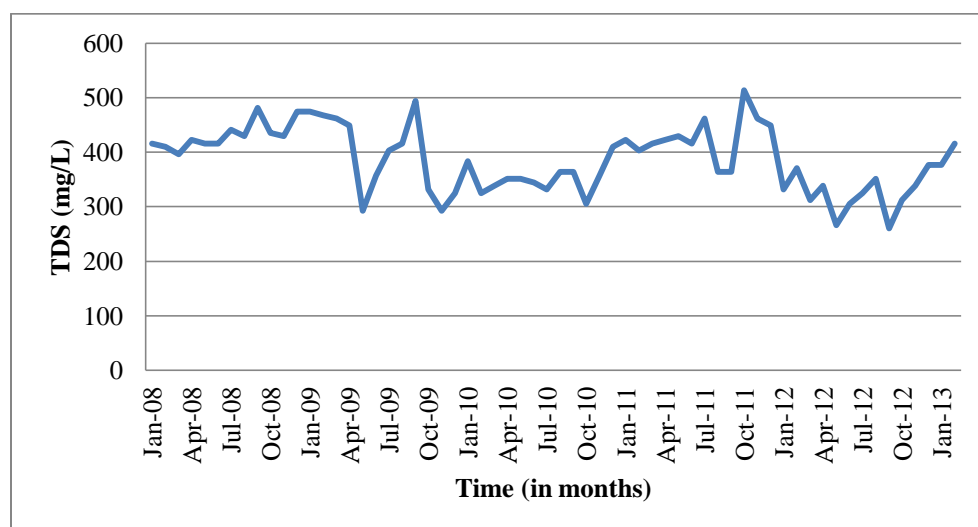
\*Site was sampled 62 times from 01/07/2008 to 02/25/2013.

### Air and water temperature

Water and air temperatures were sampled 62 times at Site 12369. Temperatures fluctuated in an expected seasonal pattern, with a maximum air temperature of 38°C in the summer of 2011, and maximum water temperatures of 30°C during the summers of 2008, 2010, and 2012. Water temperature was higher than air temperature on numerous occasions in January 2009, June 2009, December 2010, and December 2012.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 62 times and had a high of 513.5 mg/L in October 2011. The TDS readings were extremely variable at this sampling site but do show a slight, non-significant, downward trend over time.



**Figure 14: Total Dissolved Solids at Site 12369 from 01/2008 to 02/2013**

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no significant trend.

## pH

The pH values at Site 12369 showed no significant trend and remained high, near the average of 8.36.

## Transparency tube and total depth

Transparency tube readings were normally 1.2 m but were below 1 m between May 2009 and September 2010 and between January and September of 2012, showing that the water had variable levels of clarity. Total depth measures fluctuated from 2 m to 0.3 m, with a high level during the winter of 2009. No significant trends or patterns were noticed in either measurement.

## Field Observations

At Site 12369, field observations recorded during sampling events indicated that water was commonly clear (64%), but cloudy a remainder of the time; either light or dark green (34% each); and either calm or rippled (47% or 50% of the time, respectively). Water was primarily clear of debris, odorless, and algae were noted to be common at 23% of the sampling events but rare or absent at the rest. Weather was clear during 59% of the sampling events, raining during 7% of the sampling event, and cloudy or clear at the remainder of the sampling events.

## *E. coli*

The geomean for *E. coli* for this site was 10.75 CFU/100 mL. The highest *E. coli* count recorded for this site was 310 CFU/100 mL on 09/30/2012.

## Site 12376 – Pedernales River at LBJ National Historical Preserve (NHP), PR46

### Site Description

This site is located to the west of the Klein Rd. Bridge, just north of Highway 290 at the LBJ National Historic Preserve. This site features a limited riparian zone with trees around the site. The land at the site is limestone outcropping or gravel bars and the site is surrounded by open rangeland.

### Sampling Information

This is a currently active site sampled from 01/09/2008 to 03/03/2013 by LCRA CRWN members; Alison and Jay Bullington, Jeff Noftz, and Glen Clark. Sampling occurred, on average, 10 times a year, throughout the month and typically between the hours of 0900 and 1200 of the day, although variation in date and time of sampling did occur. Since 01/2008, monitors have spent a total of 66 hours and 31 minutes sampling and have traveled 146 miles to sample this site. There was an average of 72.6 minutes spent sampling and 2.65 miles spent travelling to collect samples.

**Table 7: Descriptive parameters for Site 12376 – Pedernales River at LBJ NHP**

| Parameter                                    | % Complete | Mean $\pm$ Standard Deviation | Max    | Min    |
|----------------------------------------------|------------|-------------------------------|--------|--------|
| Total Dissolved Solids (mg/L)                | 96%        | 475.0 $\pm$ 550               | 585.00 | 318.50 |
| Water Temperature (°C)                       | 98%        | 20.9 $\pm$ 6.70               | 32.0   | 5.00   |
| Dissolved Oxygen (mg/L)                      | 98%        | 8.09 $\pm$ 1.46               | 11.65  | 4.1    |
| pH                                           | 98%        | 8.24 $\pm$ 0.44               | 9.40   | 7.00   |
| Transparency tube(m)                         | 82%        | 0.65 $\pm$ 0.33               | 1.22   | 0.15   |
| Depth (m)                                    | 98%        | 0.43 $\pm$ 0.14               | 1.00   | 0.18   |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 94%        | 11.29                         | 100    | 0      |

\*Site was sampled 52 times from 01/09/2008 to 03/03/2013.

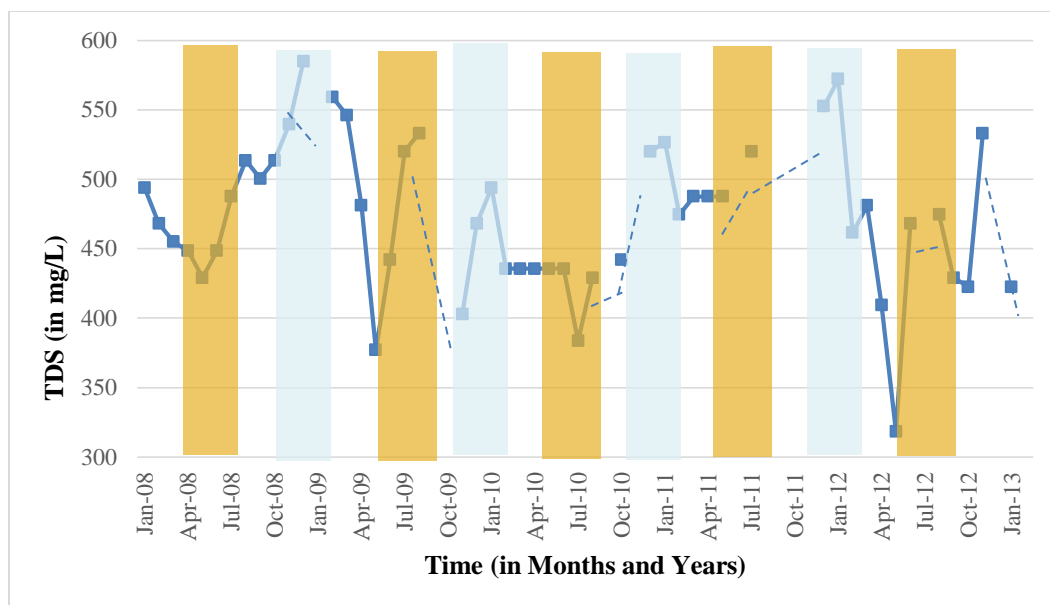
#### Air and water temperature

Water and air temperatures were sampled 51 times at Site 12376. Temperatures fluctuated in an expected seasonal pattern, with maximum air temperature of 39°C in August 2012 and a maximum water temperature of 30°C in August 2012. Water temperatures remained below air temperatures, except in two instances in the summers of 2008 and 2010. Water never reached temperatures above the Texas Surface Water Quality Standard of 32.2°C. Analyses over time showed that water temperature averages slightly decreased over time, but this trend does not appear to be significant.

#### Total Dissolved Solids

Citizen scientists sampled TDS at this site 50 times and noted an average of 475.02 mg/L. The TDS at this site was above 525 mg/L on 11 occasions (20% of the sampling events). The TDS readings showed a slight decrease over time; however the high level of variation in these results suggests that the trend is not statistically significant.





**Figure 15: Total Dissolved Solids at Site 12376 from 01/2008 to 02/2013**

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. The average DO reading at this site during the sampling period was 8.08 mg/L and never dropped below the 3.5 mg/L. Individual DO sampling event readings at this site showed a slight increase over time; however, due to the variability of the results, significance cannot be verified.

### pH

The pH values at Site 12346 had an average of 8.24 and showed a very slight decrease over time. While this pH is a bit high for Texas river water, it is not surprising given this Hill Country river originates from carbonate karst aquifers, which are more alkaline.

### Transparency tube depth and total depth

Transparency tube depth and total depth appeared to be inversely related over time, with transparency tube readings decreasing over time at the site, while total depth showed a slight increase. This suggests that as water depth increased from 2008 to 2013, the visibility decreased. This appears to support the finding that TDS increased over time and visibility decreased. Additionally, the field observations of citizen scientist monitors noted water color as primarily clear in 2008 and primarily green or tan in 2012-2013.



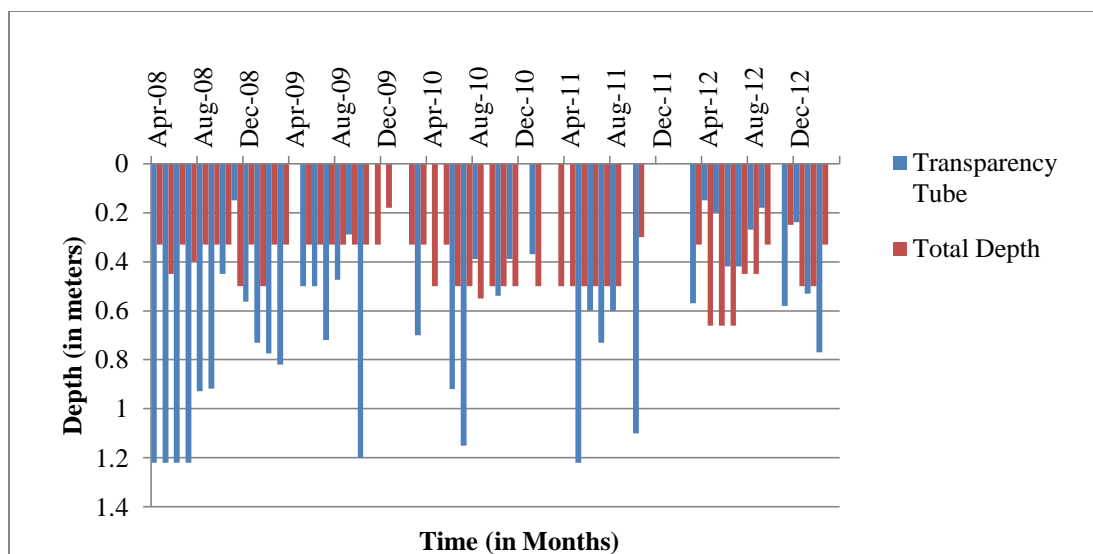


Figure 16: Transparency tube and total depth at Site 12376 from 01/2008 to 03/2013

### Field Observations

At Site 12376, field observations recorded during sampling events indicated that water had primarily clear (74%) conditions, while reading of light green, tan, or brown water color were noted 26% of the time. Water clarity was noted to be primarily clear and odorless with ripples (75% or higher). The presence of algae was found to be rare 54% of the time and common or abundant the rest of the time. Weather was noted to be either clear, cloudy, or overcast at the time of sampling (36%, 33% and 31%, respectively).

### *E. coli*

The geomean for *E. coli* for this site was 11.29 CFU/100 mL. The highest *E. coli* count recorded for this site was 100 CFU/100 mL on 08/11/2012.

## Site 17335 – Heinz Creek in the Westcave Preserve

### Site Description

This site is located east of Hamilton Pool Rd. near Westcave Preserve. This site is near two preserved natural areas (Hamilton Pool and Westcave Preserve), surrounded by rangeland, in addition to cedar and oak woodlands. The site is on a gravel/sand bar on the river, with thick riparian woodlands surrounding.

### Sampling Information

This is a currently active site sampled from 01/07/2008 to 02/26/2013 by LCRA CRWM monitors; John Ahrns, David Bennett, Steven Hubbell, and Michael Brewster. Sampling occurred, on average, 12 times a year, typically during the first 10 days of the month and in the morning from 01/2008-05/2011. Between 06/2011- 02/2013 sampling occurred more often in the last five days of the month and occurred throughout the day. Since January 2008, monitors have spent a total of 75 hours and 42 minutes sampling and have traveled 56.3 miles to sample this site. There was an average of 73.26 minutes spent sampling and 0.91 miles spent travelling to collect the samples. Sporadic sampling occurred at this site from 1998 to 2007 and an average of these sampling events is included in each parameter description for comparison.

**Table 8: Descriptive parameters for Site 17335 - Heinz Creek in the Westcave Preserve**

| Parameter                                   | % Complete | Mean $\pm$ Standard Deviation | Max   | Min   |
|---------------------------------------------|------------|-------------------------------|-------|-------|
| Total Dissolved Solids (mg/L)               | 100%       | 403.5 $\pm$ 32.37             | 442   | 266.5 |
| Water Temperature (°C)                      | 100%       | 17.33 $\pm$ 4.51              | 24    | 2.5   |
| Dissolved Oxygen (mg/L)                     | 100%       | 5.93 $\pm$ 2.04               | 10.65 | 2.35  |
| pH                                          | 98%        | 7.61 $\pm$ 0.24               | 8.6   | 7.2   |
| Transparency Tube (m)                       | 100%       | 1.17 $\pm$ 0.19               | 1.22  | 0.145 |
| Depth (m)                                   | 100%       | 2.12 $\pm$ 2.16               | 5     | 0.03  |
| <i>E coli</i> Bacteria Geomean (CFU/100 mL) | 92%        | 10.51                         | 8000  | 0     |

\*Site was sampled 62 times from 01/07/2008 to 02/26/2013.

### Air and water temperature

Water and air temperatures were sampled 62 and 60 times, respectively, at Site 17335. Temperatures fluctuated in an expected seasonal pattern, with maximum air temperature in August 2008 and a maximum water temperature in July 2011. Water temperature remained below air temperature, except during the coldest part of each year.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 62 times and had an average of 403.5 mg/L over time. Three low TDS readings ( $\leq 310$  mg/L) were noted in October 2009, March 2010, and January 2012. Beyond these three low readings, TDS readings varied little over time at this site and showed little difference when compared to the historic mean for this site.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings reached a high near 10 mg/L each winter and a low of 4 mg/L in the late summer/early fall. Over time, water temperature increased slightly, while DO readings decreased over time, as seen in Figure 17. While the average DO reading of the time period of 2008-2013 is lower than the historic average (6.53 mg/L), the difference is not statistically significant.

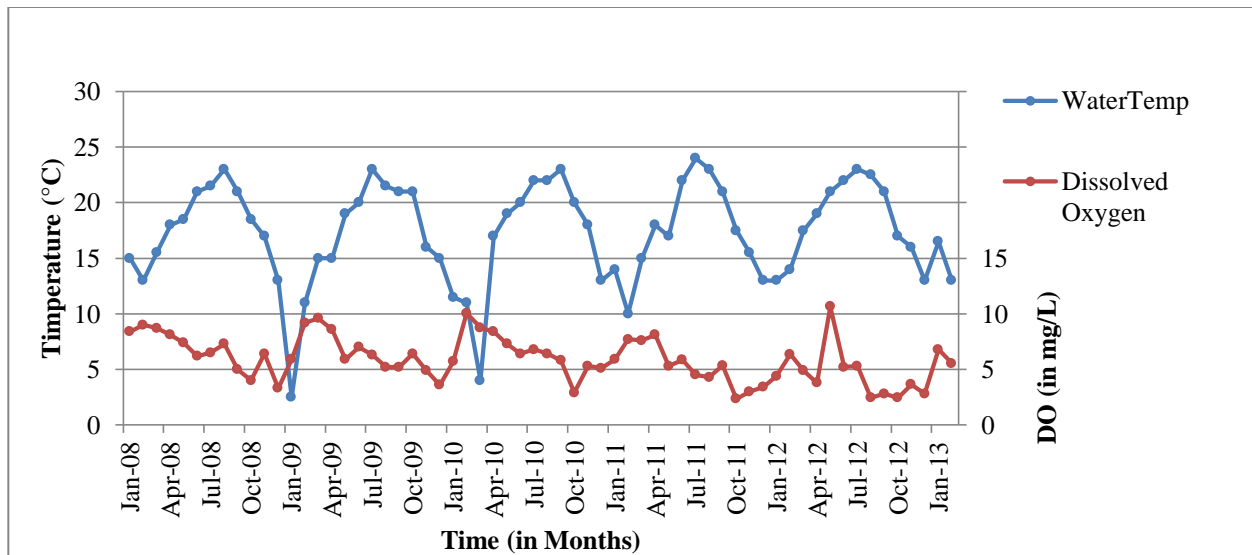


Figure 17: Dissolved Oxygen and Water Temperature at Site 17335 from 01/2008 to 02/2013

### pH

The pH readings at Site 17335 had an average of 7.6 and had little variation over the sampling period. The average pH reading for the time period 2008-2013 showed no statistically significant difference to the average of the historic data.

### Transparency tube and total depth

Transparency tube depth had an average of 1.17 m, near the maximum measureable limit of 1.2 m, and showed little variation over time. The average total depth over time period for the sampling events was 2.12 m and increased over the time period of the sampling. This suggests that, although depth is increasing at this site, water clarity is remaining constant over time.

### Field Observations

At Site 17335, field observations recorded during sampling events indicated that water was primarily calm, dark green in color, but clear in clarity and the site was clear of debris with no odor. At the site algae cover was reported as abundant to dominant. Weather was noted to be clear 56% and cloudy or overcast for the remainder of the sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 10.51 CFU/100 mL. The highest *E. coli* count recorded for this site was 8000 CFU/100 mL on 03/02/2010. This was the highest single sample count recorded in the watershed during the monitoring period.

## Site 80310 – Pedernales River at Buffalo Crossing

### Site Description

This site is located to the east of Pedernales Canyon Trail, where the Pedernales River starts to become Lake Travis. This site features open rangeland to the west and high end suburban areas to the east. The site is on a sand bar in a shallow area of the river with limited grass and reed dominated riparian zones.

### Sampling Information

This is a currently active site sampled from 01/28/2008 and 02/28/2013 by LCRA CRWN monitors; Gary Montgomery and Don Beal. Sampling occurred, on average, 11 times a year, on various days throughout the month and various times throughout the day. Sporadic sampling that occurred between August 2005 and December 2007, in addition to the average of these sampling events, is included as historic, comparison data. Since January 2008, monitors spent a total of 87 hours and 55 minutes sampling, with an average of 95.9 minutes spent sampling. Miles traveled during sampled was not recorded.

**Table 9: Descriptive parameters for Site 80310 - Pedernales River at Buffalo Crossing**

| Parameter                                   | % Complete | Mean $\pm$ Standard Deviation | Max  | Min  |
|---------------------------------------------|------------|-------------------------------|------|------|
| Total Dissolved Solids (mg/L)               | 90%        | 383.1 $\pm$ 53.7              | 494  | 260  |
| Water Temperature (°C)                      | 92%        | 22.84 $\pm$ 7.12              | 34   | 7    |
| Dissolved Oxygen (mg/L)                     | 90%        | 7.12 $\pm$ 1.41               | 10.7 | 4.55 |
| pH                                          | 92%        | 7.7 $\pm$ 0.23                | 8.2  | 7    |
| Transparency Tube (m)                       | 89%        | 0.34 $\pm$ 0.21               | 0.95 | 0.2  |
| Depth (m)                                   | 92%        | 1.98 $\pm$ 1.79               | 8.5  | 0.5  |
| <i>E coli</i> Bacteria Geomean (CFU/100 mL) | 90%        | 3.45                          | 140  | 0    |

\*Site was sampled 62 times from 01/28/2008 to 02/28/2013.

### Air and water temperature

Water and air temperatures were sampled 57 times at Site 80310. Air and water temperatures fluctuated in an expected seasonal pattern, with maximum air and water temperature in July 2009. Water temperature remained below air temperature. Water reached temperatures above the Texas Surface Water Quality Standard of 32.2°C only during July 2009. Water temperature does not appear to increase over the sampling period or over the historic mean of 22.1°C.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 56 times and found an average TDS of 383.1 mg/L. The TDS readings suggest a slight decrease over time; however, this decrease is not significant due to the high variability found in TDS readings. The variability of the TDS readings do not seem to follow a pattern and the average of the 2008-2013 TDS readings do not differ significantly from the historic 2005-2007 TDS average.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings suggest that DO increased slightly over time but the trend is not significant, and the 2008-2013 average does not significantly differ from the historic DO average. The highest DO reading during the sampling period is found in January 2008, but did not correspond with the coldest water temperature (January 2010).

### pH

The pH values at Site 80310 suggest a very slight decrease over time, but this trend is not significant due to the high level of variability and the limited decrease. The average pH value for the 2008-2013 is also

slightly lower than historic data for this site, but this difference is also not significant. No pattern is noticed in the variability of pH levels.

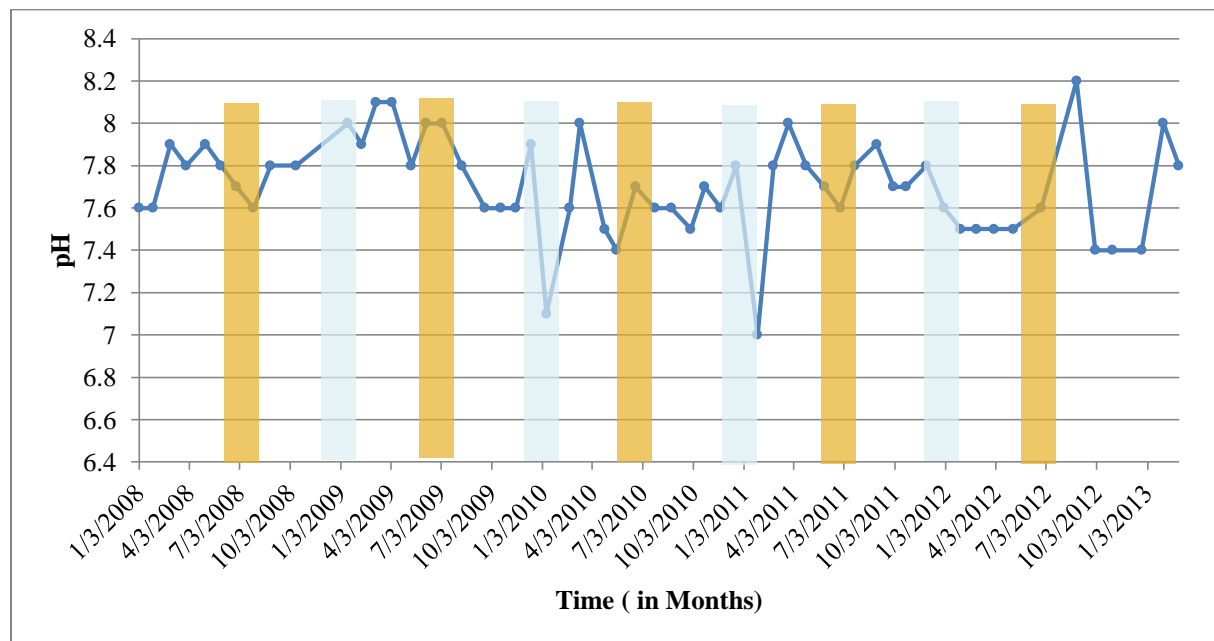


Figure 18: pH at Site 80310 from 01/2008 to 02/2013

#### Transparency tube and total depth

Transparency tube depth remained constant below 1 m, with an average of 0.33 m; while total depth varied from 0.5 m to 8.5 m, with an average depth over the course of the sampling period of 1.98 m. These results suggest that the water is turbid, and monitors noted in field observations that the water color was primarily light green.

#### Field Observations

At Site 80310, field observations recorded during sampling events indicated that water was primarily light green in color, in addition to being clear, odorless, and calm. The water surface was clear with little to no algae reported. Weather was noted to be clear during 73% of the sampling events, cloudy during 22% of the sampling events, and overcast the remainder of the time.

#### *E. coli*

The geomean for *E. coli* for this site was 3.45 CFU/100 mL. The highest *E. coli* count recorded for this site was 140 CFU/100 mL on 10/23/2011.

### Site 80311 – Pedernales River at Pedernales Falls State Park

#### Site Description

This site is located in Pedernales Falls State Park near the beach swimming area, downstream of the falls. This site is on a sand bar with limestone karst surrounding the site. A riparian area of trees and grasses are present around the site and the surrounding land is either parkland or open rangeland of ashe juniper and oak woodlands.

### Sampling Information

This is an inactive site sampled from 02/09/2008 to 07/07/2012 by LCRA CRWN monitors; Ann Clift, Brett Hulboy, and Lisa Benton. Sampling occurred, on average, 11 times a year, typically during the first part of the month and between the hours of 0900 and 1200, although variation in date and time of sampling did occur. For the entire monitoring period, monitors spent a total of 245 hours sampling and traveled 3120 miles to collect samples for this site, with an average of 282.70 minutes spent sampling and an average of 60 miles spent travelling to collect samples.

**Table 10: Descriptive parameters for Site 80311 - Pedernales River at Pedernales Falls State Park**

| Parameter                                    | % Complete | Mean $\pm$ Standard Deviation | Max   | Min  |
|----------------------------------------------|------------|-------------------------------|-------|------|
| Total Dissolved Solids (mg/L)                | 100%       | 359.04 $\pm$ 105.11           | 487.5 | 0    |
| Water Temperature (°C)                       | 95%        | 20.68 $\pm$ 6.53              | 30.5  | 9.5  |
| Dissolved Oxygen (mg/L)                      | 95%        | 7.5 $\pm$ 1.43                | 10.4  | 4.65 |
| pH                                           | 80%        | 7.83 $\pm$ 0.43               | 8.4   | 7    |
| Transparency Tube (m)                        | 95%        | 1.00 $\pm$ 0.32               | 1.2   | 0.7  |
| Depth (m)                                    | 95%        | 0.81 $\pm$ 0.42               | 2     | 0.3  |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 76%        | 12.13                         | 1030  | 0    |

\*Site was sampled 55 times from 02/09/2008 to 07/07/2012.

### Air and water temperature

Water and air temperatures were sampled 52 times at Site 80311. Temperatures fluctuated in an expected seasonal pattern, with maximum air and water temperatures in July 2009. Water temperature remained below air temperature, except for one exception in January 2009.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 55 times and noted an average of 379.75 mg/L. During the sampling period, TDS decreased slightly, as seen in Figure 19; however, this decrease is not statistically significant. Additionally, the TDS average for the sampling period shows no statistically significant change from the historic average.

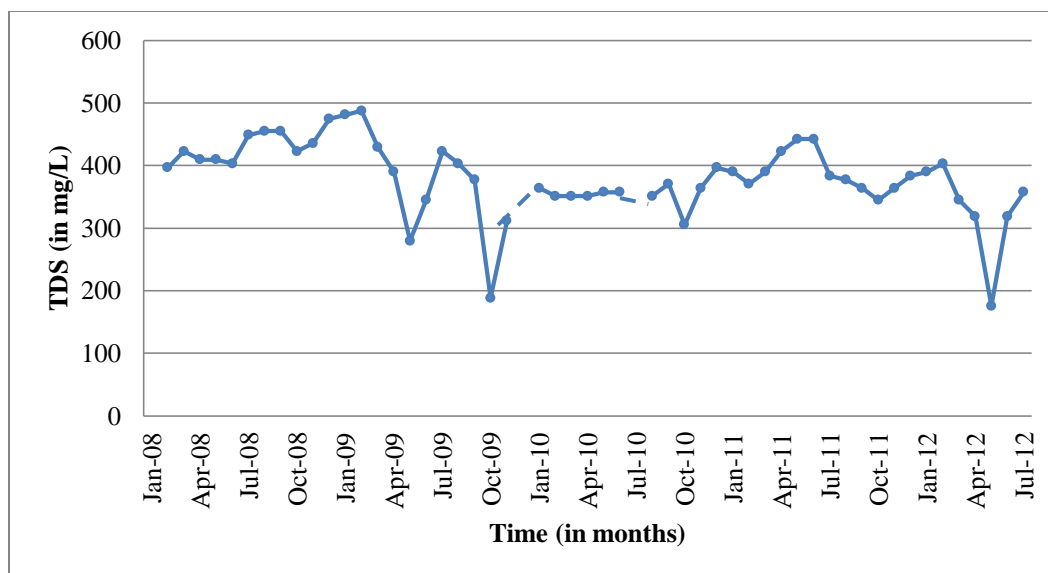


Figure 19: Total Dissolved Solids at Site 80311 from 02/2008 to 07/2012

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Beyond this seasonal variation, no significant trend is present in the results. The average DO was 7.52 mg/L. There is also no statistically significant difference between the sampling period and the historical DO average readings.

### pH

The pH values at Site 80311 increase over time with surprisingly little variation ( $R^2=0.51$ , not significant but still high for this type of result). As with other sites on this river, pH at Site 80311 is slightly alkaline, most likely from contact with limestone and karst features.

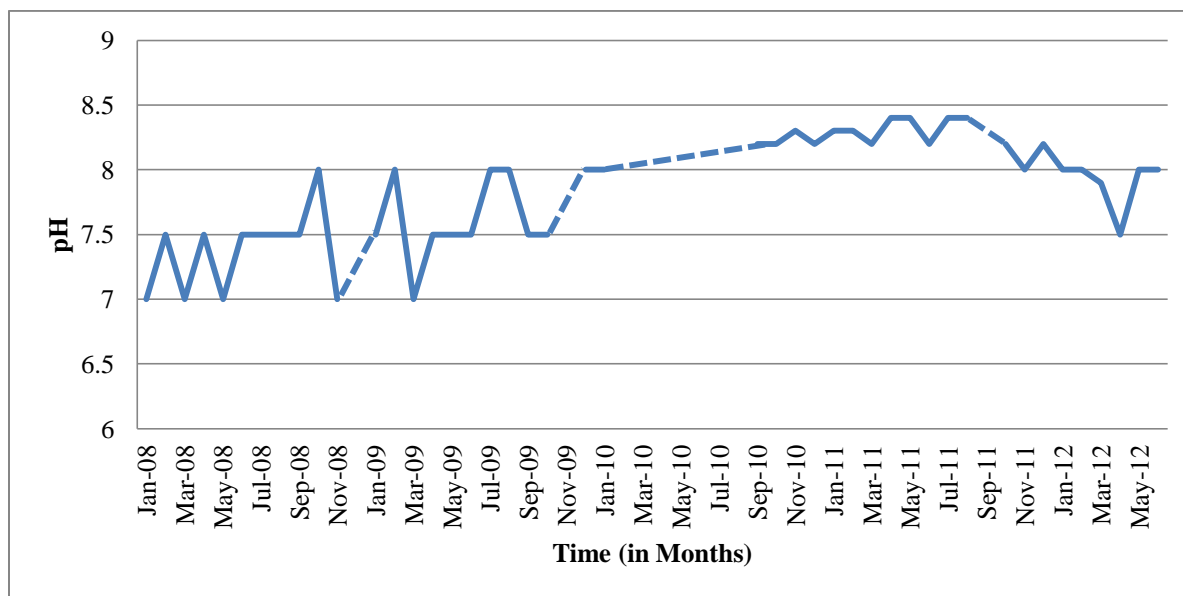


Figure 20: pH at Site 80311 from 02/2008 to 07/2012

### Transparency tube and total depth

Transparency tube depth and total depth both demonstrated no statistically significant trend over time for the sampling events. The water held a relatively constant level of clarity and depth over time. Results suggest that the water at this site had high clarity for the duration of the sampling period.

### Field Observations

At Site 80311, field observations recorded during sampling events indicated that water was primarily light green in color, clear with a clean surface, and no algae was reported to be present. The water was also reported as odorless and was either calm or had ripples. Weather was noted to be clear 60% of the time and either cloudy or overcast during the remainder of the sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 12.13 CFU/100 mL. The highest *E. coli* count recorded for this site was 1030 CFU/100 mL on 05/12/2012.

## Site 80364 – Williams Creek at the Pedernales River

### Site Description

This site is located at the confluence of Williams Creek and the Pedernales River, north of the town of Hye, on Highway 290. This site features open rangeland and some farmland. The site is located in an area of the river with large limestone outcroppings and a treed riparian zone to the south of the river.

### Sampling Information

This is an inactive site sampled from 01/06/2008 to 09/15/2011 by LCRA CRWN monitor Terry Young. Sampling occurred, on average, 12 times a year, typically during the first half of the month and between 0900 and 1200 during the day, although variation in date and time of sampling did occur. Since January 2008, a total of 63 hours and 1 minute were spent sampling and 352 miles were travelled while collecting samples at this site. There was an average of 84.02 minutes spent sampling and an average of 7.82 miles spent travelling to collect samples.

**Table 11: Descriptive parameters for Site 80364 – Williams Creek at the Pedernales River**

| Parameter                                    | % Complete | Mean ± Standard Deviation | Max     | Min  |
|----------------------------------------------|------------|---------------------------|---------|------|
| Total Dissolved Solids (mg/L)                | 98%        | 464 ± 47.6                | 539.5   | 338  |
| Water Temperature (°C)                       | 91%        | 20.67 ± 7.11              | 36      | 7    |
| Dissolved Oxygen (mg/L)                      | 91%        | 6.36 ± 1.53               | 10      | 2    |
| pH                                           | 89%        | 8.18 ± 0.47               | 9.1     | 6.9  |
| Transparency Tube (m)                        | 69%        | 0.76 ± 0.33               | 1.2     | 0.24 |
| Depth (m)                                    | 100%       | 0.85 ± 0.34               | 1       | 0    |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 91%        | 279.39                    | 4145.85 | 43.3 |

\*Site was sampled 45 times from 01/06/2008 to 09/15/2011.



### Air and water temperature

Water and air temperatures were sampled 41 times at Site 80364. Temperatures fluctuated in an expected seasonal pattern, with maximum air and water temperatures recorded in August 2011. Water temperature remained below air temperature, except once in December 2009. Water reached a high temperature of 36°C in August 2009, which was above the Texas Surface Water Quality Standard of 32.2°C. Air temperature appears to have a slight increasing trend over time at this site but this trend is not significant.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 41 times and noted 22 sampling event that recorded values above the suggested 525 mg/L. There were no statistically significant trends noted in TDS over time at this site.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no significant trends and, beyond seasonal variation, remained relatively constant over time at this site.

### pH

The pH values at Site 80364 showed a very slight increasing trend over time, but the trend was not statistically significant. The pH was high at this site, with an average of 8.18, which is likely the result of the large amount of limestone before and around the site.

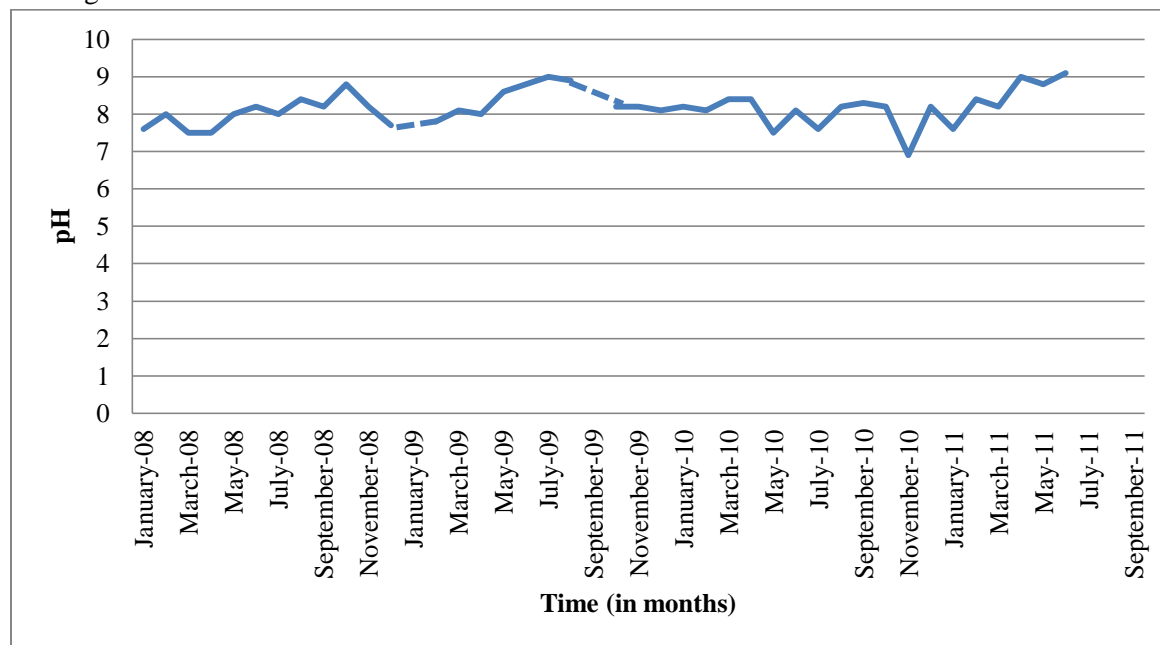


Figure 21: pH at Site 80364 from 01/2008 to 09/2011

### Transparency tube and total depth

Transparency tube depth had an average of 0.76 m, but a trend was impossible to determine due to a lack of consistent data reporting. Total depth had an average of 0.84 m, but during the summer of 2011 decreased to zero as the river dried up at the site.

### Field Observations

At Site 80364, field observations recorded during sampling events indicated that water primarily clear, odor and could be either calm or rippled (40% and 57%, respectively), with a surface that was either clear or covered in foam (40% and 50%, respectively). The site rarely had algae cover, but the presence of algae was present during 23% of the sampling events. Weather was noted to be clear during 53% of the sampling events, cloudy during 37% of the sampling events, and overcast during the remainder of the sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 279.39 CFU/100 mL. The highest *E. coli* count recorded for this site was 4145.85 CFU/100 mL on 10/06/2009.

## Site 17333 – Live Oak Creek Upstream of SH16 SW

### Site Description

This site is located on Live Oak Creek, north of SH 16 in Fredericksburg and downstream of the Lady Bird Johnson Municipal Park. This site is surrounded by open rangeland to the west and a city and airport to the north and east. Site 17333 has a riparian zone of ashe juniper and grasses, and is near a shallow gravelly area of the creek.

### Sampling Information

This is a currently active site sampled from 06/09/2010 to 02/05/2013 by LCRA CRWN monitors. Sampling occurred, on average, 12 times a year, typically during the first part of the month and late morning time of the day, although variation in date and time of sampling did occur. Since June 2010, monitors spent a total of 66 hours and 0 minutes sampling and traveled 2,010 miles to collect samples for this site. There was an average of 120 minutes spent sampling and 60.9 miles spent travelling to collect samples.

**Table 12: Descriptive parameters for Site 17333 – Live Oak Creek Upstream of SH16 SW**

| Parameter                            | % Complete | Mean $\pm$ Standard Deviation | Max   | Min |
|--------------------------------------|------------|-------------------------------|-------|-----|
| Total Dissolved Solids (mg/L)        | 100%       | 452.1 $\pm$ 17.7              | 487.5 | 403 |
| Water Temperature (°C)               | 100%       | 18.9 $\pm$ 6.78               | 27    | 2   |
| Dissolved Oxygen (mg/L)              | 100%       | 7.37 $\pm$ 1.63               | 10.7  | 4.9 |
| pH                                   | 100%       | 7.79 $\pm$ 0.26               | 8.6   | 7   |
| Transparency Tube (m)                | 100%       | 1.2 $\pm$ 0.003               | 1.2   | 1.2 |
| Depth (m)                            | 100%       | 0.76 $\pm$ 0.245              | 1.5   | 0.2 |
| <i>E. coli</i> Bacteria (CFU/100 mL) | 0%         | NA                            | NA    | NA  |

\*Site was sampled 33 times from 06/09/2010 to 02/05/2013.

### Air and water temperature

Water and air temperatures were sampled 33 times at Site 17333. Temperatures fluctuated in an expected seasonal pattern, with maximum temperatures in the summer of 2011. Water temperature remained below air temperature, except on one sampling event in February 2009. Water never reached temperatures above

the Texas Surface Water Quality Standard of 32.2°C and mirrored air temperatures constantly. Both show a slight possible trend downward over time, but this trend was not statistically significant.



Figure 22: Air and Water Temperature at Site 17333 from 06/2010 to 02/2013

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 33 times and the results show very little variation over time.

### Dissolved Oxygen

Dissolved oxygen followed a seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings remained above 5 mg/L and did not show any statistically significant trends. The DO average for this site did not differ significantly from the historic average, which was collected sporadically from 2001-2005.

### pH

The pH values at Site 17333 show a relatively constant average of 7.79 and did not differ significantly from the historic average.

### Transparency tube and total depth

While total depth fluctuated between a low of 0.2 m, to a high of 1.5 m for the sampling events; transparency tube readings remained constant at 1.2 m. This suggests that the water had a high level constant of clarity, which is supported by the field observations.

### Field Observations

At Site 17333, field observations recorded during sampling events indicated that water was primarily colorless, calm, clear, odorless, and had a clear surface, which was rarely reported to have algae. Weather

was noted to be clear during 61% of the sampling events, cloudy during 24% of the sampling events, and overcast during the remainder of the sampling events.

## Site 15419 – Pedernales River at LBJ NHP Hodges Dam

### Site Description

This site is located just east of LBJ National Historic Park on the small cove on the south side of the river. This site features a riparian zone with tree and a RV park nearby. The surrounding area is either open rangeland or parks on the outside of the city.

### Sampling Information

This is a currently active site sampled from 01/09/2008 to 03/03/2013 by LCRA CRWN monitors; Alison and Jay Bullington, and Jeff Noftz. Sampling occurred, on average, 10 times a year, throughout the month and between the hours of 0900 and 1300, although variation in date and time of sampling did occur. Since January 2008, monitors have spent a total of 68 hours and 1 minute sampling and have traveled 287 miles to collect samples at this site. There was an average of 75.57 minutes spent sampling and an average of 5.31 miles spent travelling to collect samples.

**Table 13: Descriptive parameters for Site 15419 – Pedernales River at LBJ NHP Hodges Dam**

| Parameter                                    | % Complete | Mean $\pm$ Standard Deviation | Max   | Min |
|----------------------------------------------|------------|-------------------------------|-------|-----|
| Total Dissolved Solids (mg/L)                | 78%        | 474.1 $\pm$ 53.9              | 572   | 351 |
| Water Temperature (°C)                       | 78%        | 19.93 $\pm$ 6.42              | 30    | 5   |
| Dissolved Oxygen (mg/L)                      | 78%        | 7.96 $\pm$ 1.46               | 11.15 | 4.3 |
| pH                                           | 76%        | 8.24 $\pm$ 0.32               | 9.1   | 7.4 |
| Transparency Tube (m)                        | 68%        | 0.53 $\pm$ 0.33               | 1.5   | 0.6 |
| Depth (m)                                    | 78%        | 0.40 $\pm$ 0.16               | 0.66  | 0   |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 67%        | 10.64                         | 80    | 1   |

\*Site was sampled 63 times from 01/09/2008 to 03/03/2013.

### Air and water temperature

Water and air temperatures were sampled 50 times at Site 15419. Temperatures fluctuated in an expected seasonal pattern, with a maximum air temperature of 32°C found in July 2012 and a maximum water temperature of 30°C found in May 2009. Water temperatures remained below air temperatures, except on the following occasions: April 2009, Feb 2010, Jan 2011, March 2012, and October 2012.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 49 times and the results did not show a significant trend over time. While TDS values remained close to the average of 474.1 mg/L, high readings (greater than 550 mg/L) were noted in the winters of 2011 and 2012.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no statistically significant trend over time at this site.

### pH

The pH values at Site 15419 remained constant near the average of 8.24 over time. The pH went above the recommended alkalinity for Texas streams on two different occasions; April and November of 2011.

### Transparency tube and total depth

Total depth remained constant around 0.63 m; although in September of 2009 and 2011, total depth dropped to zero for the sampling event. Transparency tube readings were variable throughout the sampling period, with highs of 1.2 m and lows of 0.06 m, suggesting that water clarity at this site was highly variable. No pattern was found to explain the variability of water clarity.

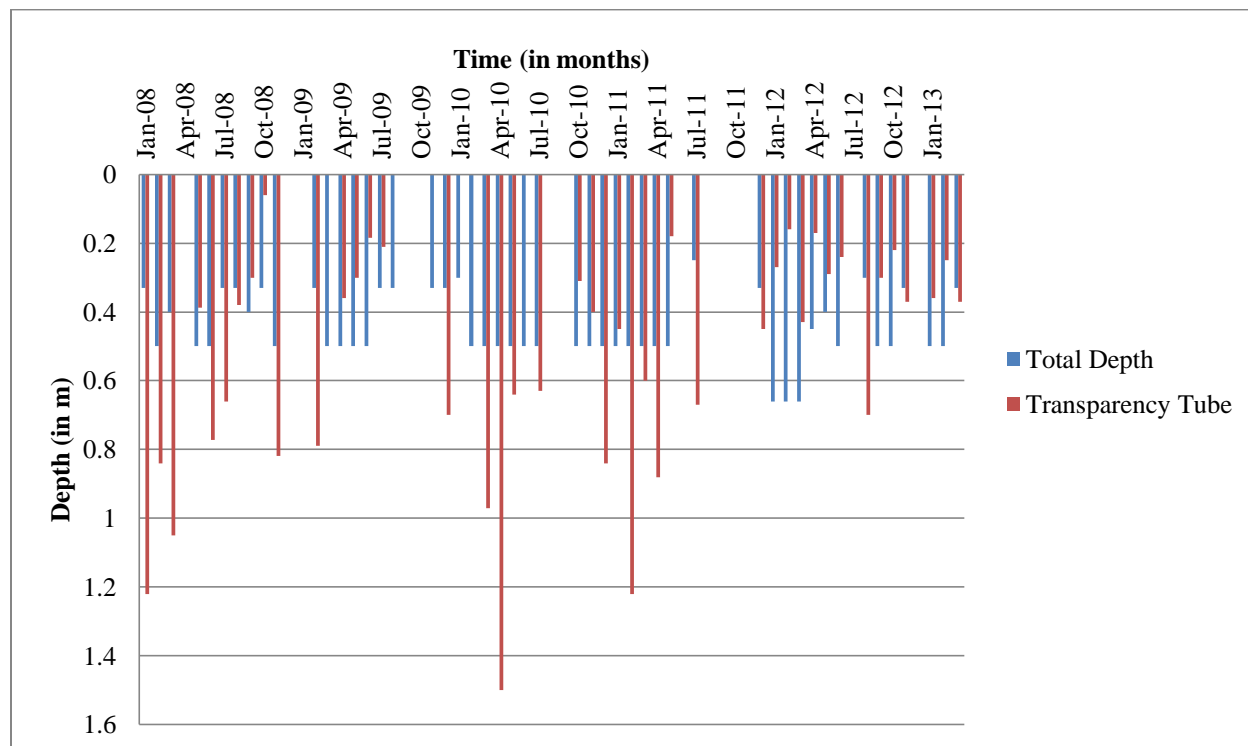


Figure 23: Total depth and transparency tube depth at Site 15419 from 01/2008 to 01/2013

### Field Observations

At Site 15419, field observations recorded during sampling events indicated that water was primarily clear, free of surface debris, odorless, and had ripples. The presence of algae was found to be present at the site during 15% of the sampling events and rare or absent during the rest of the sampling events. Water was reported to be colorless 57% of the time, but green or tan in the color during the rest of the sampling events. Weather was noted to be either clear, cloudy, or overcast (37%, 37% and 26%, respectively) of time during sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 10.64 CFU/100 mL. The highest *E. coli* count recorded for this site was 80 CFU/100 mL on 11/12/2008, 02/21/2012, and 04/01/2012.

## Site 80314 – Town Creek at Johnson Settlement

### Site Description

This site is located at the culvert on W. Main Street in Johnson City, as it passes over Town Creek. This site features several trees around the creek and is surrounded by urban and commercial zones.

### Sampling Information

This is a currently an inactive site sampled from 01/11/2008 to 12/20/2012 by LCRA CRWN monitor, Heidi Sosinski. Sampling occurred, on average, 7.6 times a year, typically during the early to middle part of the month and afternoon part of the day, although variation in date and time of sampling did occur. Since January 2008, monitors have spent a total of 27 hours and 45 minutes sampling and have traveled 4 miles to collect samples at this site, with an average of 41.63 minutes spent sampling and an average of 0.1 miles spent travelling to collect samples. This site had the highest *E. coli* geomean, the lowest DO, and the second highest TDS numbers of all of the monitored sites in the watershed.

Table 14: Descriptive parameters for Site 80314 – Town Creek at Johnson Settlement

| Parameter                                    | % Complete | Mean ± Standard Deviation | Max  | Min |
|----------------------------------------------|------------|---------------------------|------|-----|
| Total Dissolved Solids (mg/L)                | 60%        | 525.95 ± 105.77           | 728  | 208 |
| Water Temperature (°C)                       | 58%        | 17.85 ± 5.5               | 26   | 9   |
| Dissolved Oxygen (mg/L)                      | 67%        | 5.56 ± 1.91               | 9    | 0.9 |
| pH                                           | 58%        | 7.9 ± 0.25                | 8.4  | 7.4 |
| Transparency Tube (m)                        | 42%        | 0.97 ± 0.29               | 1.22 | 0.3 |
| Depth (m)                                    | 67%        | 0.29 ± 0.41               | 2.7  | 0   |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 53%        | 408.20                    | 3297 | 0   |

\*Site was to be sampled 60 times from 01/11/2008 to 12/20/2012.

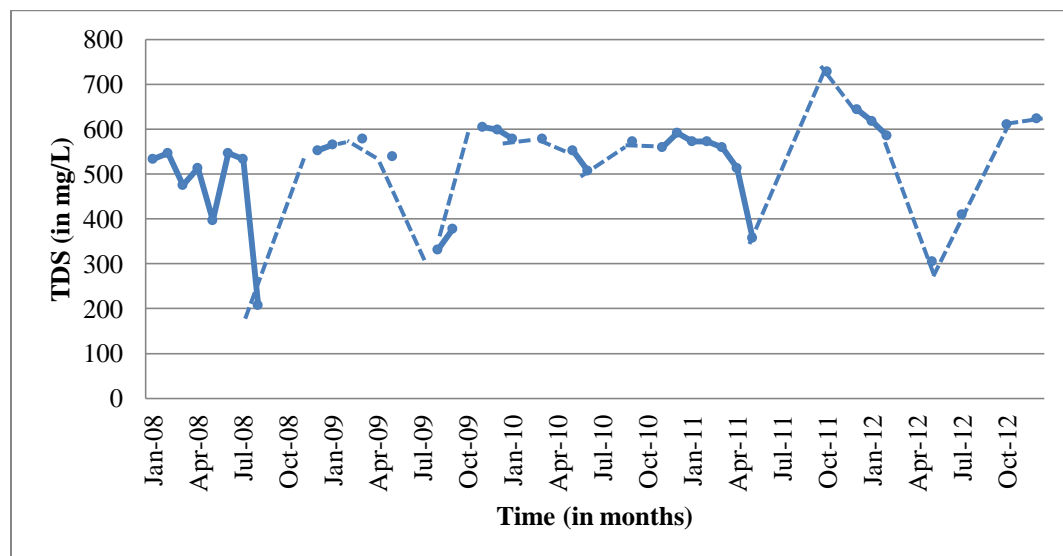
### Air and water temperature

Water and air temperatures were sampled 35 and 38 times, respectively, at Site 80314. Temperatures fluctuated in an expected seasonal pattern, with maximum temperatures in August 2009. Water temperatures remained below air temperatures, except in February 2009. Water never reached temperatures above the Texas Surface Water Quality Standard of 32.2°C and the 2008-2012 water temperature average appeared to decrease slightly (not significant) from the historic temperature of 20 (from sporadic sampling from 2005 to 2007).

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 36 times and noted that TDS was higher at this site than any other in this study other than site 80937 which has only been sampled 19 times. The TDS results suggest a

trend of increasing TDS over time at this site; however, the inconsistency of data collection makes any analysis at this site difficult.



**Figure 24: Total Dissolved Solids at Site 80314 from 01/2008 to 12/2012**

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no statistically significant trend. However, DO readings at this site were lower than other sites along the Pedernales and two readings in late summer of 2009 were below 3 mg/L, the lower limit of acceptable DO levels. These two readings were most likely due to the low water level (0.05 m) during that summer.

### pH

The pH values at Site 80314 show no statistically significant trend and remained near the average of 7.9.

### Transparency tube and total depth

Transparency tube depth shows little variation from the average of 0.97 m for the sampling events. The water had a consistently medium level of clarity. Total depth, on the other hand, was highly sporadic, going from 1 m in depth to completely dry.

### Field Observations

At Site 80314, field observations recorded during sampling events indicated that water was primarily clear, odorless, and calm. The water was clear 53% of the time, but green or tan the rest of the time, and the water surface was clear 67% of the sampling events and covered in scum, debris, or sheen the remainder of the sampling events. Weather was noted to be clear during 32% of the sampling events, cloudy during 41% of the sampling events, and overcast for the remainder of the sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 408.20 CFU/100 mL. This site had the highest geomean of all of the sites in the watershed. The highest *E. coli* count recorded for this site was 3297 CFU/100 mL on 05/11/2012.

## Site 80312 – Barons Creek at Frantzen Park

### Site Description

This site is located at Barons Creek, upstream of its merger with Town Creek. This site features a riparian zone as part of a city park and is surrounded by the suburban areas of Fredericksburg.

### Sampling Information

This is a currently active site sampled from 07/06/2011 to 02/05/2013 by LCRA CRWN monitor, John Ahrns. Sampling occurred, on average, 12 times a year, typically during the first part of the month and between the hours of 0900 and 1200, although variation in date and time of sampling did occur. Since July 2011, monitors have spent a total of 32 hours and 0 minutes sampling and have traveled 1000 miles to collect samples at this site, with an average of 96 minutes spent sampling and an average of 50 miles spent travelling to collect samples.

Table 15: Descriptive parameters for Site 80312 – Barons Creek at Frantzen Park

| Parameter                            | % Complete | Mean $\pm$ Standard Deviation | Max   | Min   |
|--------------------------------------|------------|-------------------------------|-------|-------|
| Total Dissolved Solids (mg/L)        | 100%       | 472.88 $\pm$ 31.9             | 539.5 | 442   |
| Water Temperature (°C)               | 100%       | 17.65 $\pm$ 6.28              | 25    | 7     |
| Dissolved Oxygen (mg/L)              | 100%       | 6.74 $\pm$ 2.08               | 10    | 3.2   |
| pH                                   | 100%       | 7.77 $\pm$ 0.26               | 8.2   | 7     |
| Transparency Tube (m)                | 100%       | 1.22 $\pm$ 0.001              | 1.22  | 1.225 |
| Depth (m)                            | 100%       | 0.48 $\pm$ 0.22               | 0.75  | 0.1   |
| <i>E. coli</i> Bacteria (CFU/100 mL) | 0%         | NA                            | NA    | NA    |

\*Site was sampled 20 times from 07/06/2011 to 02/05/2013.

### pH

The pH values at Site 80312 showed no statistically significant trend over time and remained near the average of 7.75.

### Transparency tube and total depth

Transparency tube depth held constant at 1.22 m for the entire sampling period. The water had constant high level of clarity. The total depth measurements were below 1 m in the fall of 2011, and above 1 m during the spring and summer of 2012.

### Field Observations

At Site 80312, field observations recorded during sampling events indicated that water was primarily clear, colorless, odorless, calm, and had a clear water surface with little to no algae. Weather was noted to be clear during 60%, cloudy during 25%, and overcast during the remainder of the sampling events.



## Site 80934 – Hamilton Pool

### Site Description

This site is located at Hamilton Pool Nature Preserve in a pool that has collected in a collapsed karst room that now forms a box canyon. The site is surrounded by a limestone canyon with thick riparian zones. While a waterfall feeds the pool, the pool itself is calm and has a small beach to one side.

### Sampling Information

This is a currently active site sampled from 01/09/2008 to 02/25/2013 by LCRA CRWN monitors; Steven Hubbell, Crystal Funke, Michael Brewster, and Sally Wolfe. Sampling occurred, on average, 10.2 times a year, typically during the last half of the month and between the hours of 1000 and 1500, although variation in date and time of sampling did occur. Since January 2008, monitors have spent a total of 109 hours and 43 minutes sampling and have traveled 1,329.5 miles to collect samples at this site, with an average of 124.2 minutes spent sampling and 25.1 miles spent travelling to collect samples at this site.

**Table 16: Descriptive parameters for Site 80934 – Hamilton Pool**

| Parameter                                    | % Complete | Mean $\pm$ Standard Deviation | Max   | Min  |
|----------------------------------------------|------------|-------------------------------|-------|------|
| Total Dissolved Solids (mg/L)                | 81%        | 303.3 $\pm$ 25.3              | 344.5 | 221  |
| Water Temperature (°C)                       | 81%        | 19.24 $\pm$ 6.46              | 28    | 1    |
| Dissolved Oxygen (mg/L)                      | 81.5%      | 6.93 $\pm$ 1.64               | 9.5   | 3.7  |
| pH                                           | 80%        | 7.2 $\pm$ 0.27                | 8     | 7    |
| Transparency Tube (m)                        | 32%        | 1.03 $\pm$ 0.26               | 1.22  | 0.31 |
| Depth (m)                                    | 7.3%       | 7.3 $\pm$ 0.83                | 7.79  | 2    |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 81.5%      | 81.53                         | 1     | 520  |

\*Site was sampled 20 times from 01/09/2008 to 02/25/2013.

### Air and water temperature

Water and air temperatures were sampled 53 times at Site 80934. Temperatures fluctuated in an expected seasonal pattern, with a maximum air temperature of 37°C in July 2012 and a maximum water temperature of 28°C found in July and August of 2011. Water temperatures remained below air temperatures, except during one reading in January 2012.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 53 times and noted a maximum recorded value of 344.5 mg/L found on 03/16/2012. The TDS results did not show a trend or pattern of significance.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no significant trends.

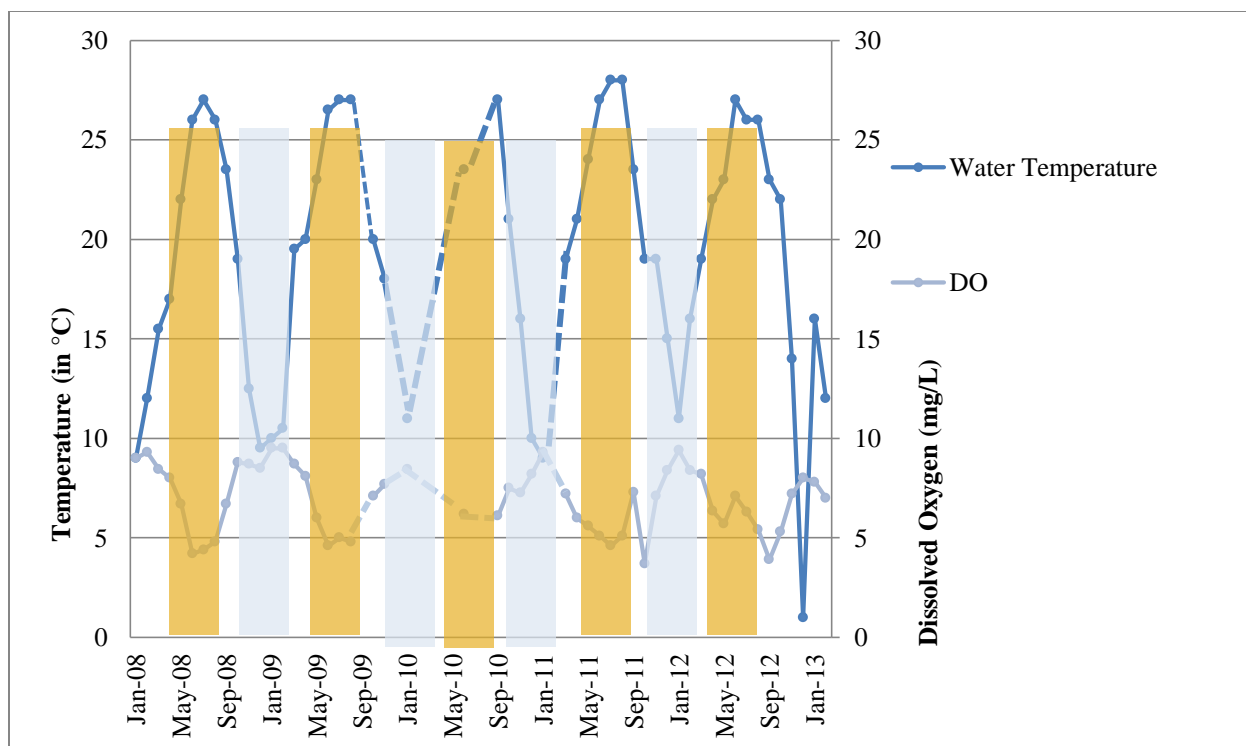


Figure 25: Dissolved Oxygen and Water Temperature at Site 80934 from 01/2008 to 02/2013

### pH

The pH values at Site 80934 remained between 7 and 7.5 for all readings, except for one high reading of 8 in April 2012.

### Transparency tube and total depth

Transparency tube depth was measured consistently from 01/2008 to 09/2009. During that time, transparency tube results fluctuated around an average of 1 m, suggesting a fairly high level of clarity. The total depth measurements remained high, between 7 m and 7.5 m, except for two low readings, 2m in November 2010 and 5 m in April 2012.

### Field Observations

At Site 80934, field observations recorded during sampling events indicated that the water was primarily dark green, calm, odorless, and had a clear water surface with little to no algae. Water could be either clear or cloudy (58% or 40% of sampling events respectively) and weather was noted to be clear during 60% of the sampling events, raining during 8% of the sampling events, and overcast or cloudy during the remainder of the sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 81.53 CFU/100 mL. The highest *E. coli* count recorded for this site was 520 CFU/100 mL on 06/29/2011.

## Site 80935- Cypress Creek at Hammett's Crossing

### Site Description

This site is located at an old bridge and crosses Cypress Creek off of Nicholson Bluff Road. This site features a small dammed area of the creek, with a riparian zone to the north and east sides of the creek. The land surrounding the site is either preserve and park land or open farm/ranch land.

### Sampling Information

This is a currently active site sampled from 03/05/2009 to 02/07/2013 by LCRA CRWN monitor, David Boyd. Sampling occurred, on average, 12 times a year, with no set time of month and between the hours of 0900 and 1400, although variation in date and time of sampling did occur. Since March 2009, the monitor spent a total of 118 hours and 5 minutes sampling and traveled 62 miles to collect samples at this site, with an average of 147.6 minutes spent sampling and, on average, 1 mile spent travelling to collect samples.

**Table 17: Descriptive parameters for Site 80935 – Cypress Creek at Hammett's Crossing**

| Parameter                                    | % Complete | Mean ± Standard Deviation | Max  | Min   |
|----------------------------------------------|------------|---------------------------|------|-------|
| Total Dissolved Solids (mg/L)                | 95.8%      | 348.46 ± 51.99            | 481  | 241.5 |
| Water Temperature (°C)                       | 100%       | 19.9 ± 7.07               | 30   | 5.5   |
| Dissolved Oxygen (mg/L)                      | 100%       | 6.76 ± 1.68               | 11.5 | 3.95  |
| pH                                           | 100%       | 7.93 ± 0.123              | 8.1  | 7.6   |
| Transparency Tube (m)                        | 62.5%      | 1.0.65 ± 0.26             | 1.22 | 0.3   |
| Depth (m)                                    | 100%       | 1.79 ± 0.17               | 2.25 | 1.5   |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 97.9%      | 12.14                     | 900  | 0     |

\*Site was sampled 48 times from 03/05/2009 to 02/07/2013.

### Air and water temperature

Water and air temperatures were sampled 48 times at Site 80935. Temperatures fluctuated in an expected seasonal pattern, with maximum air temperatures of 35°C in July 2009 and a maximum water temperature of 30°C in August 2011. Water temperatures remained below air temperatures, except during readings in the fall of 2009 and the winters of 2010, 2011, and 2012. Water temperature showed no trends of significance, aside from seasonal patterns.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 46 times and noted a maximum TDS value of 481 mg/L, recorded in January 2012. Although TDS fluctuated greatly between 200 mg/L and 480 mg/L, no significant pattern or trend was noticed in the overall results.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no statistically significant trend. A maximum DO value of 11.5 mg/L was noted in January 2010, while a minimum value of 3.95 mg/L was noted during the maximum air temperature month of July 2009.

## pH

The pH values at Site 80935 showed no significant trend and remained near the average of 7.9.

## Transparency tube and total depth

Transparency tube depth was measured consistently from 03/2009 to 10/2011. During the samples taken in 2009, transparency tube readings were between 0.4 m and 0.7 m, but held steady at 1.2 m between 02/2010 and 10/2011, suggesting a fairly high level of clarity during this period. The total depth measurements remained high, between 1.5 m and 2 m.

## Field Observations

At Site 80395, field observations recorded during sampling events indicated that the water was primarily clear, colorless, odorless, calm, and had a clear water surface, with common to abundant algae present. Weather was noted to be clear during 65% of the sampling events, was cloudy during 21%, and overcast during the remainder of the sampling events.

## *E. coli*

The geomean for *E. coli* for this site was 12.14 CFU/100 mL. The highest *E. coli* count recorded for this site was 900 CFU/100 mL on 10/16/2009.

## Site 80936 – Pogue Springs

### Site Description

This site is located at a spring in ranch land west of Highway 71 and north of Hamilton Pool Park, accessible by back roads. The site is flanked by a limestone ledge to the west and a thick tree lined riparian zone to the east.

### Sampling Information

This is a currently active site sampled from 01/19/2010 to 02/25/2013 by LCRA CRWN monitors; Sally Wolfe and Michael Brewster. Sampling occurred, on average, 10.6 times a year, typically during the last part of the month and between the hours of 1200 and 1600, although variation in date and time of sampling did occur. Since 01/2010, monitors spent a total of 50 hours and 0 minutes sampling and traveled 906 miles to collect samples for this site, with an average of 90.9 minutes spent sampling and an average of 27.5 miles travelling to collect each sample.

**Table 18: Descriptive parameters for Site 80312 – Pogue Springs**

| Parameter                                    | % Complete | Mean $\pm$ Standard Deviation | Max  | Min  |
|----------------------------------------------|------------|-------------------------------|------|------|
| Total Dissolved Solids (mg/L)                | 84%        | 318.7 $\pm$ 33.70             | 390  | 234  |
| Water Temperature (°C)                       | 84%        | 19.61 $\pm$ 6.66              | 30   | 7    |
| Dissolved Oxygen (mg/L)                      | 84%        | 6.58 $\pm$ 2.42               | 9.90 | 0.07 |
| pH                                           | 84%        | 7.09 $\pm$ 0.20               | 7.5  | 7.0  |
| Transparency Tube (m)                        | 32%        | 1.08 $\pm$ 0.11               | 1.22 | 1.00 |
| Depth (m)                                    | 84%        | 3.49 $\pm$ 0.15               | 4    | 2.8  |
| <i>E. coli</i> Bacteria Geomean (CFU/100 mL) | 82%        | 32.96                         | 760  | 0    |

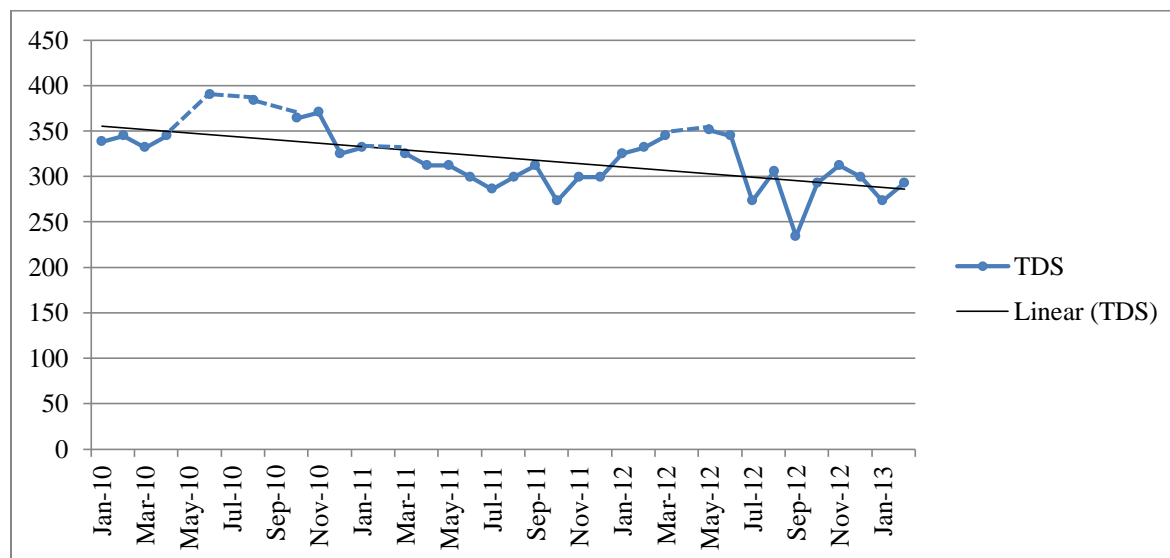
\*Site was sampled 20 times from 01/19/2010 to 02/25/2013.

### Air and water temperature

Water and air temperatures were sampled 32 times at Site 80936. Temperatures fluctuated in an expected seasonal pattern, with maximum air temperatures of 39°C in the summers of 2011 and 2012. Water temperatures remained below air temperatures, except during one reading in December 2012. Water never reached temperatures above 30°C and showed no significant trend or pattern beyond the usual seasonal patterns.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 32 times and all recorded readings were below 390 mg/L. The TDS values also suggest a downward trend over time with an  $R^2$  value of 0.37 and  $p=0.000$ , suggesting that there is variation in the sample but it is significant.



**Figure 26: Total Dissolved Solids at Site 80936 from 07/2011 to 02/2013**

## Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings show a significantly decreasing trend ( $R^2=0.31$ ,  $p=0.001$ ) over time, suggesting that there is variability but variability is much less than expected for this parameter. Water temperature did not seem to be a cause of the decreasing DO over time, since water temperature showed no significant trend.

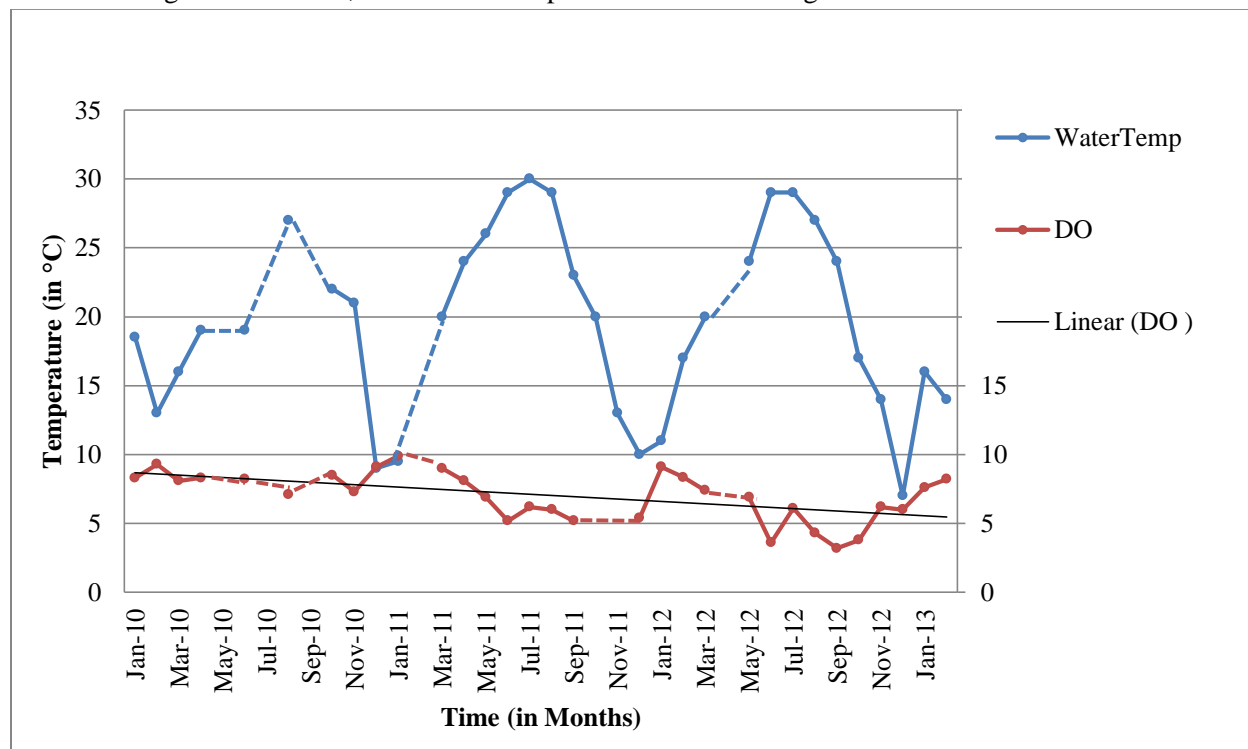


Figure 27: Dissolved Oxygen and Water Temperature at Site 80936 from 07/2011 to 02/2013

## pH

The pH values at Site 80936 showed no significant trend and measured 7.5 during the spring of 2010 and then 7 for the remainder of the sampling period.

## Transparency tube and total depth

Transparency tube depth was measured consistently from 01/2010 to 05/2011. Transparency tube readings held steady between 1 m and 1.2 m for the period it was sampled, suggesting a fairly high level of clarity during this period. The total depth measurements were consistently at 3.5 m, other than a high measurement of 4 m in January 2010 and a low of 2.8 m in September 2011.

## Field Observations

At Site 80936, field observations recorded during sampling events indicated that water was primarily clear, green, odorless, calm, and had a clear water surface, with little to no algae present. Weather was noted to be clear during 67% of sampling events, cloudy during 24% of sampling events, and overcast during the remainder of the sampling events.

### *E. coli*

The geomean for *E. coli* for this site was 32.96 CFU/100 mL. The highest *E. coli* count recorded for this site was 760 CFU/100 mL on 09/24/2012.

## Site 80937 – Barons Creek at Hwy 290

### Site Description

This site is located on a creek to the west of Highway 290 and east of Fredericksburg. This site features a riparian zone of ashe juniper and other vegetation, with sand or gravel bars to the west side of the creek. To the east side is farmland and suburban areas to the west.

### Sampling Information

This is a currently active site sampled from 07/06/2011 to 02/05/2013 by LCRA CRWN monitor, John Ahrns. Sampling occurred, on average, 12 times a year, typically during the first part of the month and between the hours of 0900 and 1200, although variation in date and time of sampling did occur. Since July 2011, monitors have spent a total of 21 hours and 18 minutes sampling and have traveled 735 miles to collect samples, with an average of 63.9 minutes spent sampling and an average of 36.75 miles travelling to collect samples.

**Table 19: Descriptive parameters for Site 80937 – Barons Creek at Hwy 290**

| Parameter                           | % Complete | Mean ± Standard Deviation | Max  | Min   |
|-------------------------------------|------------|---------------------------|------|-------|
| Total Dissolved Solids (mg/L)       | 100%       | 705.7 ± 133.9013          | 939  | 481   |
| Water Temperature (°C)              | 95%        | 17.65 ± 6.28              | 25   | 7     |
| Dissolved Oxygen (mg/L)             | 100%       | 6.74 ± 2.08               | 10   | 3.2   |
| pH                                  | 95%        | 7.77 ± 0.26               | 8.2  | 7     |
| Transparency Tube (m)               | 95%        | 1.22 ± 0.001              | 1.22 | 1.225 |
| Depth (m)                           | 100%       | 0.48±0.22                 | 0.75 | 0.1   |
| <i>E.coli</i> Bacteria (CFU/100 mL) | NA         | NA                        | NA   | NA    |

\*Site was sampled 20 times from 07/06/2011 to 02/05/2013.

### Air and water temperature

Water and air temperatures were sampled 19 times at Site 80937. Temperatures fluctuated in an expected seasonal pattern, with a maximum air temperature of 30°C in August 2011 and a maximum water temperature of 25°C during both summers sampled. Water temperatures remained below air temperatures, except during both winters sampled. No significant trends or patterns were noticed.

### Total Dissolved Solids

Citizen scientists sampled TDS at this site 19 times and noted a high reading of 936 mg/L in November of 2011. The TDS at this site is high for this section of river, with almost all readings above the suggested value of 525 mg/L and results fluctuated greatly between 481 mg/L and 900 mg/L. No significant trend or pattern was noticed.

### Dissolved Oxygen

The DO followed a normal seasonal trend, rising in the winter when the water temperature was low and decreasing in the summer when the water temperature was high. Individual DO sampling event readings showed no significant trend, but limited sampling at this site would make a trend of any kind hard to determine.

### pH

The pH values at Site 80937 shows no significant trend and fluctuated between 6.8 and 9.

### Transparency tube and total depth

Transparency tube depth held constant at 1.22 m for the entire sampling period, showing that the water had constant high level of clarity. The total depth measurements were near 0.5 m for the majority of the sampling period but dropped to near zero during the fall of 2011 and 2012.

### Field Observations

At Site 80937, field observations recorded during sampling events indicated that the water was primarily clear, colorless, odorless, calm, and had a clear water surface with rare or common algae (33% and 44% respectively). Weather was noted to be clear during 60% of the sampling events, cloudy during 30% of the sampling events, and overcast during the remainder of the sampling events.

## 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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