

Lower San Marcos River Watershed Data Report

August 2014



THE MEADOWS CENTER
FOR WATER AND THE ENVIRONMENT

TEXAS STATE UNIVERSITY



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The rising STAR of Texas



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Table of Contents

Introduction4

Watershed Location and Physical Description5

 Location and Climate5

 Physical Description and Land Use5

 Recreation6

Water Quality Parameters6

 Water Temperature6

 Dissolved Oxygen.....6

 Specific Conductivity and Total Dissolved Solids7

 pH.....7

 Secchi disk and total depth.....7

 Orthophosphate.....7

 Nitrate-Nitrogen.....8

 Texas Surface Water Quality Standards.....8

Data Analysis Methodologies9

 Data Collection9

 Processes to Prevent Contamination9

 Documentation of Field Sampling Activities9

 Data Entry and Quality Assurance10

 Data Entry10

 Quality Assurance & Quality Control10

 Data Analysis Methods10

 Standards & Exceedances11

 Methods of Analysis11

Lower San Marcos Watershed Data Analysis12

 Lower San Marcos Watershed Maps.....12

 Lower San Marcos Watershed Trends over Time12

 Sampling Trends over Time.....12

 Trend Analysis over Time.....14

 Air and water temperature.....14

Total Dissolved Solids	15
Dissolved Oxygen	16
pH	17
Orthophosphate	18
Nitrate-Nitrogen	19
Lower San Marcos Watershed Site by Site Analysis	19
Site 15491 – San Marcos River at Cummings Dam	24
Site Description	24
Sampling Information	25
Air and water temperature	25
Total Dissolved Solids	26
Dissolved Oxygen	26
pH	27
Secchi disk and total depth	28
Field Observations	28
Orthophosphate	28
Nitrate-Nitrogen	29
Site 15492 – San Marcos River at Old Bastrop Highway	30
Site Description	30
Sampling Information	30
Air and water temperature	31
Total Dissolved Solids	31
Dissolved Oxygen	32
pH	33
Secchi disk and total depth	34
Field Observations	34
Orthophosphate	34
Nitrate-Nitrogen	34
Site 14436 – San Marcos River at Sculls Crossing	35
Site Description	35
Sampling Information	35
Air and water temperature	36
Total Dissolved Solids	36

Dissolved Oxygen.....	37
pH.....	38
Secchi disk and total depth.....	38
Field Observations	38
Orthophosphate	38
Nitrate-Nitrogen.....	39
Get Involved with Texas Stream Team!.....	40
References	41
Appendix A- List of Maps, Tables, and Figures	41
Tables	41
Figures	41

Introduction

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

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

- [Texas Stream Volunteer Water Quality Monitoring Manual](#)
- [Texas Commission on Environmental Quality \(TCEQ\) Surface Water Quality Monitoring Procedures](#)

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

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

- Texas Surface Water Quality Standards
- Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)
- Texas Clean Rivers Program partner reports, such as Basin Summary Reports and Highlight Reports
- TCEQ Total Maximum Daily Load reports
- TCEQ and Texas State Soil and Water Conservation Board Nonpoint Source Program funded reports, including Watershed Protection Plans

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

Watershed Location and Physical Description

Location and Climate

The Lower San Marcos River starts at the confluence with the Blanco River, and flows approximately 75 miles along heavily wooded banks to the Guadalupe River. The river flows through five counties: Hays, Caldwell, Guadalupe, Caldwell, and Gonzales (Texas Parks and Wildlife Department (TPWD)) and two ecoregions: the Post Oak Savannah and the Blackland Prairies. The Blackland Prairies are made up of what is considered some of the best soils in the world. The prairies consist primarily of a variety of perennial and annual grasses with stands of live oaks and Ashe juniper trees. The Post Oak Savannah region is covered with native bunch grasses and forbs. A variety of oak, including post, live, and blackjack, are scattered across the savannah (Texas A&M Forest Service). Temperatures in the San Marcos Basin range from 4.4°C in January to 35.6°C in July. The average rainfall is 33 inches a year (Guadalupe-Blanco River Authority (GBRA)).

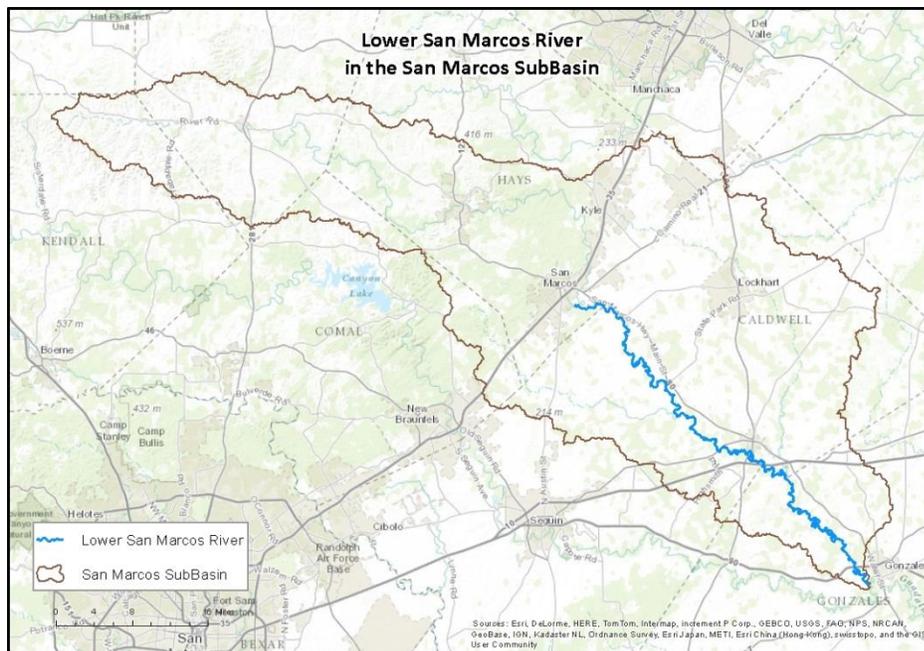


Figure 1: Map of the Lower San Marcos Watershed

Physical Description and Land Use

The Lower San Marcos River is characterized by rapids, small riffles, and numerous clear, quiet pools. The stream averages 30 feet wide, except when it narrows between steep banks, generally south of Luling. During low water periods, log jams are common (TPWD). In contrast to the Upper San Marcos, the Lower San Marcos River does not have any endangered species. Land use in the San Marcos Watershed is varied, ranging from urban and industrial use to agricultural. Common crops include corn, sorghum, hay, cotton, wheat, and pecans. Cattle, hogs, and poultry are also raised in the basin. Other land uses include oil

production. Water from the Lower San Marcos supports aquatic life, contact recreation, fish consumption, as well as public water supply (GBRA).

Recreation

The San Marcos River is one of the most popular recreational rivers in Texas. Even during dry periods there is usually sufficient water to allow (TPWD) snorkeling, tubing, canoeing (GBRA). Along the banks of the Lower San Marcos are three private campgrounds, six roadside public access areas, and two public parks. Luling City Park and Palmetto State Park both offer riverside camping (TPWD). The river is also host to part of the Texas Water Safari, an annual race from the headwaters of the San Marcos River to the Gulf Coast town of Seadrift. The canoe race has been a tradition since 1963 and is billed as the “World’s Toughest Boat Race.”

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.

Orthophosphate

Orthophosphate is the phosphate molecule all by itself. Phosphorus almost always exists in the natural environment as phosphate, which continually cycles through the ecosystem as a nutrient necessary for the growth of most organisms. Testing for orthophosphate detects the amount of phosphate in the water itself, excluding the phosphate bound up in plant and animal tissue. There are other methods to retrieve the

phosphate from the material to which it is bound, but they are too complicated and expensive to be conducted by a volunteer monitors. Testing for orthophosphate gives us an idea of the degree of phosphate in a water body. It can be used for problem identification, which can be followed up with more detailed professional monitoring, if necessary. Phosphorus inputs into a water body may be the weathering of soils and rocks, discharge from wastewater treatment plants, excessive fertilizer use, failing septic systems, livestock and pet waste, disturbed land areas, drained wetlands, water treatment, and some commercial cleaning products. The effect orthophosphate has on a water body is known as eutrophication and is described above under the “Dissolved Oxygen” section.

Nitrate-Nitrogen

Nitrogen is present in terrestrial or aquatic environments as nitrates, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with the TCEQ and other partners. Just like phosphorus, nitrogen is a nutrient necessary for the growth of most organisms. Nitrogen inputs into a water body may be livestock and pet waste, excessive fertilizer use, failing septic systems, and industrial discharges that contain corrosion inhibitors. The effect nitrogen has on a water body is known as eutrophication and is described above under the “Dissolved Oxygen” section. Nitrates dissolve more readily than phosphates, which tend to be attached to sediment, and therefore can serve as a better indicator of the possibility of sewage or manure pollution during dry weather.

Texas Surface Water Quality Standards

The Texas Surface Water Quality Standards establish explicit goals for the quality of streams, rivers, lakes, and bays throughout the state. The standards are developed to maintain the quality of surface waters in Texas so that it supports public health and protects aquatic life, consistent with the sustainable economic development of the state.

Water quality standards identify appropriate uses for the state’s surface waters, including aquatic life, recreation, and sources of public water supply (or drinking water). The criteria for evaluating support of those uses include DO, temperature, pH, TDS, toxic substances, and bacteria.

The Texas Surface Water Quality Standards also contain narrative criteria (verbal descriptions) that apply to all waters of the state and are used to evaluate support of applicable uses. Narrative criteria include general descriptions, such as the existence of excessive aquatic plant growth, foaming of surface waters, taste- and odor producing substances, sediment build-up, and toxic materials. Narrative criteria are evaluated by using screening levels, if they are available, as well as other information, including water quality studies, existence of fish kills or contaminant spills, photographic evidence, and local knowledge. Screening levels serve as a reference point to indicate when water quality parameters may be approaching levels of concern.

Data Analysis Methodologies

Data Collection

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

Table 1: Sample Storage, Preservation, and Handling Requirements

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

*Preservation performed within 15 minutes of collection.

Processes to Prevent Contamination

Procedures documented in 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 Lower San Marcos Watershed, as seen below in Table 2.

Table 2: Summary of Surface Water Quality Standards for the Lower San Marcos Watershed

Parameter	Texas Surface Water Quality Standard 2014
<i>Water Temperature (°C)</i>	32.2
<i>Total Dissolved Solids (mg/L)</i>	400
<i>Dissolved Oxygen (mg/L)</i>	5.0
<i>pH (su)</i>	6.5-9.0
<i>E.coli (CFU/100 mL)</i>	126 (geomean during sampling period)

Methods of Analysis

All data collected from the Lower San Marcos were exported from the Texas Stream Team database and were then grouped by site.

Once compiled, data was sorted and graphed in Microsoft Excel 2010 using standard methods. Trends over time were analyzed using a linear regression analysis in Minitab v 15. Statistically significant trends were added to Excel to be graphed. The cut off for statistical significance was set to a p-value of ≤ 0.05 . A p-value of ≤ 0.05 means that the probability that the observed data matches the actual conditions found in nature is 95%. As the p-value decreases, the confidence that it matches actual conditions in nature increases.

For this report, specific conductivity measurements, gathered by volunteers, were converted to TDS using the TCEQ-recommended conversion formula of specific conductivity 0.65. This conversion was made so that volunteer gathered data could be more readily compared to state gathered data.

Lower San Marcos Watershed Data Analysis

Lower San Marcos 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.

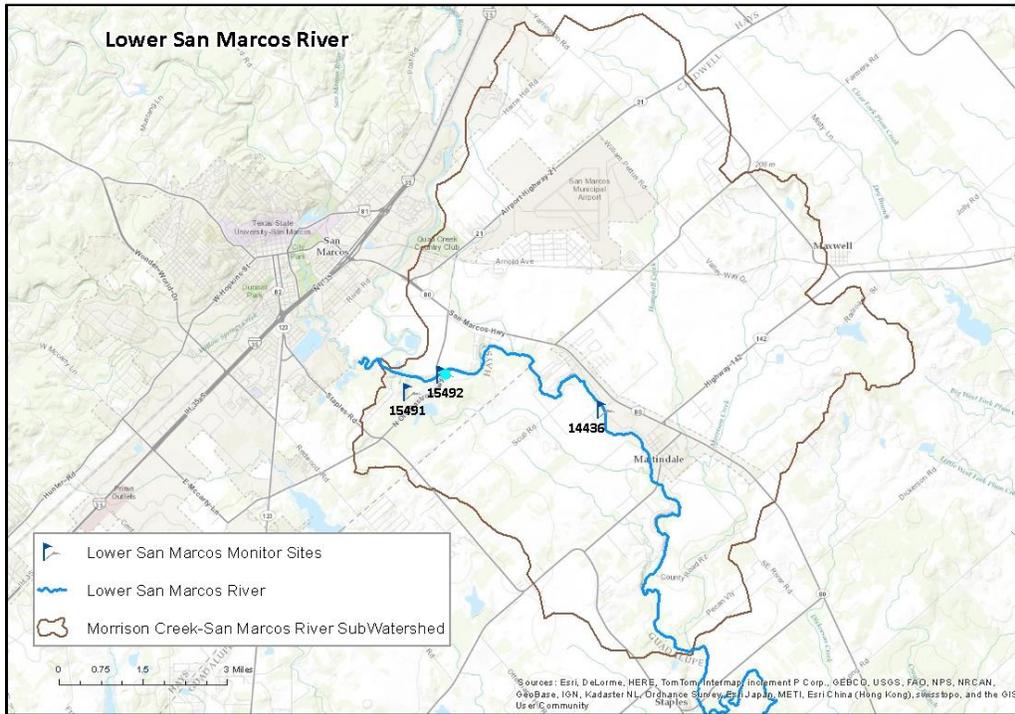


Figure 2: Map of the Lower San Marcos Watershed with Texas Stream Team Monitor Sites

Lower San Marcos Watershed Trends over Time

Sampling Trends over Time

Sampling in the Lower San Marcos Watershed began in September of 1995 and continue to this day. A total of 544 individual monitoring events from 3 sites were analyzed. Monthly monitoring occurred on a consistent basis throughout the years except for a slight decrease that occurred for the months of June and November. The sites were usually monitored in the morning hours between 08:00 and 09:00.

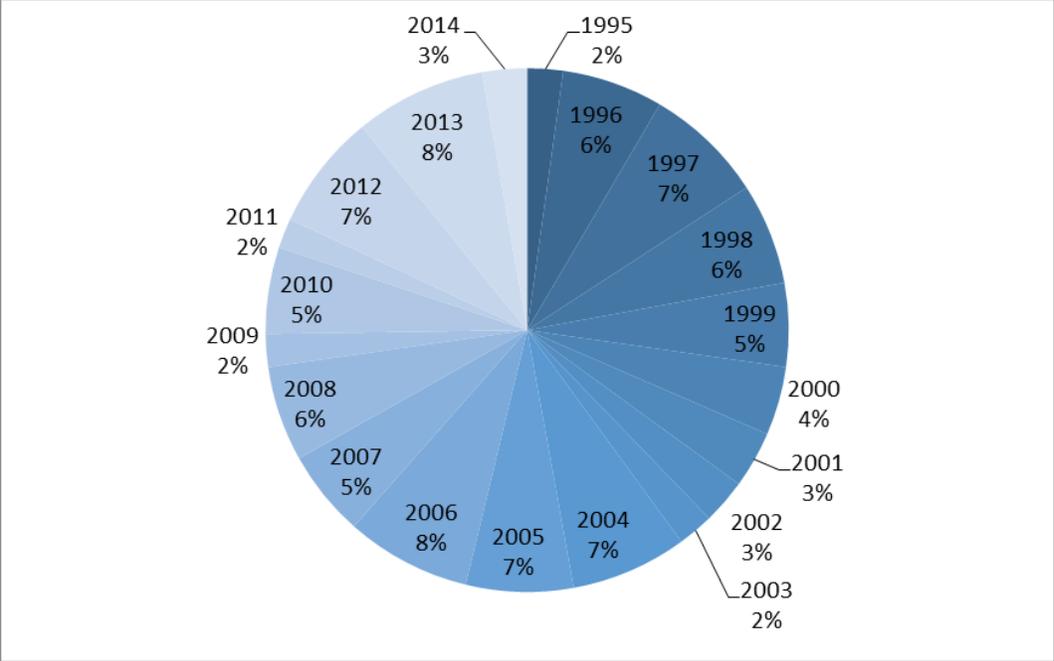


Figure 3: Breakdown of monitoring events by year.

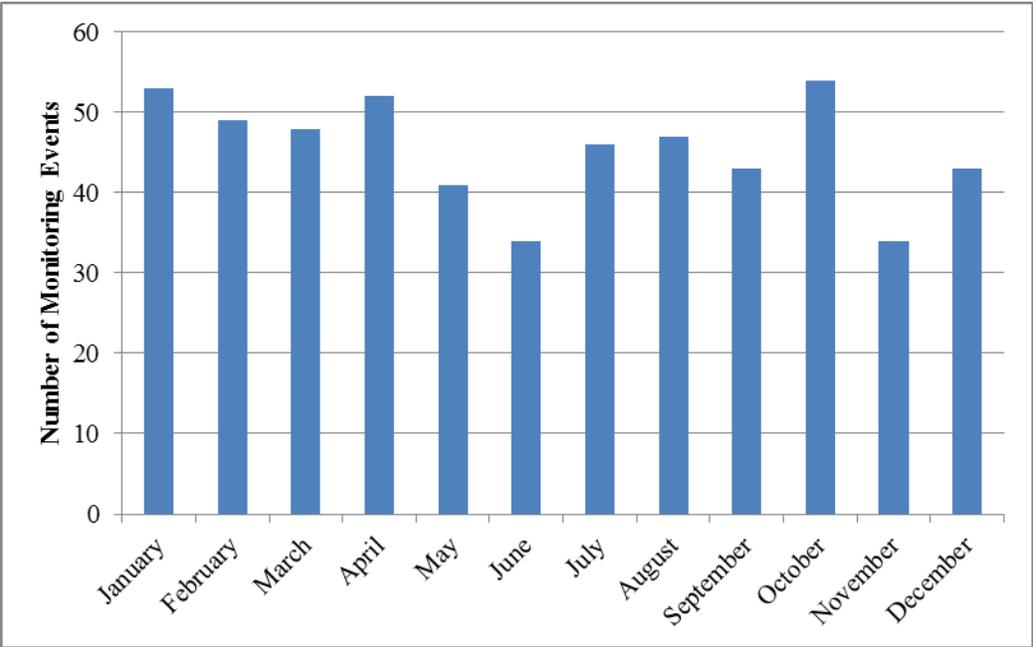


Figure 4: Breakdown of monitoring events by month.

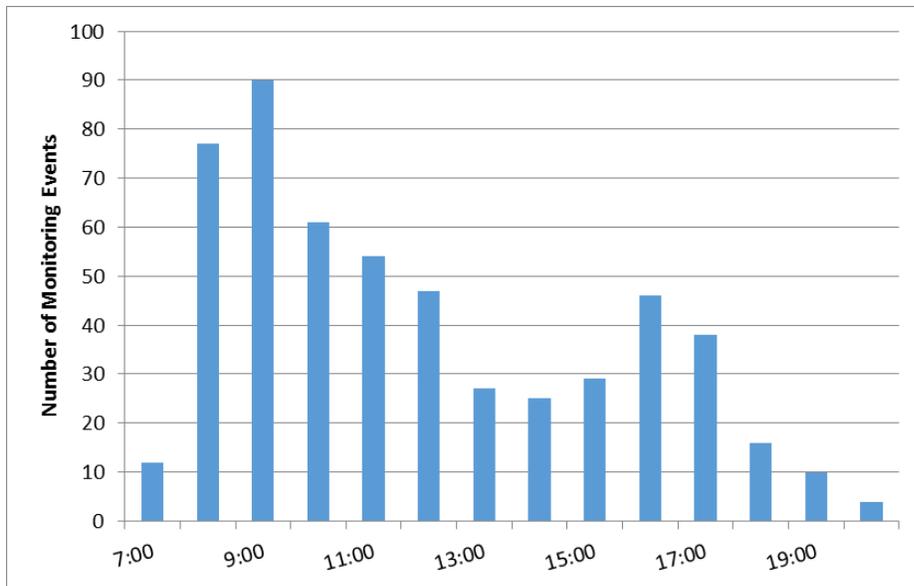


Figure 5: Breakdown of time of monitoring in the Lower San Marcos Watershed

Table 3: Descriptive parameters for all sites in the Lower San Marcos River Watershed

Lower San Marcos Watershed September 1995 – July 2014				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	487	388 ± 74	195	774
Water Temperature (°C)	532	21.5 ± 4.0	0	35.0
Dissolved Oxygen (mg/L)	516	7.9 ± 1.2	4.0	11.8
pH	526	7.8 ± 0.3	6.8	8.9
Nitrates	186	0.97 ± 1.7	0	13.2
Phosphates	195	0.27 ± 0.45	0	4.0

There were a total of 544 sampling events between 9/22/1995 and 07/6/2014. Mean is listed for all parameters except for E. coli which is represented as the geomean.

Trend Analysis over Time

Air and water temperature

A total of 532 air and water temperatures were collected in the Lower San Marcos Watershed between 1995 and 2014. Water temperatures exceeded the TCEQ optimal temperatures of 32.2°C only once during this time. Air temperature varied between 0°C and 41.0°C.

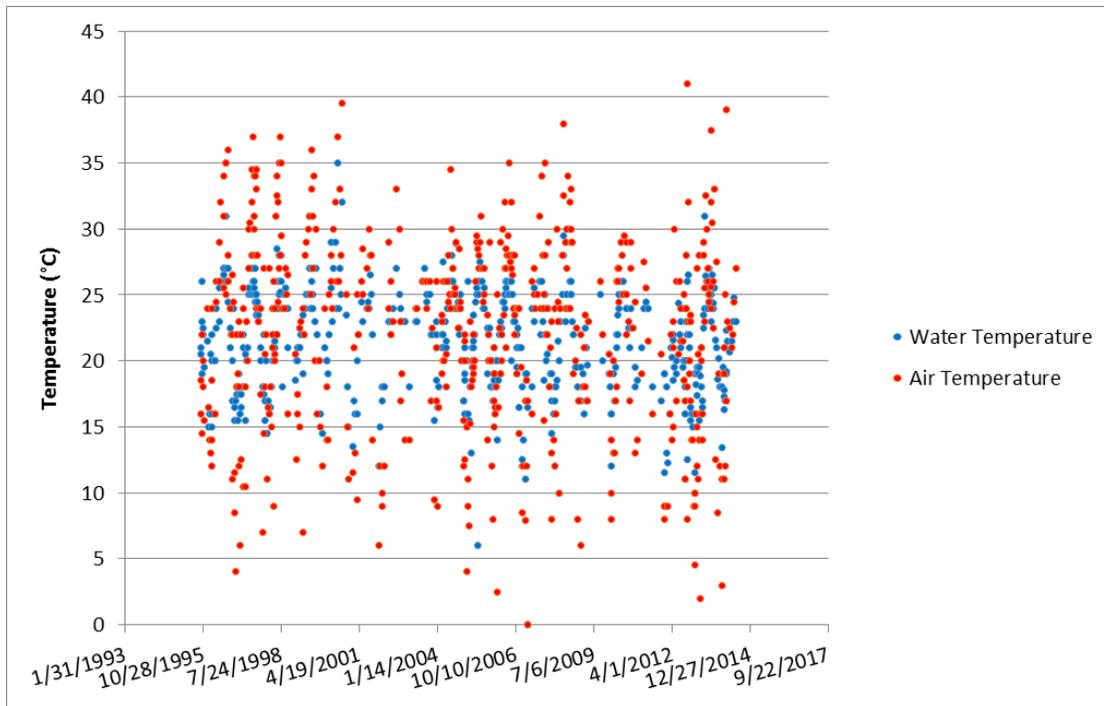


Figure 6: Air and water temperature over time at all sites within the Lower San Marcos Watershed

Total Dissolved Solids

Citizen scientists collected a total of 487 TDS samples within the watershed. The TDS measurement was completed for 89.5% of all monitoring events. The average TDS measurement for all sites was 388 mg/L. There was no significant trend in TDS concentrations over time observed.

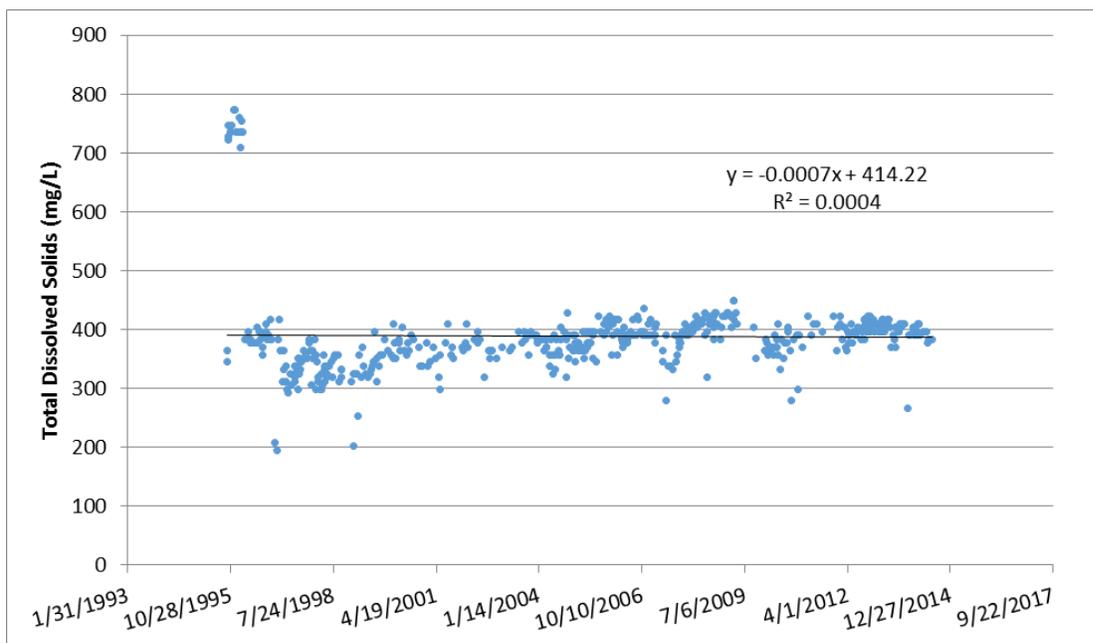


Figure 7: Total Dissolved Solids over time at all sites within the Lower San Marcos Watershed

Dissolved Oxygen

Citizen scientists collected a total of 516 DO samples in the Lower San Marcos Watershed. The mean DO was 7.9 mg/L and it ranged from a low of 4.0 mg/L in August of 2013, to a high of 11.8 mg/L in March of 2004. Plants and algae add a substantial amount of DO via photosynthesis, resulting in the diurnal trends of high DO levels observed during the daylight hours, peaking in the late afternoon, and decreasing after dark. This pattern is shown in Table 4.

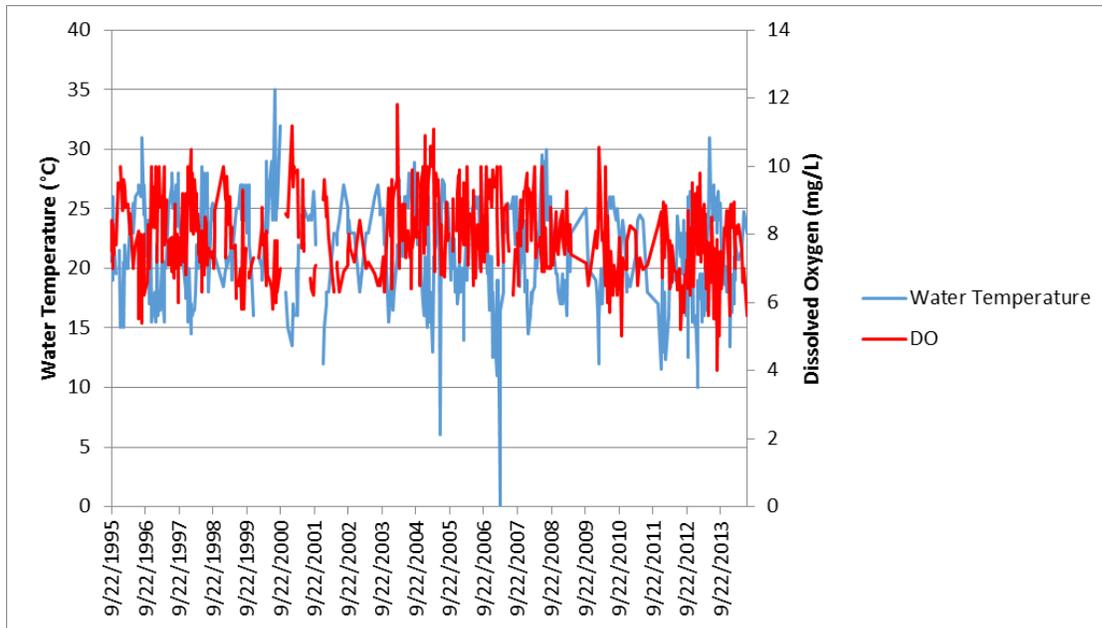


Figure 8: Dissolved oxygen and water temperature over time at all sites in the Lower San Marcos Watershed

Table 4: Average Dissolved Oxygen values by Sampling Time within the Lower San Marcos Watershed

Time	Average DO (mg/L)	Standard Deviation
07:00 – 08:00	7.2	1.0
08:00 – 09:00	7.3	1.2
09:00 – 10:00	7.5	1.0
10:00 – 11:00	7.9	1.2
11:00 – 12:00	8.0	1.1
12:00 – 13:00	8.5	1.1
13:00 – 14:00	8.2	1.0
14:00 – 15:00	8.1	1.2
15:00 – 16:00	8.5	1.1
16:00 – 17:00	8.3	1.2
17:00 – 18:00	8.2	1.2
18:00 – 19:00	7.8	0.8
19:00 – 20:00	9.1	1.1
20:00 – 21:00	7.5	0.7

pH

The pH was measured for 96.7% of all sampling events in the watershed. The mean pH was 7.8 and it ranged from 6.8 to 8.9 for all sites. There was a significant decrease in pH over time observed in the watershed ($p = 0.000$). The R^2 value of 0.1398 indicates that this relationship explains about 14% of the variation in the data.

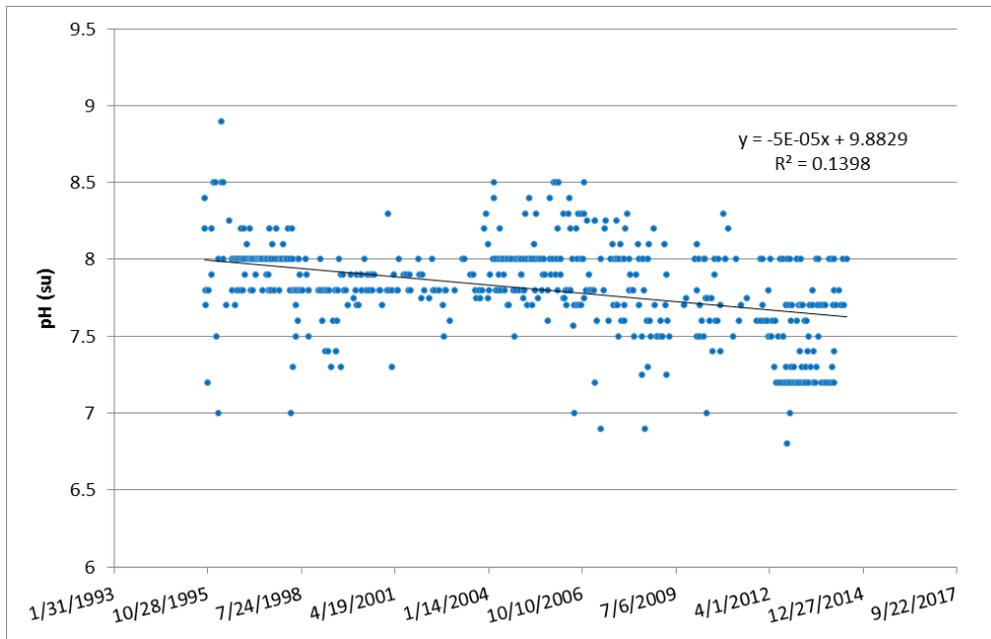


Figure 9: pH over time at all sites within the Lower San Marcos Watershed

Orthophosphate

A total of 195 phosphate measurements were taken in the watershed. The mean phosphate concentration was 0.27 mg/L. Phosphate concentrations ranged from a low of 0.0 mg/L to a high of 4.0 mg/L in October, 2004. There was no significant trend in phosphate concentration over time observed in the watershed during this time.

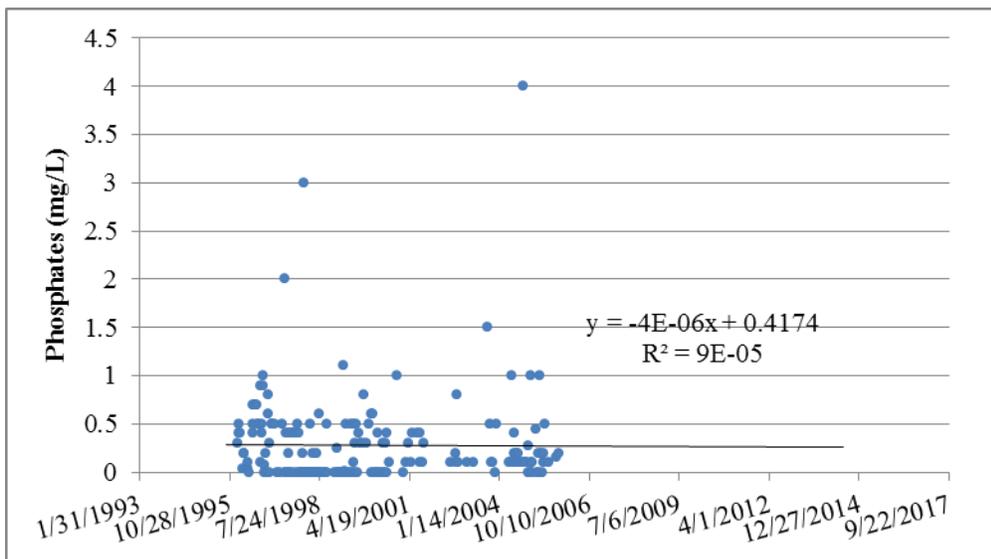


Figure 10: Phosphates over time at all sites within the Lower San Marcos Watershed

Nitrate-Nitrogen

A total of 186 nitrate samples were taken in the watershed. The mean nitrate concentration in the watershed was 0.97 mg/L and the nitrates ranged from 0 mg/L to 13.2 mg/L. There was no significant trend in nitrate concentrations over time in this watershed.

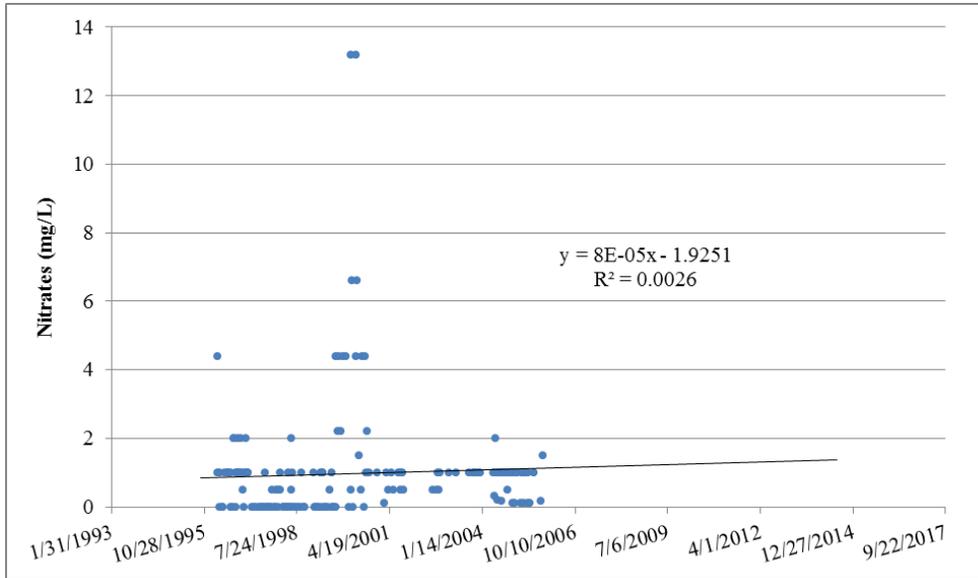


Figure 11: Nitrates over time at all sites within the Lower San Marcos Watershed

Lower San Marcos Watershed Site by Site Analysis

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

As previously mentioned in the ‘Water Quality Parameters’ section, TDS is an important indicator of turbidity and specific conductivity. The higher the TDS measurement, the more conductive the water is. A high TDS result can indicate increased nutrients present in the water. Site 15492 had the highest overall average for TDS, with a result of 400 ± 87 mg/L. Site 14436 had the lowest average TDS, with a result of 376 ± 30 mg/L.

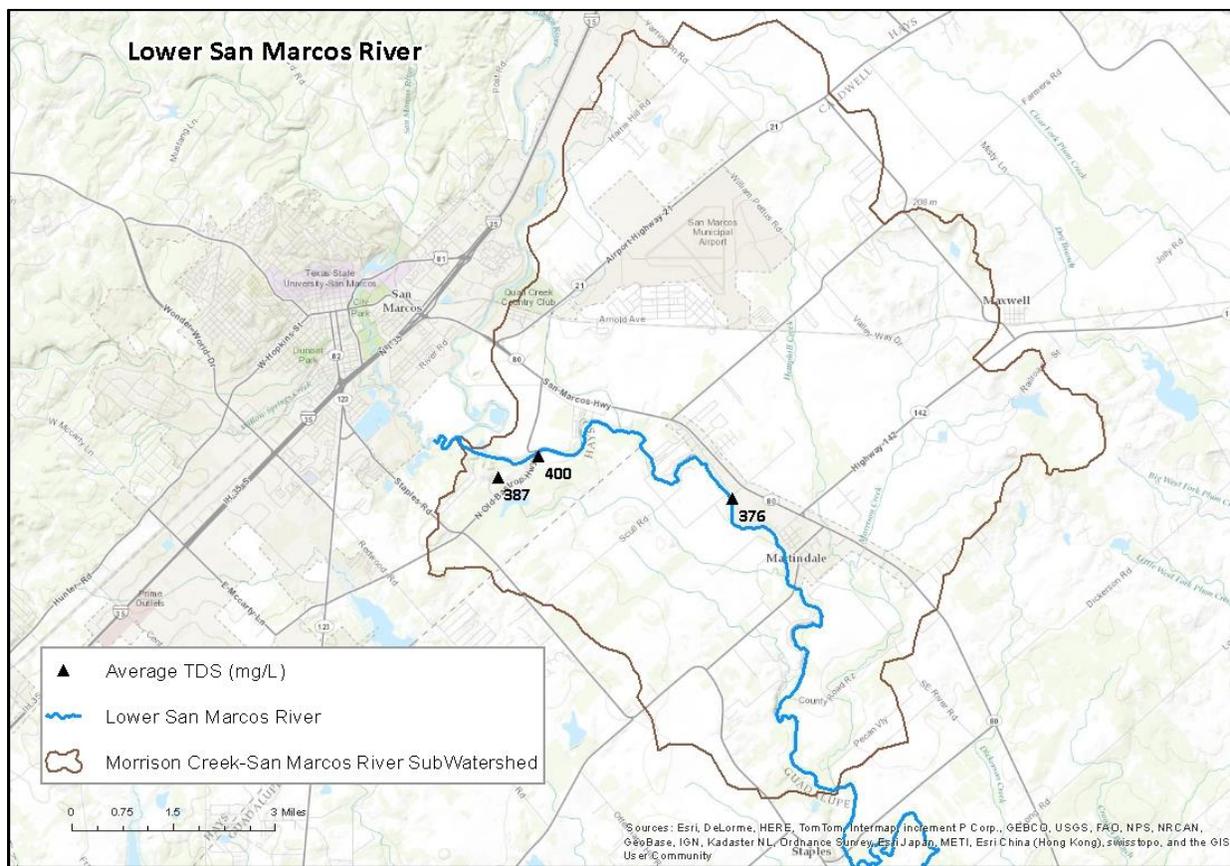


Figure 12: Map of the average total dissolved solids for sites in the Lower San Marcos Watershed

The DO measurement can help to understand the overall health of the aquatic community. If there is a large influx of nutrients into the water body than there will be an increase in surface vegetation growth, which can then reduce photosynthesis in the subsurface, thus decreasing the level of DO. Low DO can be dangerous for aquatic inhabitants, which rely upon the dissolved oxygen to breathe. The DO levels can also be impacted by temperature; a high temperature can limit the amount of oxygen solubility, which can also lead to a low DO measurement. Site 15491 had the lowest average DO reading, with a result of 7.2 ± 0.8 mg/L. Site 15495 had the highest average DO reading, with a result of 8.2 ± 1.1 mg/L.

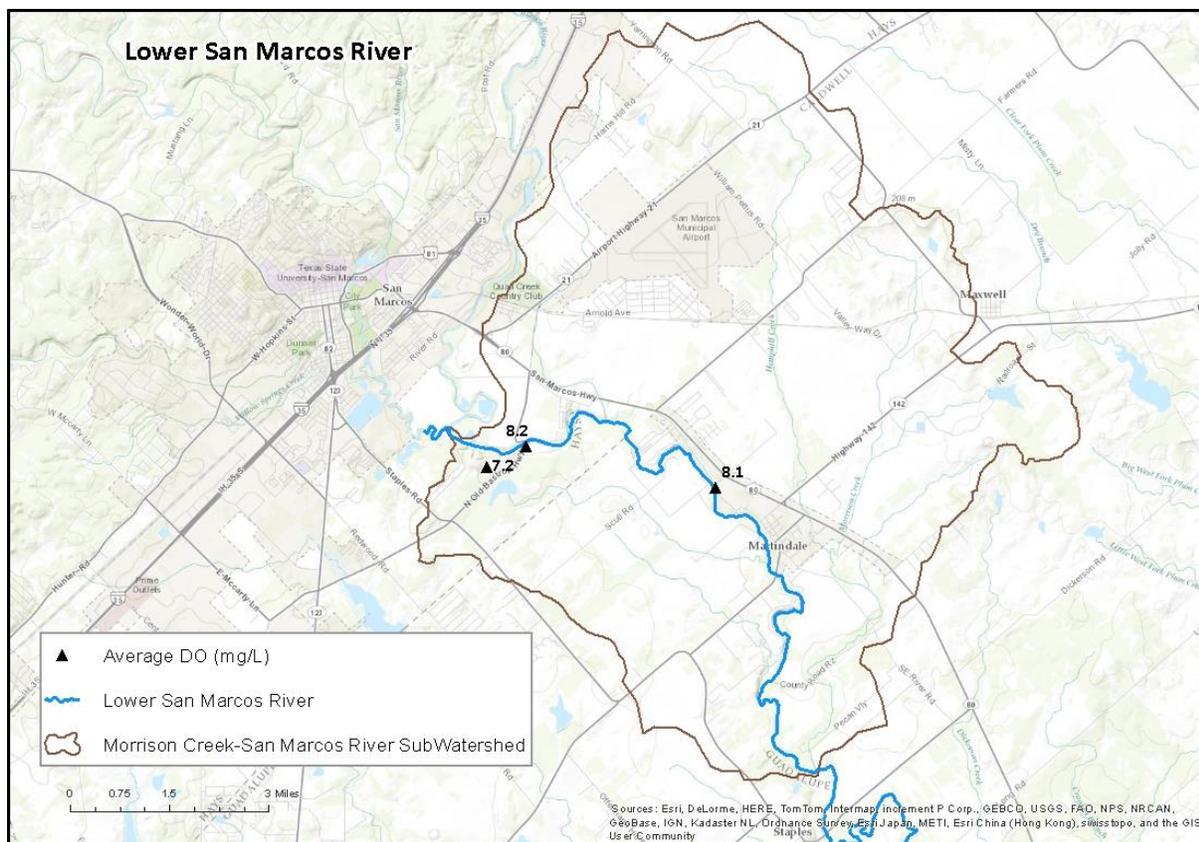


Figure 13: Map of dissolved oxygen for sites in the Lower San Marcos Watershed

The pH levels are an important indicator for the overall health of the watershed as well. Aquatic inhabitants typically require a pH range between 6.5 and 9 for the most optimum environment. Anything below 6.5 or above 9 can negatively impact reproduction or can result in fish kills. There were no reported pH levels outside of this widely accepted range. Sites 15491 and 19492 had the highest average pH level, with a result of 7.9 ± 0.3 , and 7.9 ± 0.2 respectively. Site 14436 had the lowest average pH level, with a result of 7.8 ± 0.3 .

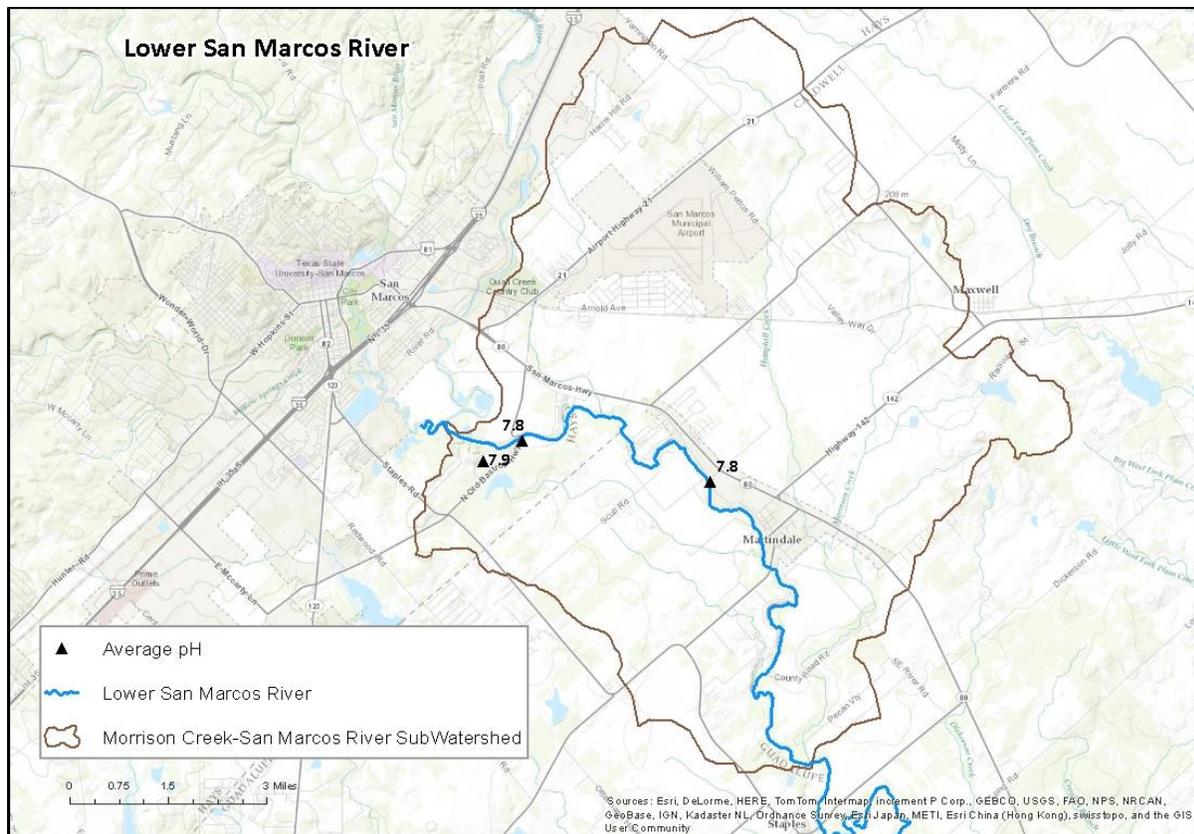


Figure 14: Map of pH for sites in the Lower San Marcos Watershed

Nitrates and phosphates from sewage, fertilizers, and pet waste can cause depressed oxygen concentrations in the water due to eutrophication. Site 15492 had the minimum nitrate and phosphate concentrations with $0.53 \pm 0.59\text{mg/L}$ and $0.16 \pm 0.23 \text{ mg/L}$ respectively. Site 15491 had the highest nitrate and phosphates with concentrations of $1.5 \pm 2.7 \text{ mg/L}$ and $0.35 \pm 0.54 \text{ mg/L}$ respectively.

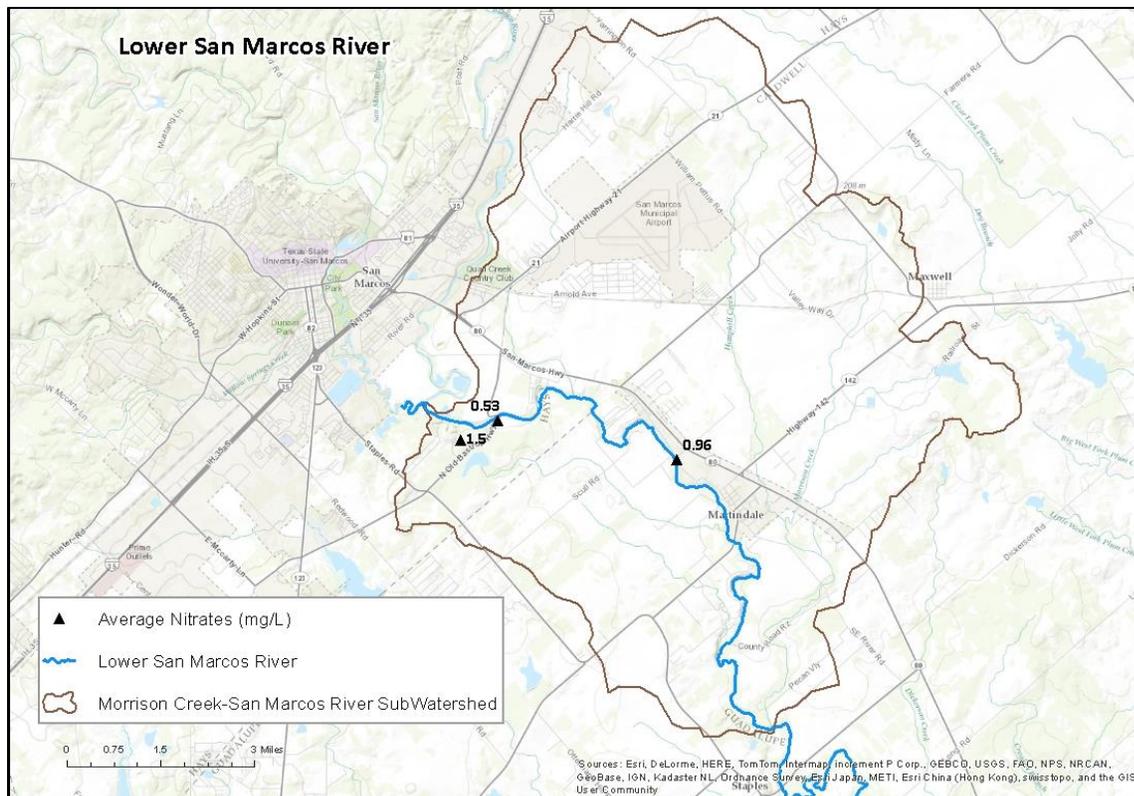


Figure 15: Map of nitrates for sites in the Lower San Marcos Watershed

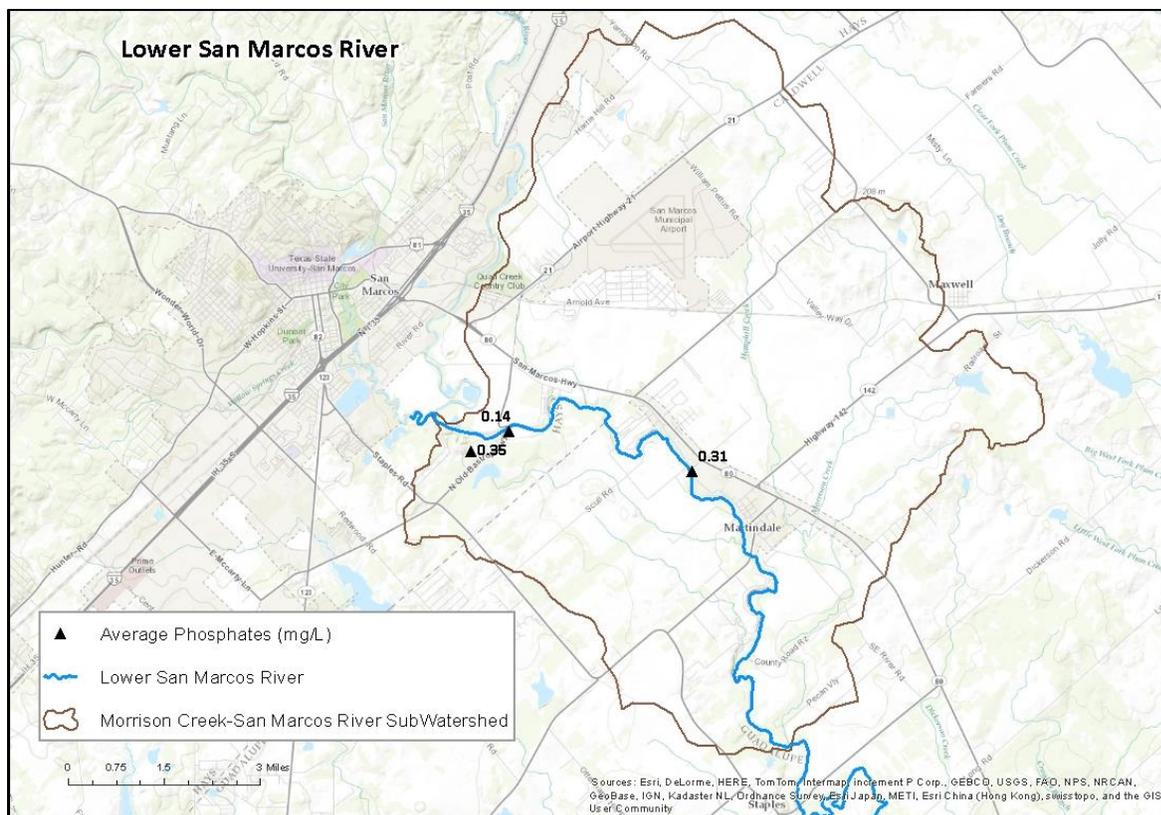


Figure 16: Map of phosphates for sites in the Lower San Marcos Watershed

Please see Table 5 for a summary of average results at all sites. It is important to note that not all sites were tested for *E. coli*. Additionally, it is also important to note that there was variation in the number of times each site was tested, the time of day at which each site was tested, and the time of month the sampling occurred. While this is a quick overview of the results, it is important to keep in mind that there is natural diurnal and seasonal variation in these water quality parameters. Texas Stream Team citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards.

Table 5: Average Values for all sites

Site Number	TDS (mg/L)	DO (mg/L)	pH	Nitrates (mg/L)	Phosphates (mg/L)
14436	376 ± 30 (min)	8.1 ± 1.4	7.8 ± 0.3 (min)	0.95 ± 1.3	0.31 ± 0.50
15491	387 ± 88	7.2 ± 0.8 (min)	7.9 ± 0.3 (max)	1.5 ± 2.7 (max)	0.35 ± 0.54 (max)
15492	400 ± 87 (max)	8.2 ± 1.1 (max)	7.9 ± 0.4 (max)	0.53 ± 0.59 (min)	0.16 ± 0.23 (min)

Site 15491 – San Marcos River at Cummings Dam

Site Description

This site is located just downstream of the confluence of the Blanco River with the San Marcos. A 15 – 20 ft. tall dam widens and deepens the river at this location. Both banks of the river have private property and remain undeveloped. Cypress trees are along the banks of the river at this site.

Sampling Information

This site was sampled 139 times between 9/22/1995 and 7/6/2014. The time of sampling for this site ranged from 08:00 to 20:00.

Table 6: Descriptive parameters for Site 15491

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	125	387 ± 88	202	774
Water Temperature (°C)	133	22.3 ± 3.9	12.0	35.0
Dissolved Oxygen (mg/L)	132	7.2 ± 0.8	5.2	9.5
pH	131	7.9 ± 0.3	6.9	8.9
Nitrates	50	1.48 ± 2.70	0	13.2
Phosphates	51	0.35 ± 0.54	0	3.0

Site was sampled 139 times between 9/22/1995 and 7/6/2014.

Air and water temperature

Air and water temperatures were taken 133 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 39.5 °C in September of 2000, and the lowest temperature of 6.0 in December of 2001. The mean water temperature was 22.3°C. Water temperature ranged from a low of 12.0°C in December of 2001, to a high of 35°C in June of 2000.

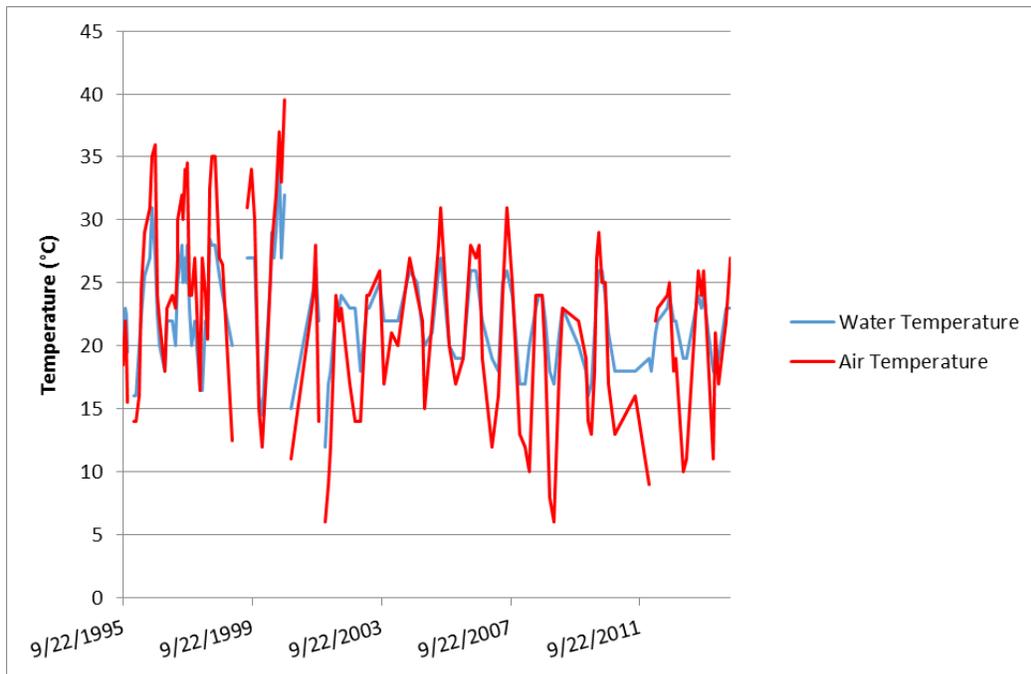


Figure 17: Air and Water Temperature at site 15491

Total Dissolved Solids

A total of 125 TDS samples were taken at this site during this time period. The mean concentration was 387 mg/L. The concentration of TDS ranged from a minimum of 202 mg/L in January of 1999, to a maximum of 774 mg/L in December of 1995. There was no significant trend in TDS concentration over time observed at this site.

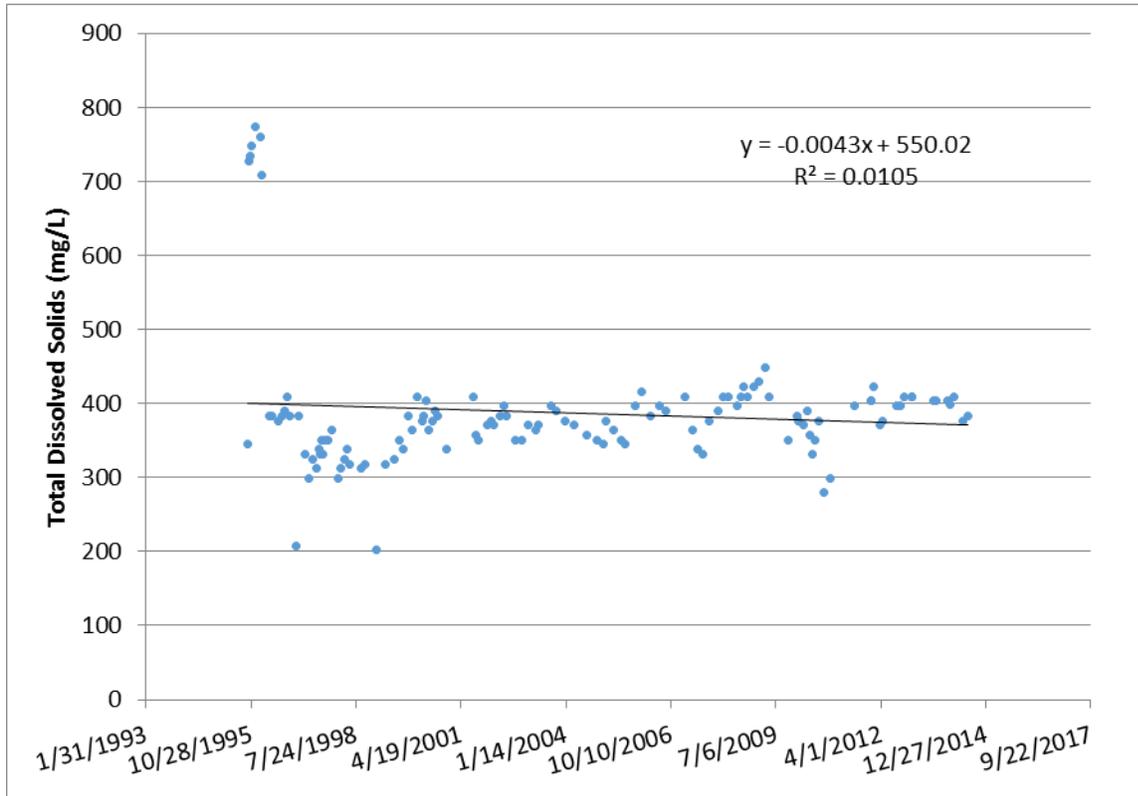


Figure 18: Total dissolved solids at site 15491

Dissolved Oxygen

Citizen scientists collected 132 DO samples at this site during this time period. The mean DO concentration was 7.2 mg/L. DO ranged from a low of 5.2 mg/L in July of 2012 to a high of 9.5 mg/L in December of 1995. There was a significant decrease in DO concentration over time observed at this site ($p = 0.000$). The R^2 value of 0.1608 indicates that this relationship explains about 16% of the variation in the data.

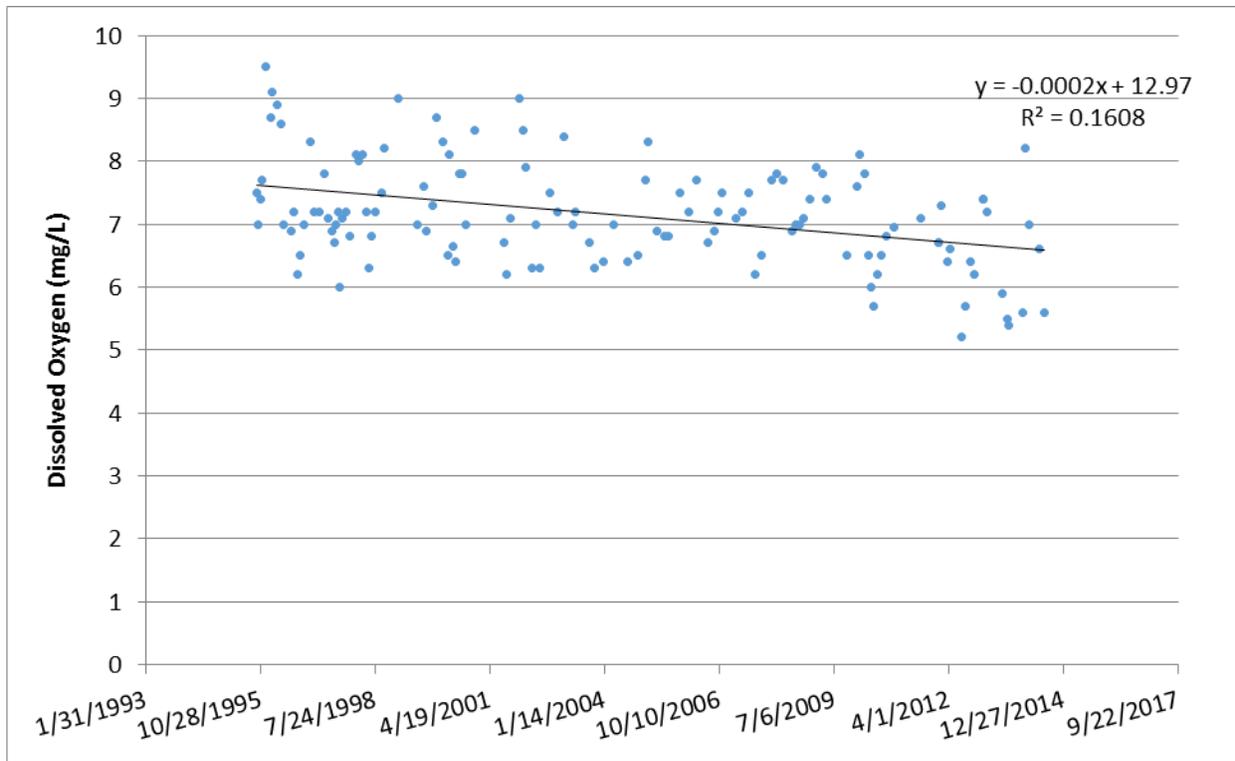


Figure 19: Dissolved oxygen at site 15491

pH

There were 131 pH measurements taken at this site during this time period. The mean pH was 7.9 and pH ranged from a low of 6.9 taken in August, 2008, to a high of 8.9 taken in in March 1996. There was no significant trend in pH over time observed at this site during this time.

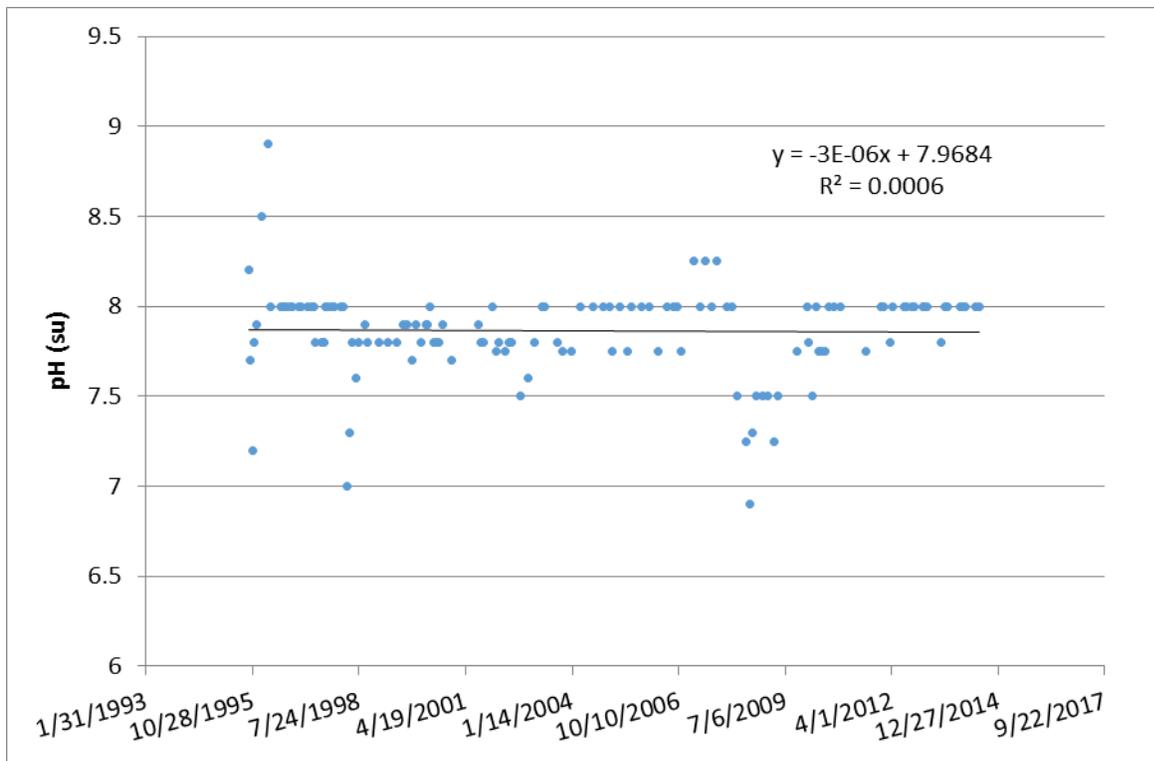


Figure 20: pH at site 15491

Secchi disk and total depth

The mean total depth of this site was 4.24 m. The Secchi disk depth was always less than the total depth which indicates that the water clarity was not clear enough to see the bottom at this site. The mean Secchi disk depth was 1.24 m and ranged from a low of 0.1 m to a high of 2.1 m.

Field Observations

The flow was typically recorded as normal. Algae cover was absent or rare. The water color was described as light green, and water clarity was clear. The water usually had no odor, but on a couple of occasions, the water was described as fishy smelling.

Orthophosphate

Citizen scientists collected 51 phosphate samples at this site. The mean phosphate concentration was 0.35 mg/L. Phosphate concentrations ranged from 0.0 mg/L to 3.0 mg/L, taken in February, 1998. There was no significant trend in phosphate concentrations over time observed at this site.

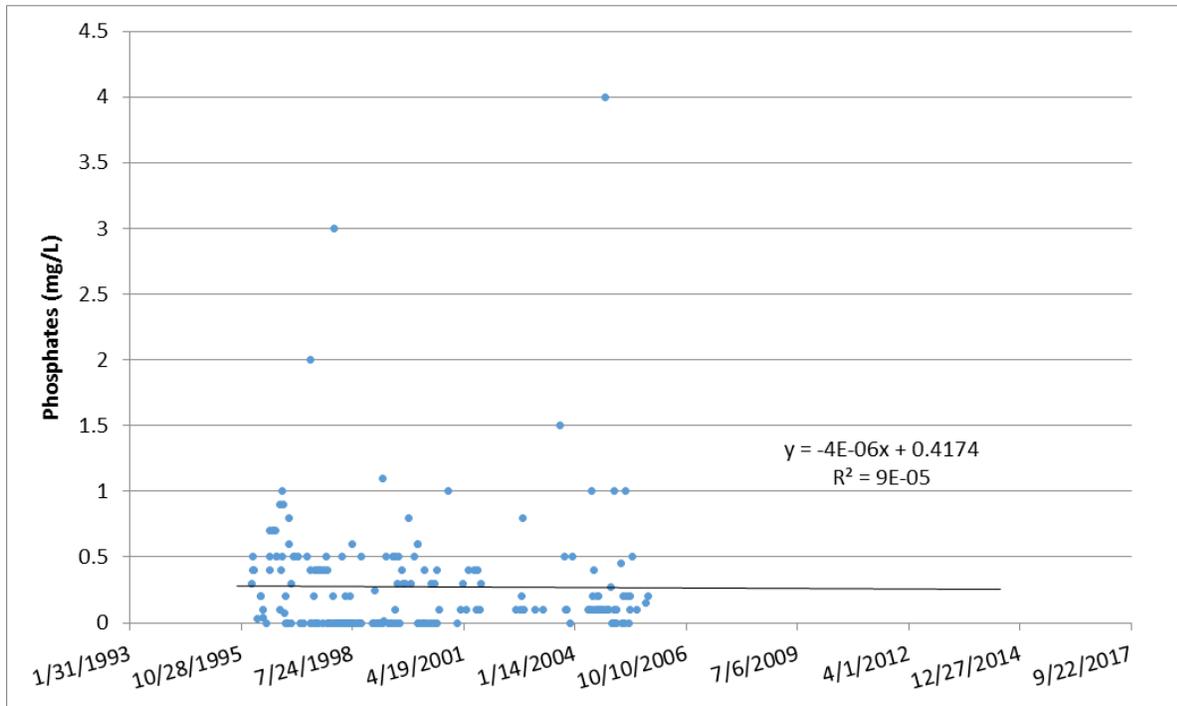


Figure 21: Phosphates at site 15491

Nitrate-Nitrogen

Citizen scientists collected 50 nitrate samples at this site. The mean nitrate concentration was 1.48 mg/L. Nitrate concentration ranged from 0.0 mg/L to 13.2 mg/L, which was taken in February and April of 2000. There was no significant trend in nitrate concentration over time observed at this site during this time.

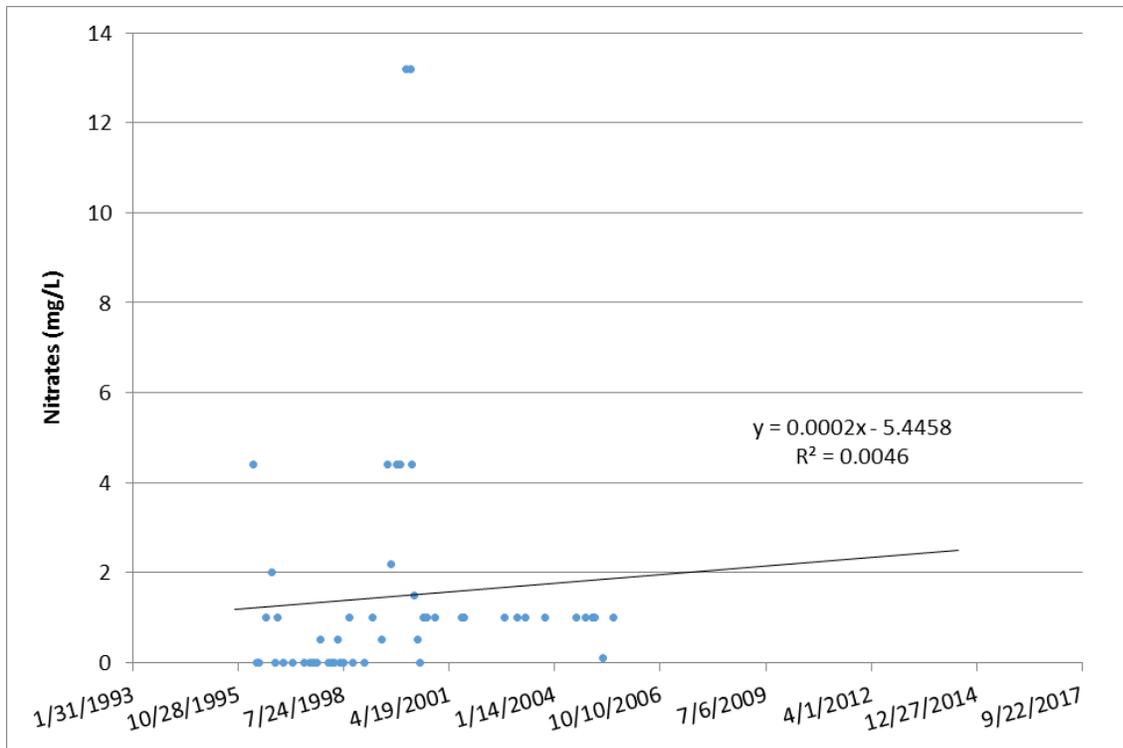


Figure 22: Nitrates at site 15491

Site 15492 – San Marcos River at Old Bastrop Highway

Site Description

This site is located at the Old Bastrop Highway crossing of the river. It is slightly downstream of a small riffle and is fairly shallow. An RV park is located on the north bank, and undeveloped rangeland is on the south bank. Both sides of the river have cypress trees. This spot is a popular put in location for paddlers and tubers.

Sampling Information

This site was sampled 208 times between 9/22/1995 and 6/4/2014. The time of sampling at this site between 08:00 and 20:00.

Table 7: Descriptive parameters for Site 15492

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	195	400 ± 87	195	774
Water Temperature (°C)	206	21.3 ± 3.8	0	31.0
Dissolved Oxygen (mg/L)	202	8.2 ± 1.1	5.0	10.6
pH	202	7.8 ± 0.3	6.8	8.5
Nitrates	54	0.53 ± 0.59	0	2.0
Phosphates	62	0.16 ± 0.22	0	0.8

Site was sampled 208 times between 9/22/1995 and 6/4/2014.

Air and water temperature

Air and water temperatures were taken 206 times at this site. The highest air temperature was 41°C and occurred in October of 2012. The lowest air temperature was 0°C and took place in March of 2007. The mean water temperature was 21.3°C. The lowest water temperature was 0°C, and was recorded in March of 2007. The highest water temperature was 31°C in May of 2013.

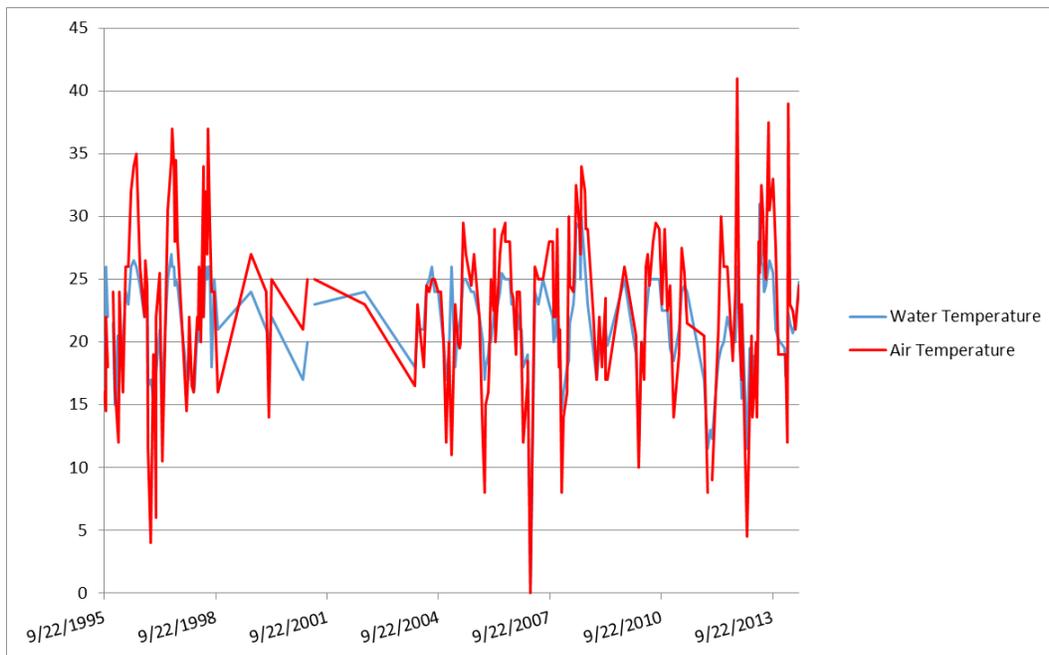


Figure 23: Air and water temperatures at site 15492

Total Dissolved Solids

Citizen scientists took 195 TDS measurements at this site during this time. The mean TDS concentration was 400 mg/L. The TDS concentrations ranged from a low of 195 mg/L in January of 1997, to a high of 774 mg/L in December of 1995. There was no significant correlation between TDS concentrations and time observed for this site.

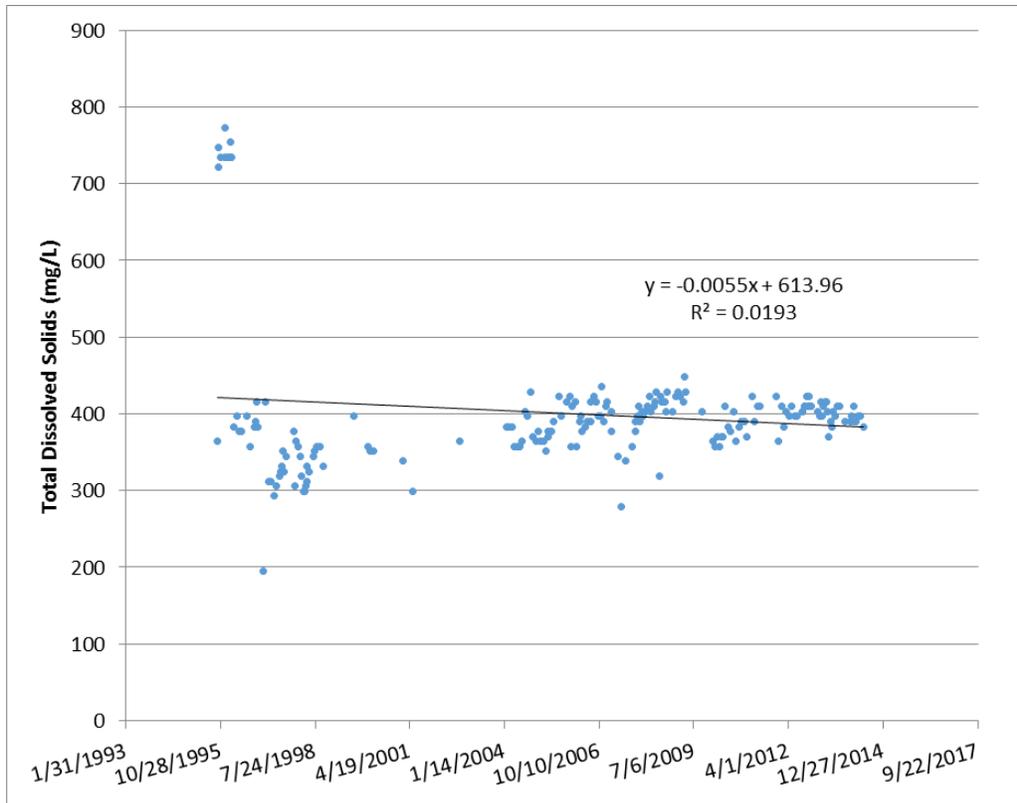


Figure 24: Total Dissolved Solids at site 15492

Dissolved Oxygen

Citizen scientists collected 202 DO samples at this site during this time. The mean DO concentration was 8.2 mg/L. The minimum DO concentration was 5.0 and was taken in October of 2010. The maximum DO concentration was 10.6 mg/L and was taken in February of 2006. There was a significant decrease in dissolved oxygen over time observed at this site ($p = 0.000$). The R^2 value of 0.0947 indicates that this relationship explains about 9.5% of the variation in the data.

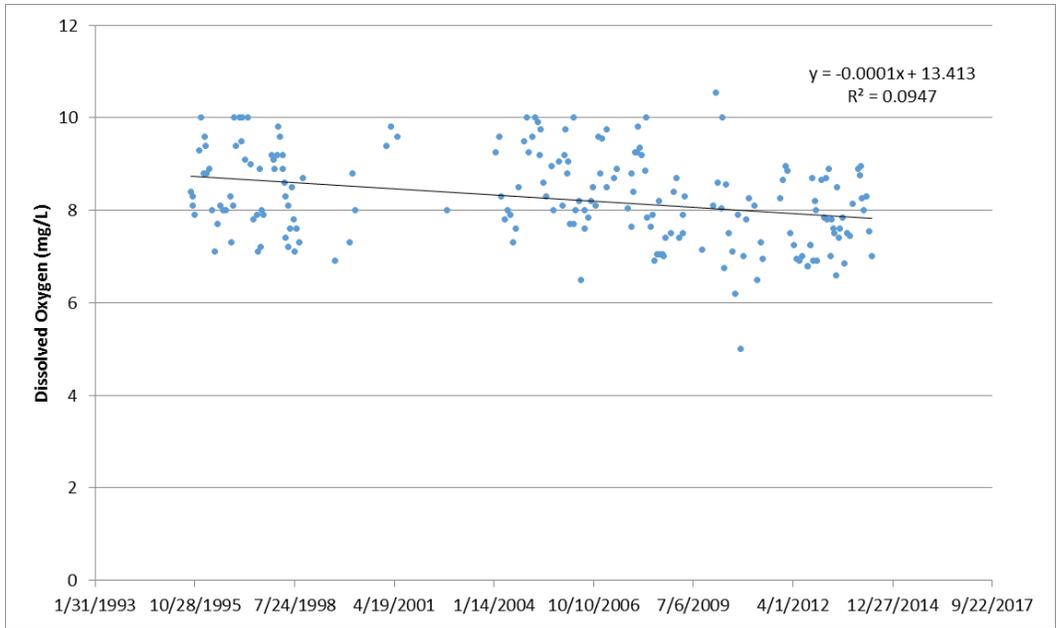


Figure 25: Dissolved Oxygen at site 15492

pH

There were 202 pH measurements taken from this site during this time. The mean pH was 7.8 and it ranged from a low of 6.8 in October of 2012, to a high of 8.5 on several occasions. There was a significant decrease in pH over time. The R^2 value of 0.208 indicates that this relationship between pH and time at this site is a relatively strong correlation.

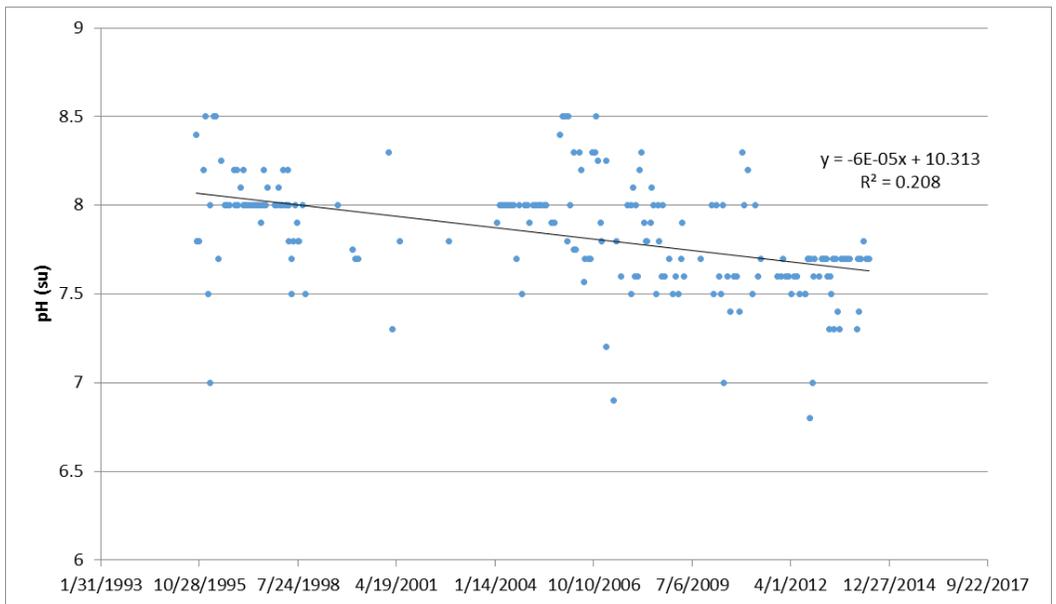


Figure 26: pH at site 15492

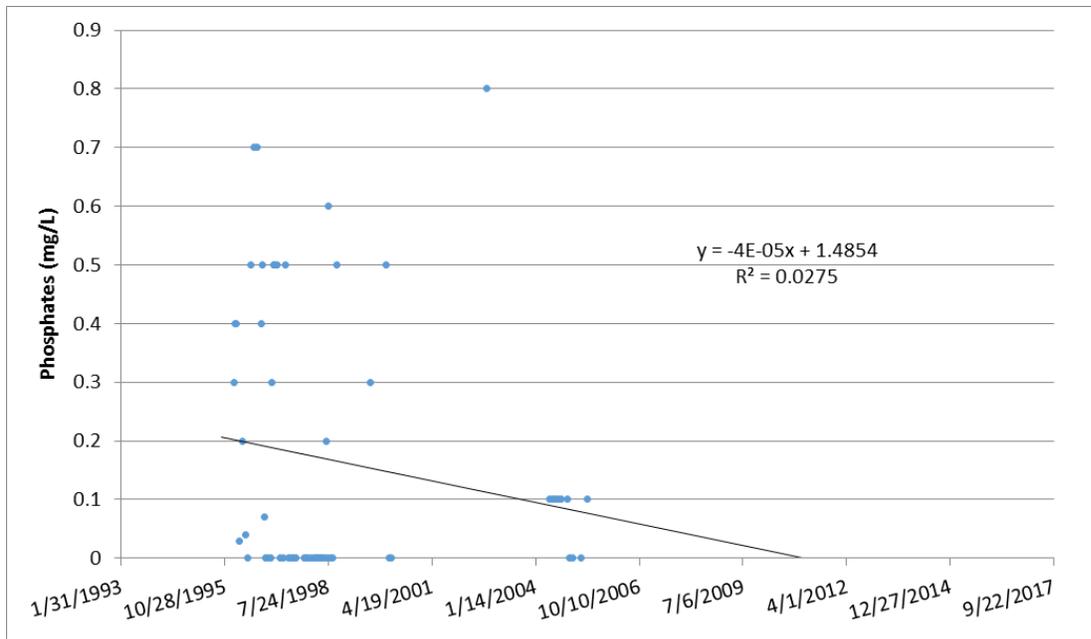


Figure 28: Nitrates at site 15492

Site 14436 – San Marcos River at Sculls Crossing

Site Description

This site is located at the Scull Rd. low water crossing. There is farmland on the east bank of the river and several houses on both sides. Scull Rd. crosses the river over a gravel shoal. There are cypress trees on both banks of the river.

Sampling Information

This site was sampled 197 times between 7/14/1996 and 2/23/2014. The time of sampling ranged from 07:00 to 19:00.

Table 8: Descriptive parameters for Site 14436

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	167	375 ± 30	254	429
Water Temperature (°C)	193	21.2 ± 4.2	6.0	28.9
Dissolved Oxygen (mg/L)	183	8.1 ± 1.4	4.0	11.8
pH	193	7.8 ± 0.3	7.0	8.5
Nitrates	80	0.96 ± 1.3	0	6.6
Phosphates	82	0.31 ± 0.50	0	4.0

Site was sampled 197 times between 7/14/1996 and 2/23/2014.

Air and water temperature

Air and water temperatures were taken 193 times at this site during this time period. Air temperatures ranged from a low of 2°C in March of 2013, to a high of 38°C in June of 2008. The mean water temperature was 21.2°C. Water temperature ranged from a low of 6°C to a high of 28.9°C in August of 2002.

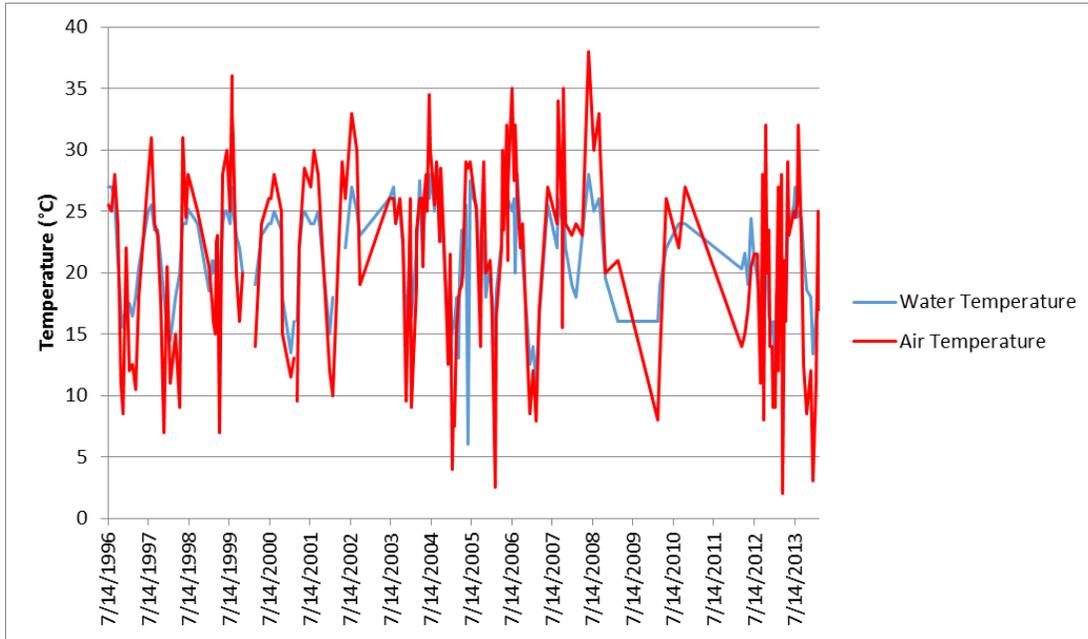


Figure 29: Air and water temperatures at site 14436

Total Dissolved Solids

Citizen scientists recorded 167 TDS measurements at this site. The mean TDS concentration was 375 mg/L. The minimum TDS concentration was 254 mg/L and was recorded in March, 1999. The maximum TDS concentration was 429 mg/L and was recorded in September of 2008. There was a significant increasing trend in TDS concentrations over time observed ($p = 0.000$). The R^2 value of 0.3328 indicates that this was a relatively strong correlation between TDS concentrations and time for this site.

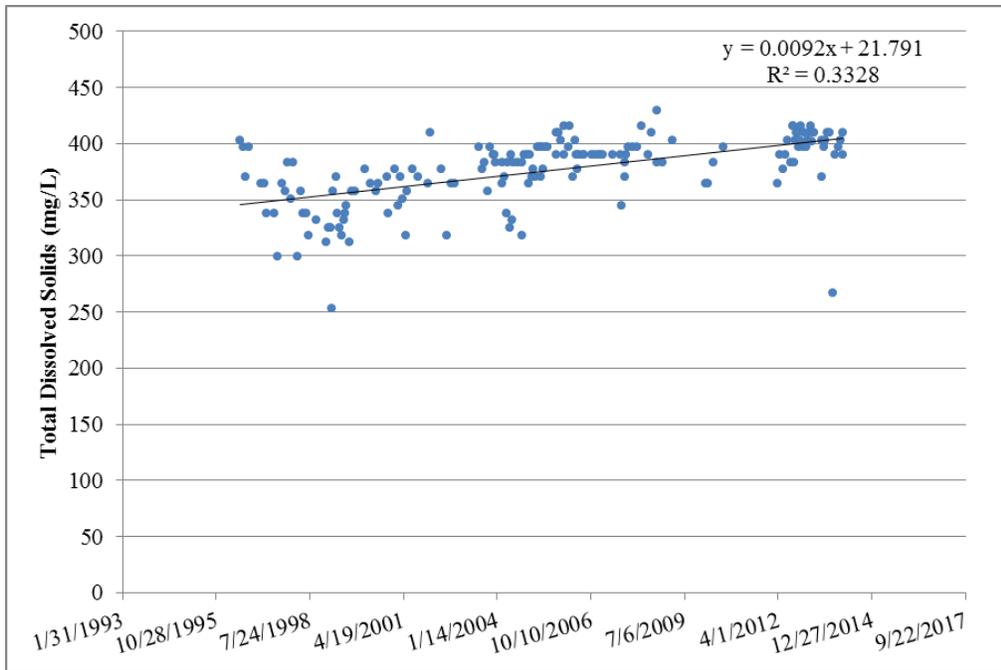


Figure 30: Total Dissolved Solids at site 14436

Dissolved Oxygen

Citizen scientists collected 183 DO samples during this time period. The mean DO concentration was 8.1 mg/L. DO concentrations ranged from a minimum of 4.0 mg/L in August of 2013, to a high of 11.8 mg/L in March of 2004. There was no significant increase or decrease in DO concentrations for this site during this time.

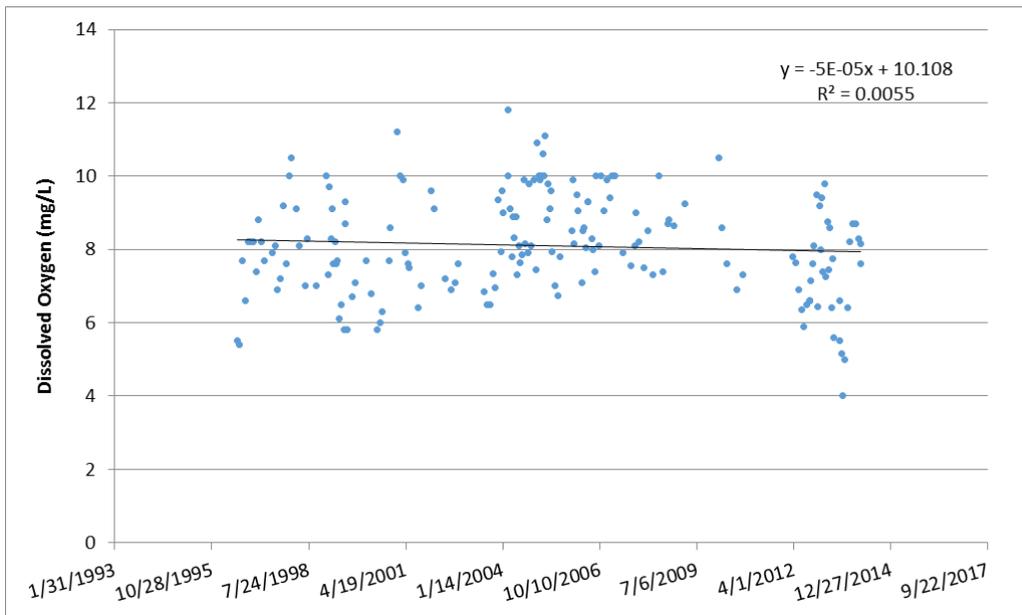


Figure 31: Dissolved Oxygen at site 14436

pH

Citizen scientists took 193 pH measurements at this site during this time. The mean pH was 7.8. The range of pH varied from a low of 7.0 in July of 2006, to a high of 8.5 in January of 2006. There was a significant decrease in pH over time observed at this site. The R^2 value of 0.2462 indicated that this relationship explains about 24.6% of the variation in the data.

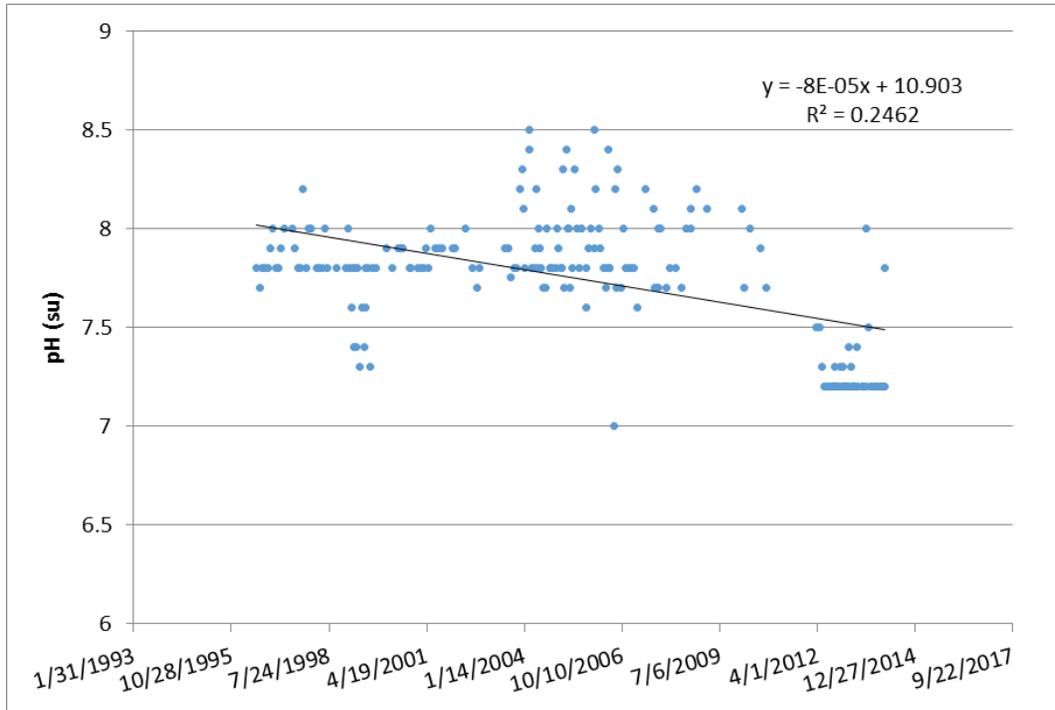


Figure 32: pH at site 14436

Secchi disk and total depth

The Secchi disk depth was rarely greater than the total depth, indicating that the water clarity at this site was such that the bottom of the river was usually not visible. The mean total depth at this site was 2.02 m, and the mean Secchi disk depth was 1.28 m. Secchi disk depth ranged from 0.4 to 2.1 m at this site.

Field Observations

Flow at this site was usually described as normal or low. The algae cover was usually absent or rare, but there were a few instances where it was described as common (26 – 50%). Water color was clear to light green. The water clarity was clear with a few instances of the water being described as cloudy. The water had no discernible odor at this site.

Orthophosphate

Citizen scientists took 82 phosphate samples at this site. The mean phosphate concentration was 0.31 mg/L. Phosphate concentrations ranged from a minimum of 0.0 mg/L to a maximum of 4.0 mg/L in October of 2004. There was no significant trend in phosphate concentrations over time observed at this site.

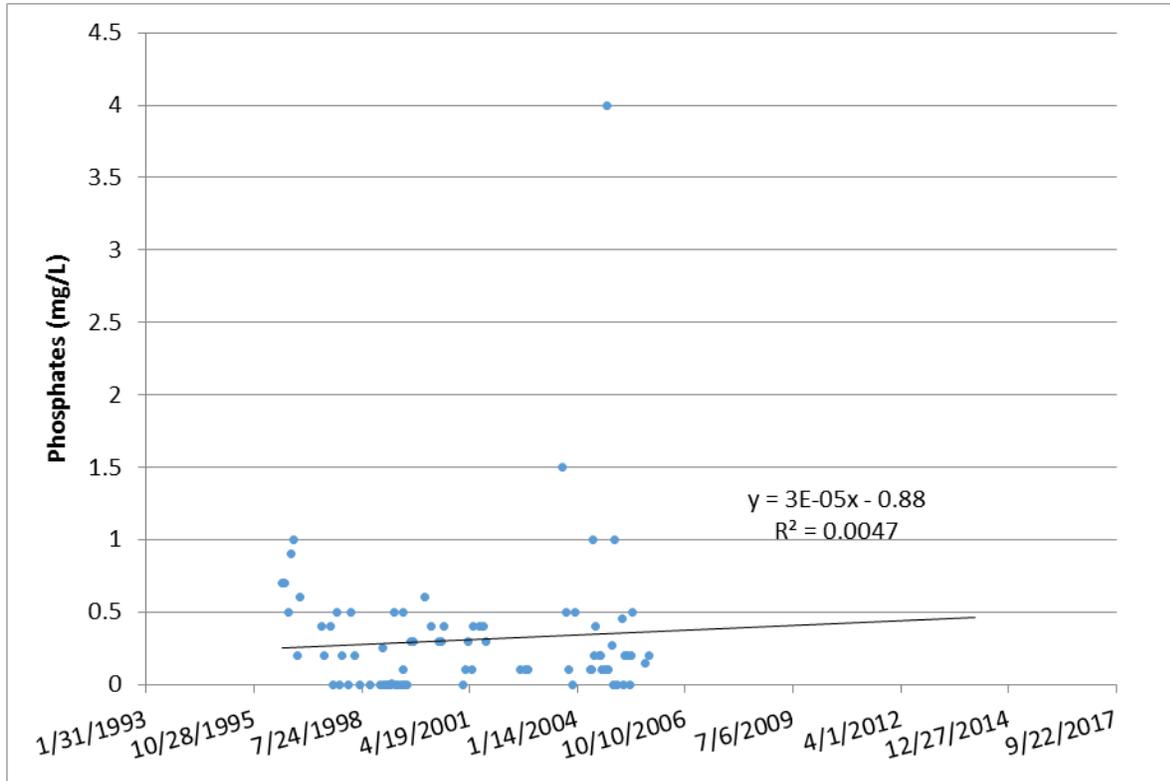


Figure 33: Phosphates at site 14436

Nitrate-Nitrogen

Citizen scientists collected a total of 80 nitrate samples at this site. The mean nitrate concentration was 0.96 mg/L. Nitrate concentrations ranged from a low of 0.0 mg/L to a high of 6.6 mg/L in March, 2000. There was no significant trend in nitrate concentrations over time observed at this site.

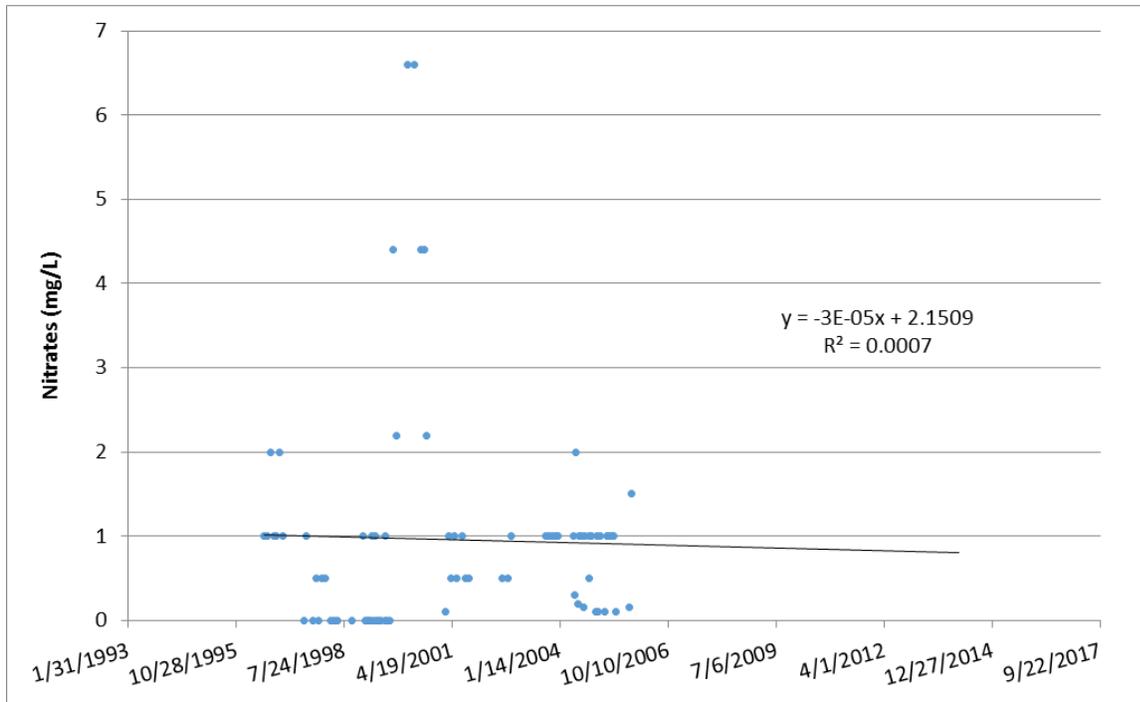


Figure 34: Nitrates at site 14436

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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- Texas Water Safari, <http://www.texaswatersafari.org>

Appendix A- List of Maps, Tables, and Figures

Tables

Table 1: Sample Storage, Preservation, and Handling Requirements	9
Table 2: Summary of Surface Water Quality Standards for the Lower San Marcos Watershed	11
Table 3: Descriptive parameters for all sites in the Lower San Marcos River Watershed	14
Table 4: Average Dissolved Oxygen values by Sampling Time within the Lower San Marcos Watershed	17
Table 5: Average Values for all sites	24
Table 6: Descriptive parameters for Site 15491	25
Table 7: Descriptive parameters for Site 15492	30
Table 8: Descriptive parameters for Site 14436	35

Figures

Figure 1: Map of the Lower San Marcos Watershed.....	5
Figure 2: Map of the Lower San Marcos Watershed with Texas Stream Team Monitor Sites	12
Figure 3: Breakdown of monitoring events by year.	13
Figure 4: Breakdown of monitoring events by month.	13
Figure 5: Breakdown of time of monitoring in the Lower San Marcos Watershed	14
Figure 6: Air and water temperature over time at all sites within the Lower San Marcos Watershed	15
Figure 7: Total Dissolved Solids over time at all sites within the Lower San Marcos Watershed.....	15
Figure 8: Dissolved oxygen and water temperature over time at all sites in the Lower San Marcos Watershed	16
Figure 9: pH over time at all sites within the Lower San Marcos Watershed	18
Figure 10: Phosphates over time at all sites within the Lower San Marcos Watershed	18
Figure 11: Nitrates over time at all sites within the Lower San Marcos Watershed	19
Figure 12: Map of the average total dissolved solids for sites in the Lower San Marcos Watershed	20

Figure 13: Map of dissolved oxygen for sites in the Lower San Marcos Watershed	21
Figure 14: Map of pH for sites in the Lower San Marcos Watershed	22
Figure 15: Map of nitrates for sites in the Lower San Marcos Watershed.....	23
Figure 16: Map of phosphates for sites in the Lower San Marcos Watershed.....	24
Figure 17: Air and Water Temperature at site 15491	25
Figure 18: Total dissolved solids at site 15491	26
Figure 19: Dissolved oxygen at site 15491	27
Figure 20: pH at site 15491.....	28
Figure 21: Phosphates at site 15491.....	29
Figure 22: Nitrates at site 15491	30
Figure 23: Air and water temperatures at site 15492.....	31
Figure 24: Total Dissolved Solids at site 15492.....	32
Figure 25: Dissolved Oxygen at site 15492	33
Figure 26: pH at site 15492.....	33
Figure 27: Phosphates at site 15492.....	34
Figure 28: Nitrates at site 15492	35
Figure 29: Air and water temperatures at site 14436.....	36
Figure 30: Total Dissolved Solids at site 14436.....	37
Figure 31: Dissolved Oxygen at site 14436	37
Figure 32: pH at site 14436.....	38
Figure 33: Phosphates at site 14436.....	39
Figure 34: Nitrates at site 14436	40