The Meadows Center for Water and the Environment
Texas State University
Texas Stream Team

MEDINA RIVER WATERSHED DATA REPORT

October 2019

Photo courtesy of Matthew Lee High

EPA United States Environmental Protection Agency

Texas Commission on Environmental Quality

TEXAS STATE UNIVERSITY
The rising STAR of Texas

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INTRODUCTION

Texas Stream Team

Texas Stream Team is a volunteer-based citizen science water quality monitoring program. Citizen scientist water quality monitoring occurs at predetermined monitoring sites, at roughly the same time of day each month. The information that Texas Stream Team citizen scientists collect is covered under a Texas Commission on Environmental Quality (TCEQ)-approved Quality Assurance Project Plan (QAPP) to ensure that a standard set of methods are used. The data may be used by professionals to identify surface 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 is not used by the state to assess whether water bodies are meeting the designated surface water quality standards. The data collected by Texas Stream Team provide valuable records, often collected in portions of a water body that professionals are not able to monitor frequently or monitor at all.

For additional information about water quality monitoring methods and procedures, including the differences between professional and volunteer citizens science monitoring, please refer to the following sources:

- Texas Stream Team Core Water Quality Citizen Scientist Manual
- Texas Stream Team Advanced Water Quality Citizen Scientist Manual
- Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring Procedures

The purpose of this report is to provide analysis of data collected by Texas Stream Team citizen scientists to inform partners and the public regarding the status of water quality at selected monitoring sites within the Medina River watershed. The data presented in this report should be considered in conjunction with other relevant water quality reports 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 Surface Water Quality
- Texas Clean Rivers Program (CRP) partner reports, such as Basin Summary Report and Basin Highlights Report
- TCEQ Total Maximum Daily Load (TMDL) reports and Implementation Plans (I-Plans)
- TCEQ and Texas State Soil and Water Conservation Board Nonpoint Source Program funded reports, including Watershed Protection Plans (WPPs)

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

Get Involved with Texas Stream Team

Once trained, citizen scientists 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 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.

Steering committee participants include representatives from the public, government, industry, business, agriculture, and environmental groups. For more information about participating in these steering committee meetings, please contact the CRP partner agency for your river basin.

WATERSHED DESCRIPTION

Location

The Medina River watershed is located entirely within south central Texas and is a part of the larger San Antonio River basin. Over 3,400 square kilometers of land make up the Medina River watershed and the watershed finds itself partially within Kerr, Kendall, Bandera, Medina, Bexar and Atascosa Counties (U.S. Geological Survey 2019, Hays 2004). The main stem of the Medina River begins at the confluence of the North Prong Medina River and the West Prong Medina River, which originate mostly from springs in northwest Bandera County. Cities that are along the Medina River include Medina, Bandera, Castroville and the southern boundaries of San Antonio. Before reaching southern San Antonio, the river flows into its only major reservoir within the basin, Medina Lake. The river flows generally southeast and east until it reaches the San Antonio River and continues to its terminus at San Antonio Bay near Seadrift, Texas. Here at the Central Texas Coast, the waters in San Antonio Bay make their way to the Gulf of Mexico.

While this report intends to describe the location, physical description, climate, ecoregion, land use, history and impairments of the entire Medina River watershed, the Texas Stream Team data included in this report is solely located within the watershed in Bandera County. See Figure 1 below to note the Medina River watershed on the western edge of the larger San Antonio River basin.

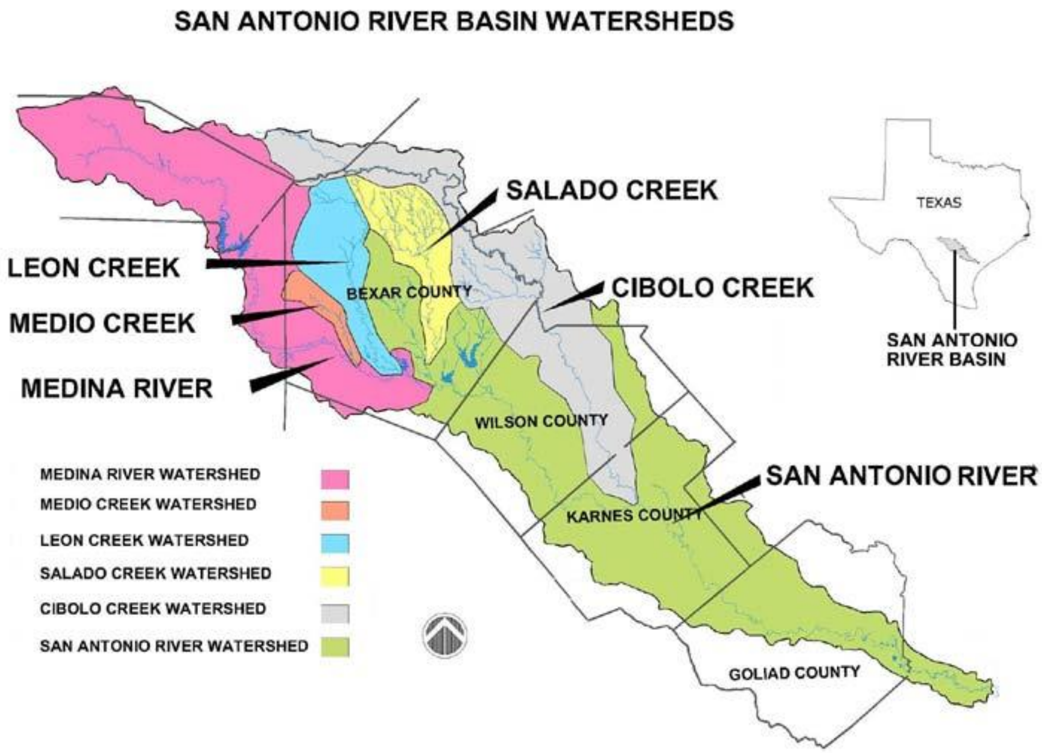

Figure 1: San Antonio River basin watersheds (San Antonio River Authority)

Physical Description

Largely found within the physiographic unit of North America known as the Great Plains, the Medina River originates from groundwater sources in the unique central Texas landscape commonly known as the Texas Hill Country (Mendel 2018, Holt 1959) and mostly follows a southeastern direction towards the Gulf of Mexico. The landscape of the Medina River watershed within the Texas Hill Country is characterized by cretaceous limestone bedrock, shallow to deep soils, and karst features such as sinkholes, river-cut terrain and unique aquifer systems (Bureau of Economic Geology 1996). Nearly halfway through its complete course, the river cuts across the Balcones Escarpment, a major fault line which acts as a barrier between the American Great Plains and the Gulf Coastal Plains (National Park Service 2017). Some surface flows of the Medina River are lost near the Balcones Escarpment due to infiltration (George 2011). Roughly between the river below the escarpment and its terminus at the confluence with the San Antonio River, the Medina River watershed is more characterized by rolling plains, deep clay soils, thorny brush and agricultural operations (Handbook of Texas Online 2010).

The topography of the watershed is highly dependent on each of the three ecoregions which the river traverses. These three ecoregions are individually explained in detail on the following page. From incised bedrock streams with high gradients (the ratio in drop of elevation) and meanders in the Texas Hill Country to lesser gradients and increasing meanders in the rolling plains, the river experiences varied topography before converging with the San Antonio River, which ultimately runs into the Gulf of Mexico (Mendel 2018).

Climate

The climate of most of the watershed is classified as subtropical and subhumid, characterized by hot summers and mild, dry winters (Larkin and Bomar 1983). During most years the hottest month is July and coldest month is January (Climate-Data.org 2019). Rainfall rates within the watershed range between 660 to 762 millimeters per year (Spatial Climate Analysis Service 2000). Average gross lake surface evaporation rates within the watershed range between 1702 and 1600 millimeters per year (Larkin and Bomar 1983).

Ecoregion

As the Medina River begins in northwestern Bandera County in the Texas Hill Country, it transects the Edwards Plateau ecoregion southeast-ward until a sharp southernly direction begins towards Medina Lake in southeastern Bandera County. The Edwards Plateau is characterized by karst topography (related to the weathering of limestone, a calcium carbonate substrate), grasslands, juniper-oak savanna, and mesquite-oak savanna with soils being mostly Mollisols. Here the river is largely fed by natural springs and is known to represent some of the most diverse habitats in the nation and some of the most scenic land in Texas (Holt 1959, Nature Conservancy 2019). This ecoregion is largely a dissected limestone plateau that is hillier to the south and east where a sharp fault line easily distinguishes it from bordering ecological regions (Griffith et al. 2004). Exiting Medina Lake the river courses southward again through the Southern Texas Plains and cuts eastward across the Texas Blackland Prairies as it finishes this 129-kilometer stretch from Medina Dam to its confluence with the San Antonio River (Griffith et al. 2004, Texas Commission on Environmental Quality 2002). The rolling hills among the Southern Texas Plains today are characterized by livestock grazing, fire suppression, and thorny brush such as mesquite with soils that range from alkaline to slightly acidic clay and clay loams (Griffith et al. 2004).

Land Use

The Medina River watershed is mostly undeveloped, has small-scale agriculture, or has low-intensity rural development. The watershed land within the Texas Hill Country is largely covered by deciduous forest and grassland with dense riparian zones and the agricultural activity is mostly confined to low-scale family farms which are usually under 99 acres in size (El-Hassan et al. 2015, Texas Land Trends 2017). While mostly undeveloped and rural, the watershed within the Texas Blackland Prairies ecoregion on the southern boundary of the City of San Antonio has some large-scale agricultural operations and industrial sites. Southerly-oriented tributaries of the Medina River drain areas with high-density urban development.

Because a large portion of the Edwards Aquifer is within the Medina River watershed, local and federal policies are often applied for the purpose of conservation. This includes the Edwards Aquifer Authority Act, adopted by the Texas Legislature in 1993, which created a regional water management agency responsible for the regulation of the Edwards Aquifer, the largest source of drinking water in the San Antonio region. This agency, the Edwards Aquifer Authority, has complete regulatory jurisdiction in many counties within the Medina River watershed and regulates groundwater pumping and water quality based on land use within the watershed (Edwards Aquifer Authority, 2019). Locally, conservation easements are common within the Medina River watershed with over 5,000 acres of land being under conservation easements within Bexar, Medina and Bandera counties (Lund et al. 2019). Local conservation efforts also include activities on the part of non-profit organizations, including the Medina River Protection Fund, the Lake Medina Conservation Society, and the Nature Conservancy.

History

The Medina River watershed has likely been inhabited by peoples that would have been present in prehistoric times based on scattered artifacts found within the watershed. Several Native American tribes have been documented to have roamed the upper portions of the watershed, including Lipan Apache, Apache and Comanche (Nature Conservancy 2019). The river itself is named after the Spanish engineer Pedro Medina by the power of the governor of Coahuila, Alonso De León, in 1689. Medina created navigation tables that helped De León map his route through the river valley (Tobin 2010). Historic maps indicate the Medina River was previously named Río Mariano, Río San José, and Río de Bagres—Catfish River (Tobin, 2010). In 1718, the western boundary of Texas was identified as the Medina River and eventually was changed to the Nueces River (Frkuska 1982). The Republican Army of the North, fighting for Mexican independence from Spain, were defeated in the battle of Medina on August 18, 1813. At the very same battle site, Santa Anna paused to gather forces in 1836 before heading on to meet with Texans in the Alamo (Tobin 2010). In 1844, Henri Castro negotiated contracts to colonize the new Republic of Texas (Frkuska 1982). He was granted land in parts of Medina, Uvalde, and Frio Counties, and chose a site at a bend of the river to be designated as farmland for French and German immigrants (Tobin 2010). This area of the Medina valley would be known as Castroville, however Castro and his partner, A. F. Louis Huth, would continue colonizing other areas in the valley. The floods and droughts of the Balcones Fault zone influenced Castro to supposedly be the first to foresee a dam on the box canyon. An earthen dam was built in 1850, and later replaced by stone for use of a downriver mill (Tobin, 2010).

Small bands of shingle makers and charcoal burners began camping along the river in the late 1840s, protected from Native American threats by the Texas Rangers, and utilizing the abundance of pecan and cypress trees. In 1852, John James, Charles Demontel, and John Herndon formed a partnership to form a cypress-lumber mill and a town at one of these shingle-maker camps. This town became known as Bandera, Spanish for ‘flag’. Henri Castro’s idea of a dam on box canyon fully came into fruition when Alex Walton, Frederick Stark Pearson and Clint Kearny launched a project to build a dam with canals to carry irrigation water to farmlands around Natalia. The new Medina Lake stood dry for a whole year after its construction in 1912 and suffered record dry periods in the 1930s and 1950s. On August 2, 1978, a ‘500-year’ flood brought forty-eight inches on the North Prong in under twenty-four-hours, as well as twenty-two deaths and millions of dollars of property damage. Medina valley became characterized by livestock and recreation hunting until the 1980s, when Baxter Adams, Jr. began a dwarf apple tree orchard. The especially sweet apples became so prevalent by 1989, that the Texas Department of Agriculture declared Medina the Apple Capital of Texas. To this day, Medina hosts the annual Medina Apple Festival on the last Saturday of July (Tobin 2010, Smyrl 2010).

Water Quality Impairments

The TCEQ’s 2016 Texas Integrated Report of Surface Water Quality divides the Medina River into four Unique Segment identification numbers (SEGID) within the San Antonio River Basin, starting from the confluence of the San Antonio River and spanning to the headwaters in Bandera County. The Integrated

Report specifies whether each segment meets water quality standards, does not meet water quality standards (referred to as an impairment), or has a concern for not meeting water quality standards. The Integrated Report shows that there are no water quality impairments in the headwater segment of the Medina River or in the segment that solely includes Medina Lake and Medina Diversion Lake. Impaired segments listed in the Texas Integrated Report's 303(d) list, a list of water bodies with one or more impairments, include the Medina River below Medina Diversion Lake to the San Antonio River (SEGID 1903) and the Medina River above Medina Lake (SEGID 1905). The State's water quality impairments and concerns for Medina River are detailed as follows.

SEGID #1903 encompasses the Medina River Below the Medina Diversion Lake and has five further subdivisions (Unique Assessment Unit codes or AUID). Starting downstream and moving upstream, AUID #1903_01 was reported to have a concern for nitrate and total phosphorus. AUID #1903_02, which starts 2 kilometers up from Palo Blanco Creek and runs to the confluence of Lower Leon Creek, is impaired for high levels of *E. coli*. AUID #1903_02 was also reported as having a concern for ammonia, nitrate, and total phosphorus. AUID #1903_03, which runs upstream from Lower Leon Creek to Medio Creek, was also reported as having a concern for nitrate and *E. coli*. AUID #1903_04, which runs from Medio Creek to Polecat Creek, was also reported with a concerning level of nitrate. There are no water quality impairments in AUID #1903_05, or in SEGID #1904, which encompasses Medina Lake and has three Assessment Units. SEGID #1905, which encompasses the Medina River above Medina Lake, has two Assessment Units. AUID #1905_01, which runs upstream of Red Bluff Creek to RM 470, was reported as having concern for an impaired habitat and was on the 303(d) List for an impaired fish community. AUID #1905_2, which runs from RM 470 to the North Prong Medina River, was reported as having a concern for an impaired fish community. These impaired fish communities likely are caused by an abundance of low water crossings and small dams that disable passage for fish. Lastly, SEGID #1905A, which runs from the confluence with the Medina River to the headwaters in Bandera County, shows no water quality impairments (Texas Commission on Environmental Quality 2018).

In the TCEQ's 2016 Texas Integrated Report of Surface Water Quality there were no sites along the Medina river which were removed from the previous Texas Integrated Report's 303(d) list. There was a site along the Leon River, a tributary of the Medina River, removed from the 303(d) list. This site is SEGID #1906 and was originally listed due to depressed dissolved oxygen. This site now meets water quality standards (Texas Commission on Environmental Quality 2018). According to the Texas Fish Consumption Advisory Viewer provided by Texas Health and Human Services, there are no fish advisory warnings along the Medina River. There are several fish advisory warnings along Leon Creek, a tributary of the Medina River. The advisories listed for Leon Creek state that fish should not be consumed from Lower Leon Creek due to high levels of PCB found in fish tissue (Texas Health and Human Services 2019).

Wastewater Treatment Facilities

Wastewater treatment facilities (WWTFs) are considered direct discharges of pollutant loads and can be a continuous source of bacteria or nutrient loading. WWTFs are operated under permits issued by the TCEQ's Texas Pollutant Discharge Elimination System.

Texas Stream Team has identified five WWTFs within the Medina River watershed that discharge into surface waters. Within the portion of the watershed upstream of Medina Lake, one WWTF exists at the city of Bandera and discharges into the Medina River. Two cities downstream of Medina Lake that each have WWTF are the cities of Castroville and Lacoste and they both discharge into the Medina River. Other WWTFs within the lower portion of the basin include two WWTF discharge points operated by the San Antonio Water System.

On-Site Sewage Facilities

Bacteria and nutrient loads from On-Site Sewage Facilities (OSSF) are considered nonpoint sources of pollution. OSSFs typically treat waste from single residences that are not connected by a sanitary sewer line to a WWTF and are commonly found in rural parts of the state such as the Medina River watershed.

Endangered Species and Conservation Needs

Within the six counties in the Medina River watershed (Bandera, Kerr, Kendall, Medina, Bexar, and Atascosa Counties), there are 205 species listed as rare, threatened, or endangered (under the authority of Texas state law and/or under the US Endangered Species Act). Please see Appendix 1: at the end of this report for this information.

WATER QUALITY PARAMETERS

Water Temperature

Water temperature influences the physiological processes of aquatic organisms, and each species has an optimum temperature for survival. The ability of water to hold oxygen in solution (solubility) decreases as temperature increases. Therefore, 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.

Natural variations in water temperature occur seasonally and diurnally (daily). Water temperatures tend to increase during summer and decrease in winter in the Northern Hemisphere. Diurnal water temperature changes occur during normal heating and cooling patterns. Man-made sources of warm water can include power plant effluent used for cooling and releases of warm water by hydroelectric plants. 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

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in water. 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 streamflow.
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 and algae, which may starve subsurface vegetation of sunlight and, therefore, limit the amount of DO in a water body due

to reduced photosynthesis and increased decomposition of decaying organic matter. 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 inflows of groundwater which have minimal aeration, high temperatures that reduce oxygen solubility, or water releases from deeper portions of dams where thermal and DO stratification occur. Supersaturation typically occurs in areas underneath waterfalls or dams with water flowing over the top where water is continually aerated.

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 microsiemens per centimeter (µS/cm). A body of water is more conductive if it has more total dissolved solids (TDS) 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 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 measured in milligrams per liter (mg/L).

pH

The pH scale measures the concentration of hydrogen ions on a range of zero 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 one-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. Sources of carbon dioxide emissions may result from deforestation and burning of fossil fuels. The most suitable pH range for healthy organisms is between 6.5 and 9.0.

Secchi Disk and Total Depth

The Secchi disk is used to determine the clarity of the water, a condition known as turbidity. Two depth readings are taken by Citizen Scientists and averaged for a final value. The first reading is taken from lowering the disk and noting when it disappears, and the second reading is taken from bringing the disk up from a depth where it is not visible to a depth at which it reappears (barely visible). 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 commonly transported in sediment rather than in the water. Turbid waters can result from high flows, 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 cloudy or more turbid water. Readings that are equal to total depth indicate clear water.

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. A pathogen is a biological agent that causes disease. The standard for *E. coli* impairment according to TCEQ is based on a single sample maximum criterion (399 CFU/100 mL) and the geometric mean (geomean) (126 CFU/100 mL). 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. A water body is considered impaired if the geometric mean is higher than 126 CFU/100 mL. *E. coli* samples may also be evaluated with the single sample criterion for purposes of swimmer safety notification programs and wastewater permit compliance.

Texas Water Quality Standards

The Texas Surface Water Quality Standards establish explicit goals in the form of numeric and narrative standards and criteria 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 they support public health and protect 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 (drinking water). The water quality parameters used to evaluate support of those uses include DO, temperature, pH, TDS, toxic substances, and bacteria.

The Texas Surface Water Quality Standards also consist of 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 Core Water Quality Citizen Scientist Manual, the Texas Stream Team Advanced Water Quality Citizen Scientist Manual, 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).

Processes to Prevent Contamination

Procedures documented in Texas Stream Team Water Quality Citizen Scientist Manuals 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 samples or blanks are collected to verify that contamination has not occurred.

Documentation of Field Sampling Activities

Field sampling activities are documented on the Citizen Scientist Environmental Monitoring Form. 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. Sampling is not encouraged with expired reagents and bacteria media; the corresponding values will be flagged in the Texas Stream Team database and excluded from data reports.

Detailed observational data is 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 scientists collect field data and report the measurement results on Texas Stream Team approved physical or electronic monitoring form. The physical monitoring form is submitted to the Texas Stream Team and local partner, if applicable. The electronic monitoring form is accessible in the online Waterways Dataviewer and, upon submission and verification, is uploaded directly to the Texas Stream Team database.

Quality Assurance and 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 (https://www.meadowscenter.txstate.edu/Service/TexasStreamTeam/citizenscientists.html)

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 is verified and evaluated against project specifications and is 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 Citizen Scientist enters data electronically, the system will automatically flag data outside of possible values for the specific parameter and the user 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 email or telephone and corrective action will be implemented.

Data Analysis Methods

Texas Stream Team Data analyzed in this report was compared to state water quality standards as defined in the Texas Surface Water Quality Standards (2014), 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 and assessment methods and oversight than used by citizen scientists and staff in this report. The citizen water quality monitoring data is 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 and Exceedances

The TCEQ determines a water body to be impaired through assessment of professional water quality monitoring. When an observed sample value does not meet the standard for the parameter being analyzed, it is referred to as an exceedance. The Draft 2018 Guidance for Assessing and Reporting Surface Water Quality in Texas: In Compliance with Sections 305(b) and 303(d) of the Federal Clean Water Act document was used to calculate the criteria for exceedances for the Medina River watershed. The Texas Stream Team data presented in this report are compared to TCEQ standards for visual and relative comparative purposes.

Methods of Analysis

All data collected from the watershed and its tributaries were exported from the Texas Stream Team Waterways Dataviewer database. Data were reviewed and, for the sake of data analysis, only one sampling event per day, per site were selected for the entire study duration. If more than one sampling event occurred per day, per site, the most complete, correct, and representative sampling event was selected.

Once compiled, data were sorted, analyzed and graphed in Microsoft Excel 2010 using standard methods. Statistically significant trends were graphed in Excel. R-squared is a statistical measure of how close the data are to the fitted regression line. Zero-percent indicates that the model explains none of the variability of the response data around its mean. The p-value is the level of marginal significance within a statistical hypothesis test representing the probability of the occurrence of a given event. 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-precent. As the p-value decreases, the confidence that it matches actual conditions in nature increases.

For this report, specific conductivity measurements, gathered by citizen scientists, were converted to TDS using the TCEQ-recommended conversion formula of specific conductivity: TDS (mg/L) = SC (µS/cm)*0.65 . This conversion was made so that data gathered by citizen scientists could be more readily compared to data gathered by the state.

Geometric means were also calculated for the *E. coli* data. The bacteria data were then used for the trends analysis and for comparison to the water quality standards.

Table 1: TCEQ stream segment, designated use, and water quality standards (Texas Commission on Environmental Quality 2018).

General Information			Exceptional Aquatic Life Use		Recreation Use (Primary Contact Recreation 1)		General Use		
Segment No.	**Segment Name**	**Description**	**Dissolved Oxygen 24-hour mean (mg/L)**	**Dissolved Oxygen 24-hour minimum (mg/L)**	***E. coli*** **single sample (CFU/100mL)**	***E. coli*** **geometric mean (CFU/100mL)**	**Water Temp absolute maxima (°C)**	**pH (SU)**	**TDS (mg/L)**
1905	Medina River above Medina Lake	From a point immediately upstream of the confluence of Red Bluff Creek in Bandera County to the confluence of the North Prong Medina River and the West Prong Medina River in Bandera County	6.0	4.0	399	126	31.0	6.5-9.0	400

MEDINA RIVER WATERSHED DATA ANALYSIS

Maps

Maps were prepared to show spatial variation of the parameter averages by site (Figures 8-11). The parameters mapped include water temperature, TDS, DO, pH, and *E. coli*. Figure 2 is a reference map with featured Texas Stream Team sites for this report.

Reference points are shown in all maps. Layers including monitoring sites, tributaries, watershed boundary, and an inset map were included. All shapefiles were downloaded from reliable federal, state, and local agencies.

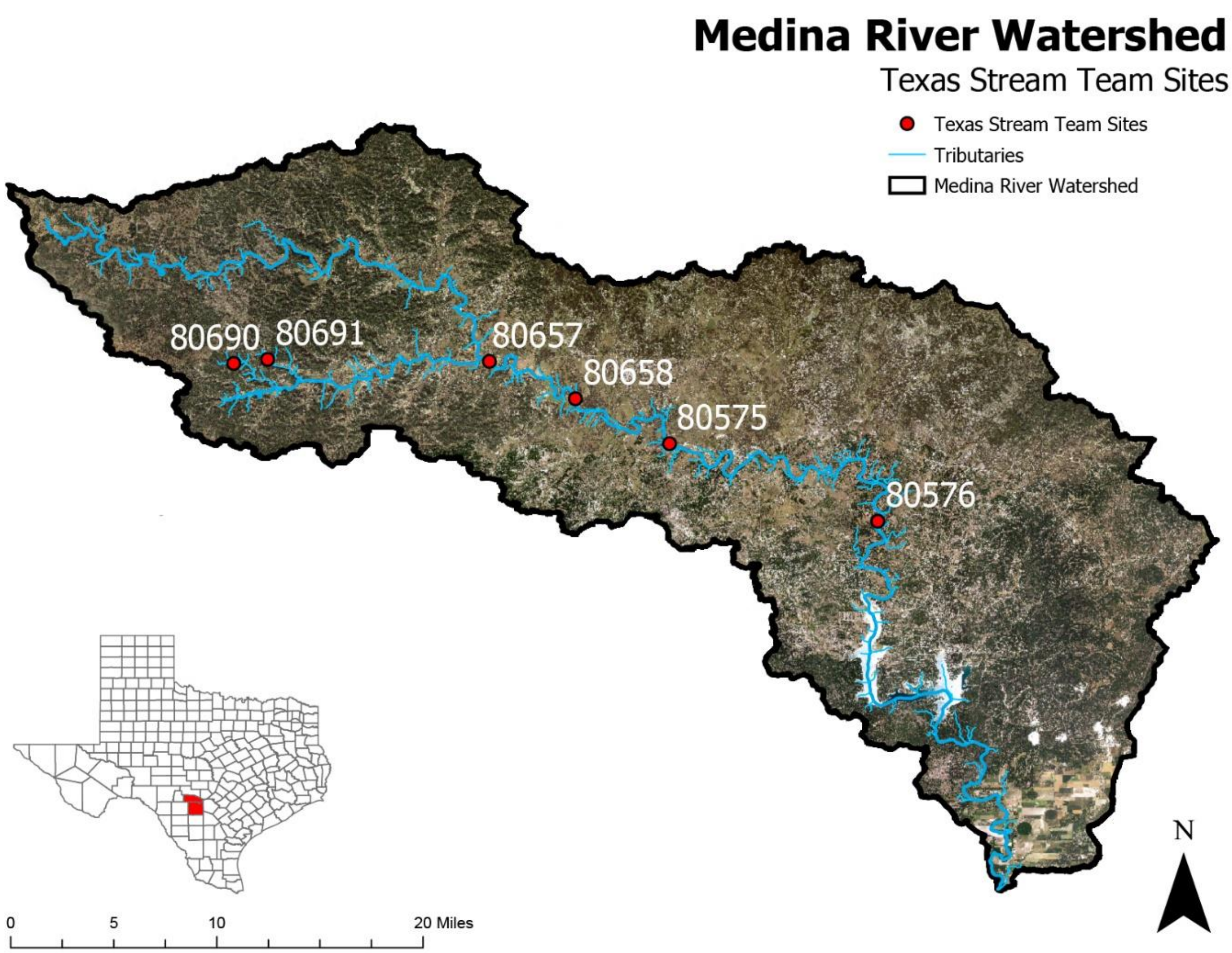

Figure 2: Watershed and featured Texas Stream Team sites in Segment 1905 Medina River above Medina Lake

Medina River Watershed Trends over Time

Sampling Trends Over Time

Texas Stream Team Citizen Scientist water quality sampling within the Medina River watershed began in October of 2010 and continues to this day. A total of 327 individual monitoring events from six sites all on segment 1905, Medina River above Medina Lake, were analyzed for this report. From 2011 to present, monthly monitoring has occurred on a near-consistent basis at two of the sites, Site ID# 80690 - Love Creek roughly 5 km down Love Creek Road and Site ID# 80691 - Elam Creek roughly 3 km down Elam Creek Road. Three sites were only monitored on a near-consistent monthly basis throughout the years of 2010 to 2015. Those sites include Site ID# 80657 Medina River at Patterson Ave, Medina, Texas, Site ID# 80658 Medina River at Bandina Ranch Road, and Site ID# 80575 Medina River at HWY 16 Rangers Crossing. The last site, Site ID# 80576 - Medina River at English Crossing was only monitored from late 2010 to mid-2012.

Table 2: Descriptive parameters measured at six Texas Stream Team sites in the Medina River including 327 sampling events between 10/19/2010 and 9/25/2019. The mean is listed for all parameters except for *E. coli* which is represented as the geomean.

Medina River Above Medina Lake (Seg. 1905) October 2010 – September 2019				
Parameter	**Number of Samples**	**Mean ± Standard Deviation**	**Min**	**Max**
Water Temperature (°C)	326	19.9 ± 6.0	5.5	36.0
Total Dissolved Solids (mg/L)	319	331 ± 98	169	650
Dissolved Oxygen (mg/L)	324	7.3 ± 1.7	2.6	13.9
pH (su)	323	7.5 ± 0.4	6.8	8.3
E. coli (CFU/100mL)	270	24 ± 122	1	1010

Trend Analysis over Time

Air and Water Temperature

A total of 327 and 326 air and water temperatures, respectively, were collected in the Medina River watershed between 2010 and 2019 by Texas Stream Team Citizen Scientists. The average water temperature for all sites was 19.9°C. Water temperature exceeded the TCEQ optimal temperature of 31.0°C on four occasions sites 80690, 80575 and 80658. Air temperature for all sites averaged 21.4°C and ranged from 7.0°C to 37.0°C.

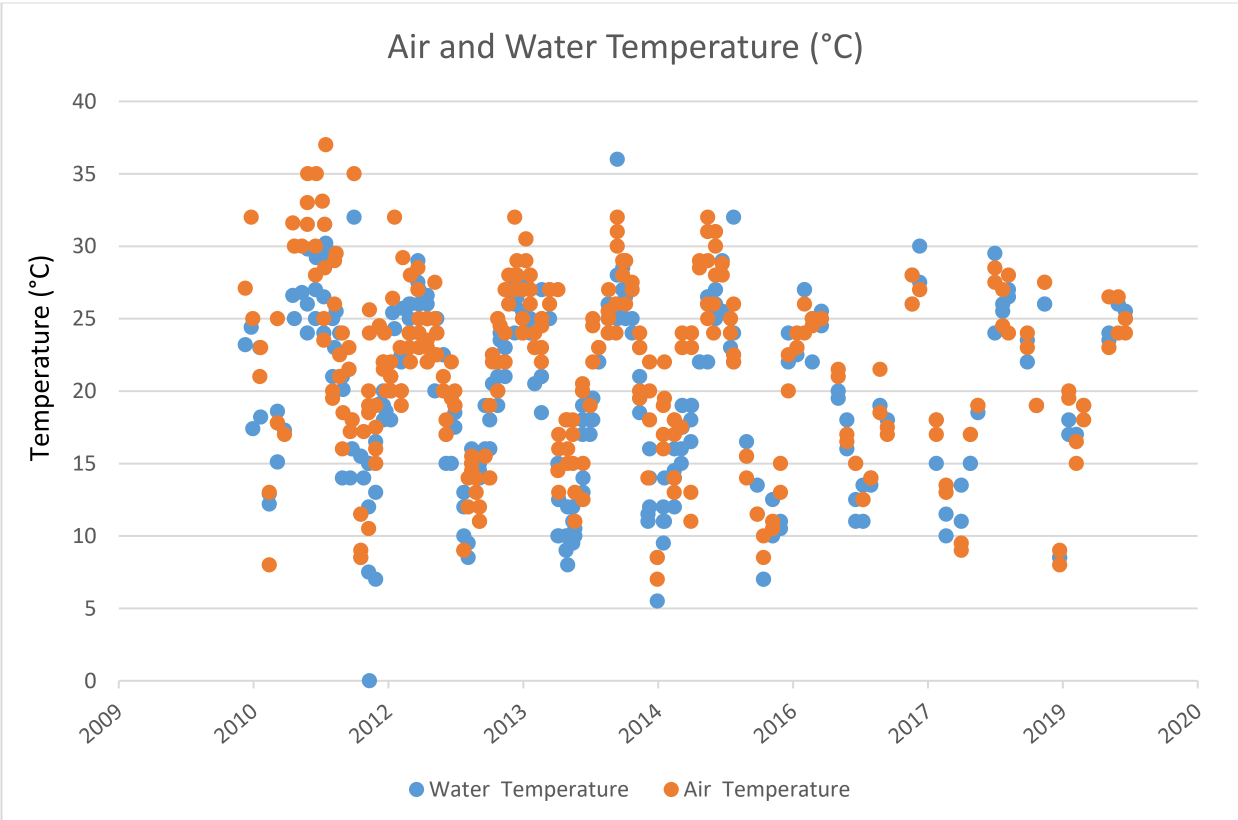

Figure 3: Air and water temperature over time at sites within the Medina River watershed

Total Dissolved Solids

Citizen scientists collected 319 TDS samples within the Medina River watershed. The average TDS measurement for all sites was 311 mg/L. Measurements ranged from a low of 169 mg/L in March of 2019 to a high of 650 mg/L in December of 2011.

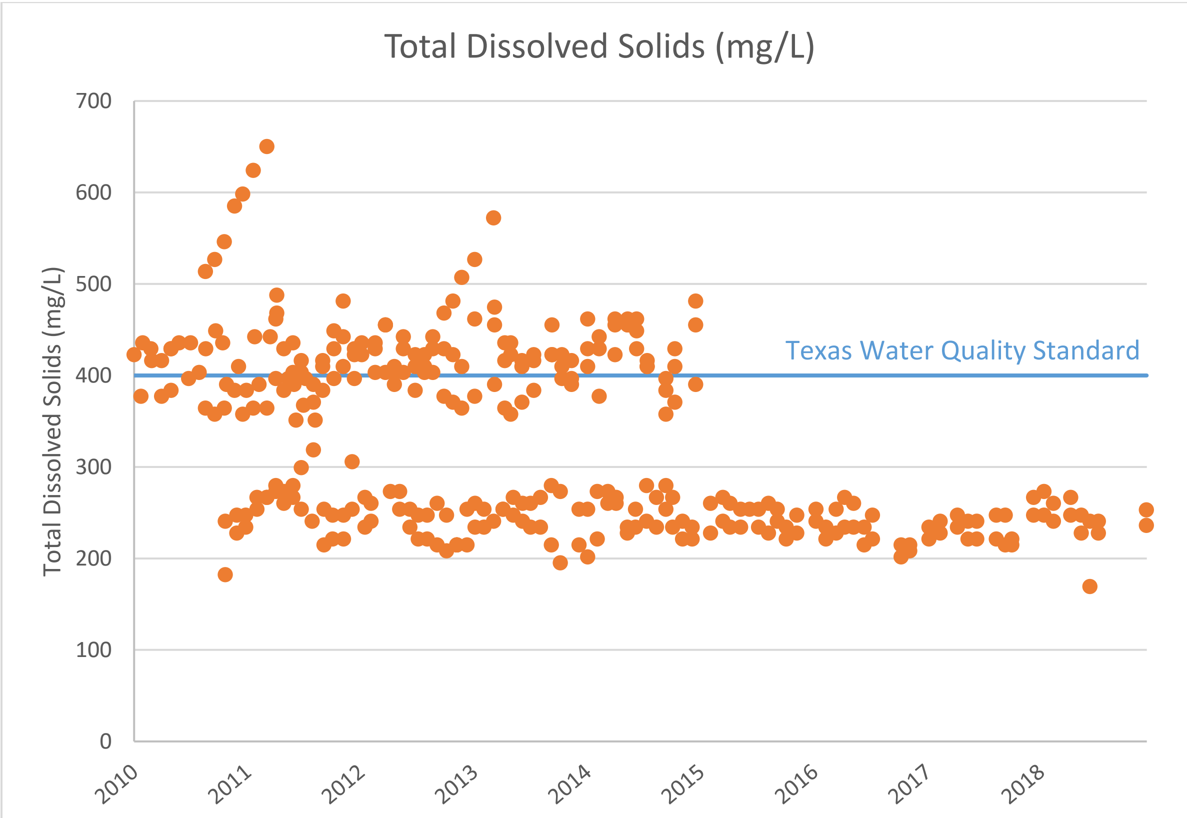

Figure 4: Total dissolved solids over time at sites within the Medina River watershed

Dissolved Oxygen

Citizen scientists collected a total of 324 DO samples in the Medina River watershed. The mean DO was 7.3 mg/L. Measurements ranged from a low of 2.6 mg/L in September of 2015 to a high of 13.9 mg/L in January of 2012.

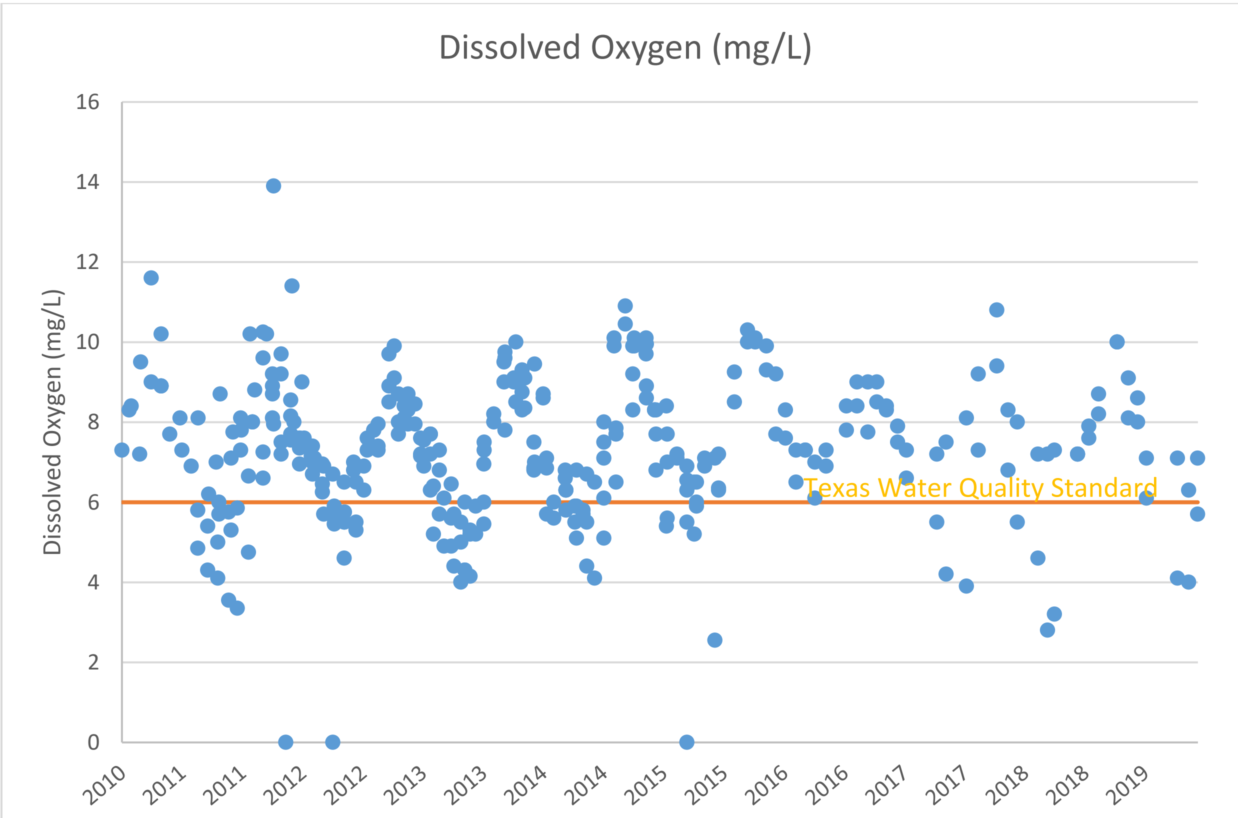

Figure 5: Dissolved oxygen over time at sites in the Medina River watershed

pH

Citizen scientists collected a total of 323 pH samples in the Medina River watershed. The mean pH was 7.5 and the values ranged from 6.8 to 8.3.

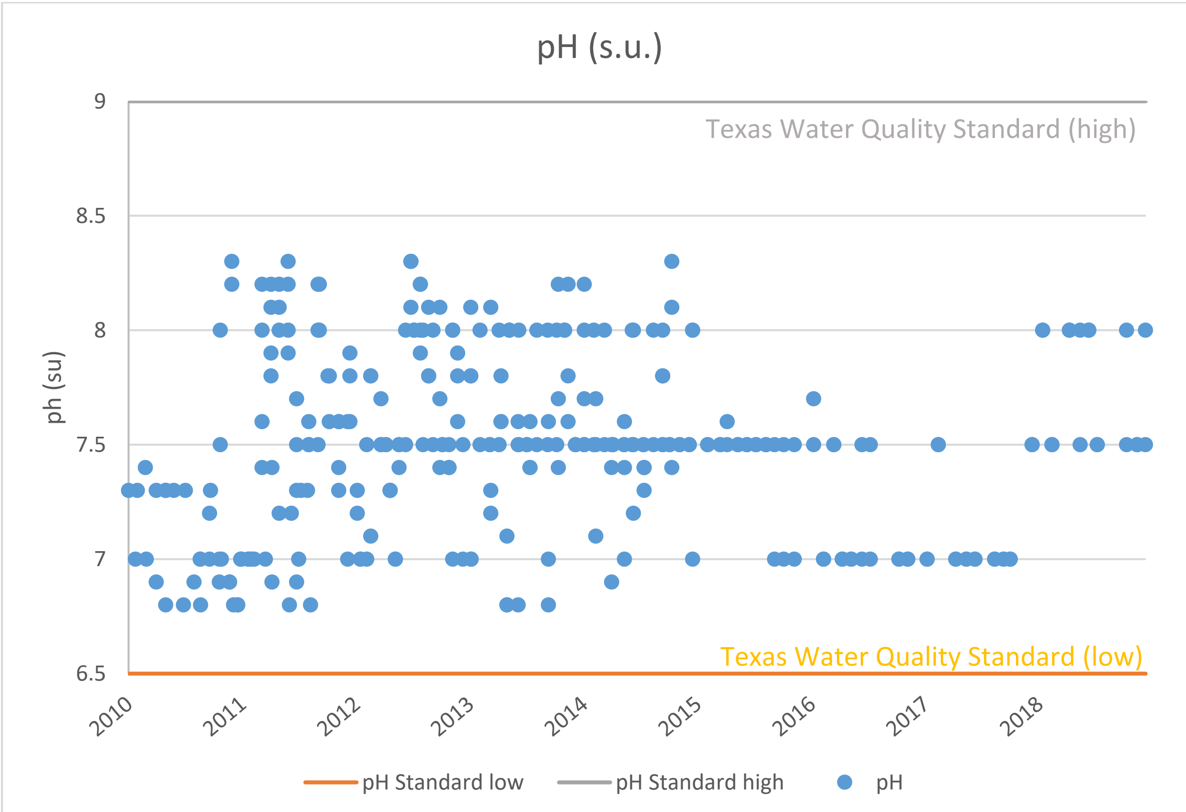

Figure 6: pH over time at sites within the Medina River watershed

E. coli Bacteria

E. coli samples were collected for the majority of all sampling events within the Medina River watershed. A total of 270 *E. coli* samples were collected. The geomean for *E. coli* results was 24 CFU/100 mL. The *E. coli* counts ranged from 1 CFU/100 mL (which signifies that no *E. coli* colonies were counted) to a high of 1010 CFU/100 mL in March of 2014.

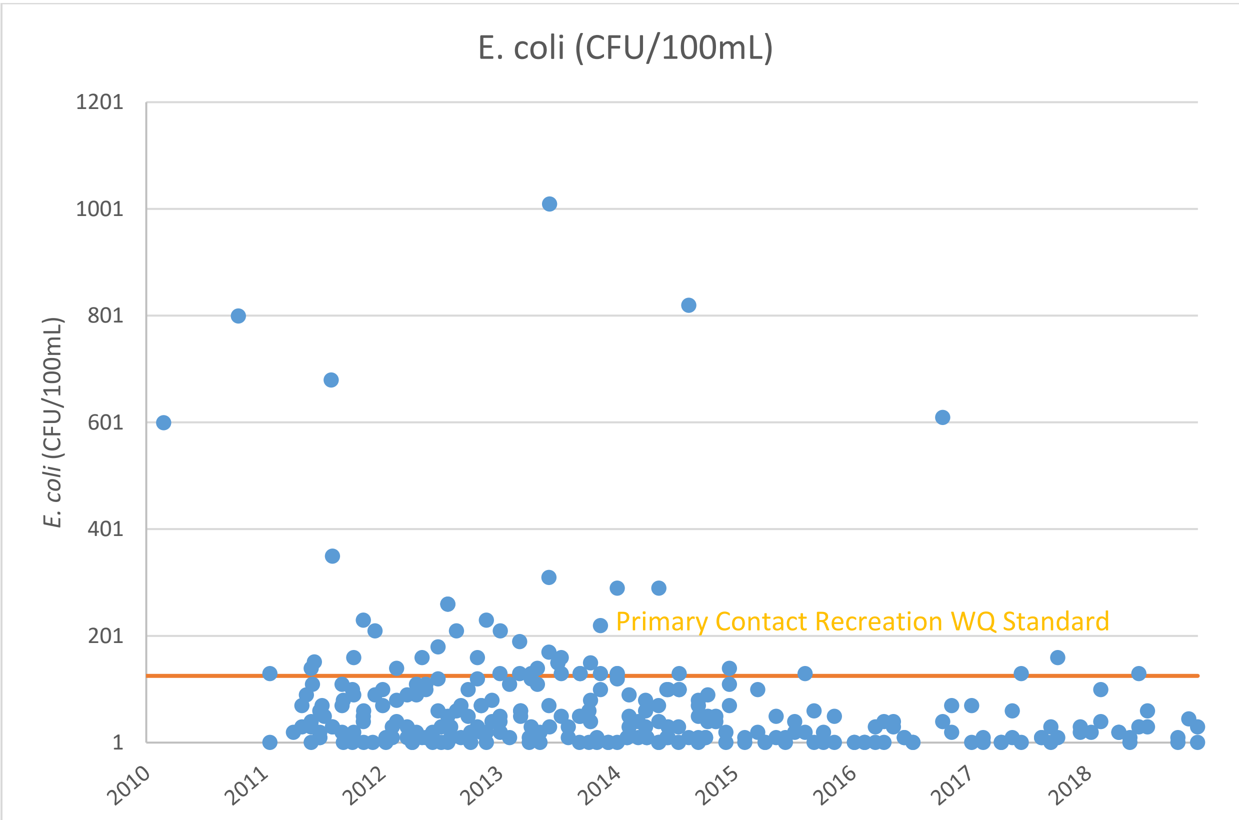

Figure 7: *E. coli* over time at sites within the Medina River watershed

WATERSHED SITE BY SITE ANALYSIS

The following sections provide a brief summary of the analysis by site. The average values are reported to provide a quick overview of the watershed. The air and water temperature, TDS, DO and pH values are presented as an average, plus or minus the standard deviation. The *E. coli* is presented as a geomean. Table 3 provides an overview of the results for sites on Medina River above Lake Medina (Seg. 1905).

Table 3: Average values for Medina River sites.

Site Number	Number of samples	TDS (mg/L)	DO (mg/L)	pH (su)	*E.coli** (CFU/100 mL) *geomean	Water temperature (°C)	Air temperature (°C)
80690	85	226 ± 40	7.1 ± 0.4	7.5 ± 0.4	14 ± 135	18.9 ± 6.3	20.6 ± 6.1
80691	88	257 ± 50	7.9 ± 1.3	7.5 ± 0.3	10 ± 99	19.8 ± 6.3	20.3 ± 5.9
80657	45	390 ± 24	6.8 ± 1.3	7.5 ± 0.3	60 ± 53	19.9 ± 4.3	21.2 ± 5.0
80658	45	462 ± 59	6.2 ± 1.5	7.5 ± 0.4	38 ± 73	20.8 ± 5.5	21.8 ± 5.5
80575	48	422 ± 35	7.6 ± 1.2	7.5 ± 0.4	123 ± 169	20.4 ± 6.3	23.5 ± 6.0
80576	16	400 ± 33	9.3 ± 1.8	6.9 ± 0.1	88 ± 20	22.1 ± 5.7	25.6 ± 7.3

Air and Water Temperature

Water temperature is a critical indicator for the health of a stream along with its aquatic inhabitants. Generally, temperatures above 32°C can be threatening to aquatic life. Average temperatures for each site indicated healthy temperatures and possibly a slight warming of the river's water as flows continued downstream.

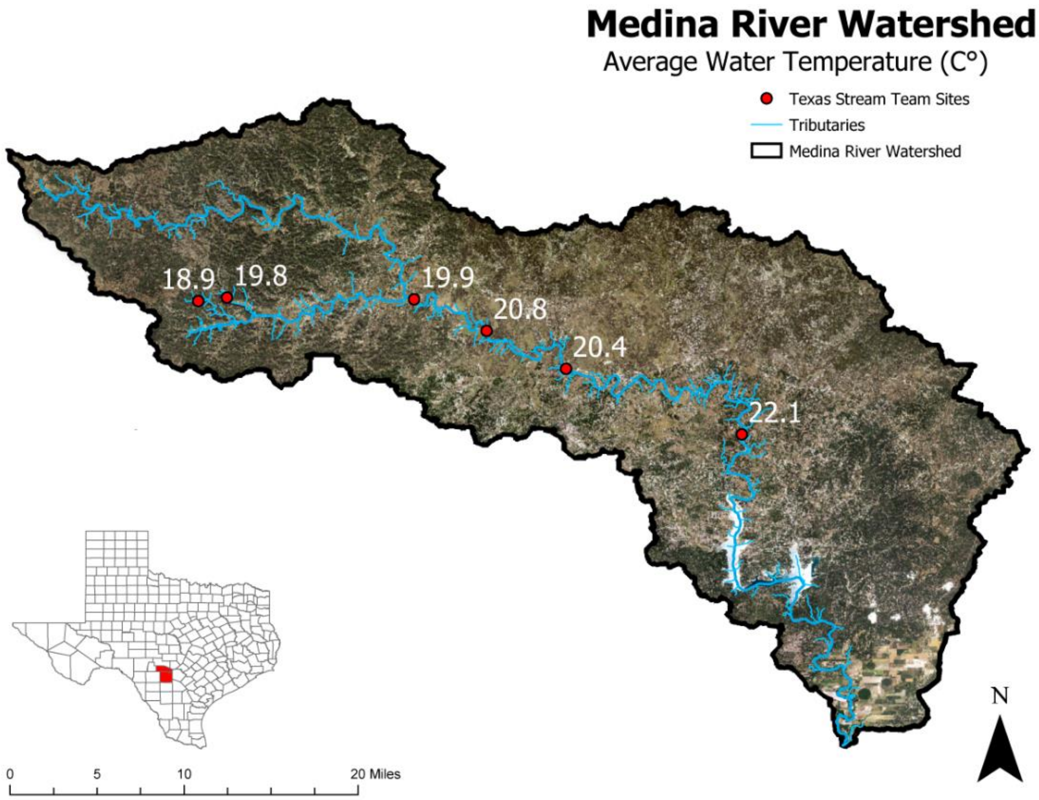

Figure 8: Map of the average water temperatures for sites in the Medina River watershed

Total Dissolved Solids

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 ID# 80658 - Medina River at Bandina Ranch Road had the highest overall average for TDS, with a result of 462 ± 59 mg/L. Site ID# 80690 – Love Creek roughly 5 km down Love Creek Road had the lowest average TDS, with a result of 226 ± 40 mg/L.

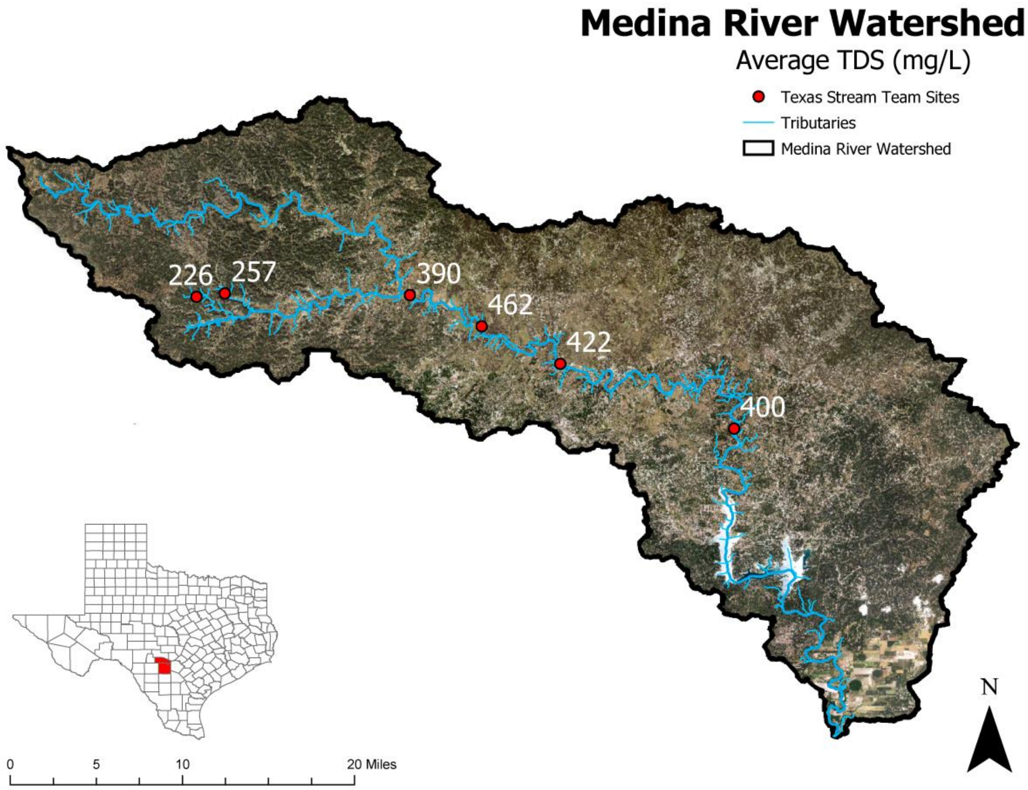

Figure 9: Map of the average total dissolved solids for sites in the Medina River watershed

Dissolved Oxygen

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 then 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. The DO levels can also be impacted by temperature; a high temperature reduces oxygen solubility, which can also lead to a low DO measurement. TCEQ has established that Segment 1905 – Medina River Above Medina Lake is designated for exceptional aquatic life use and has a DO Water Quality Standard of 6.0 mg/L. This designation only applies to Texas streams that exhibit outstanding natural variability in habitat, an exceptional or unusual species assemblage present, has abundant sensitive species, exceptionally high species diversity, exceptionally high species richness, and a consistently balanced trophic structure (Texas Commission on Environmental Quality 2018).

Site 80658 – Medina River at Bandina Ranch Road had the lowest average DO reading, with a result of 6.2 ± 1.5 mg/L. Site 80576 – Medina River at English Crossing had the highest average DO reading, with a result of 9.3 ± 1.8 mg/L.

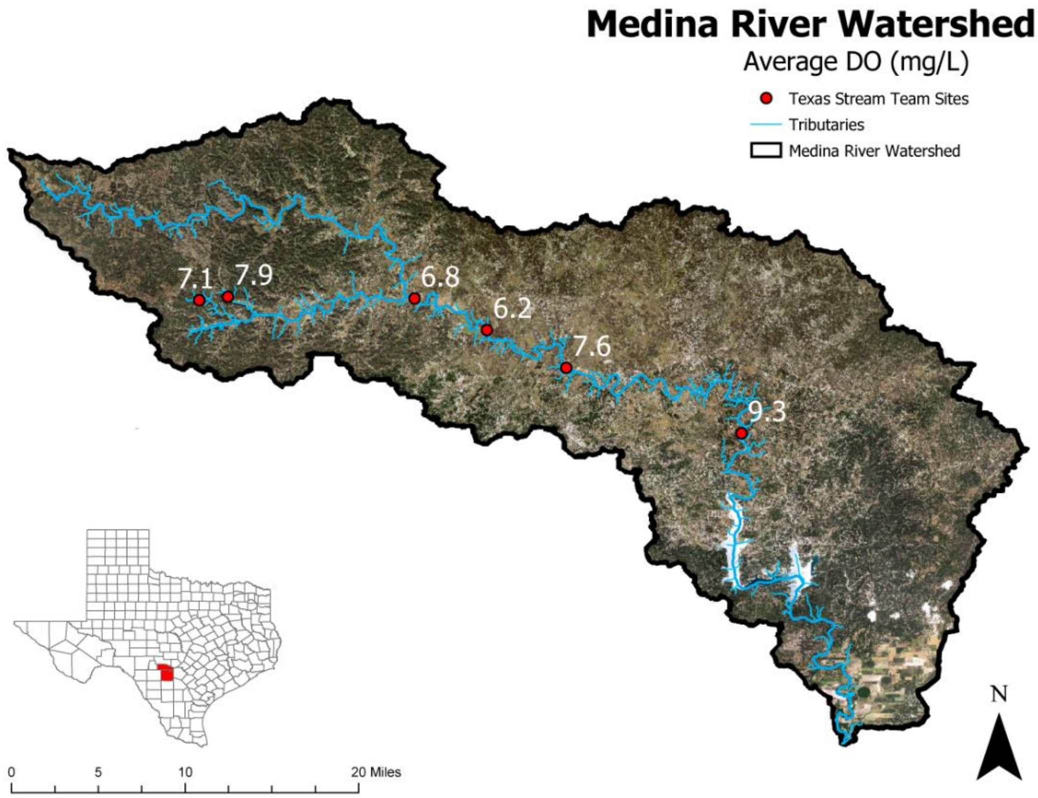

Figure 10: Map of the average dissolved oxygen concentration for sites in the Medina River watershed

pH

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 8.2 for the most optimum environment (Ecology and the Environment 2018). Anything below 6.5 or above 9.0 can negatively impact reproduction or can result in fish kills. There were no instances where the pH was reported outside of this widely accepted range. All sites averaged 7.5 for pH levels except for Site 80576 – Medina River at English Crossing which had an average pH value of 6.9 ± 0.1.

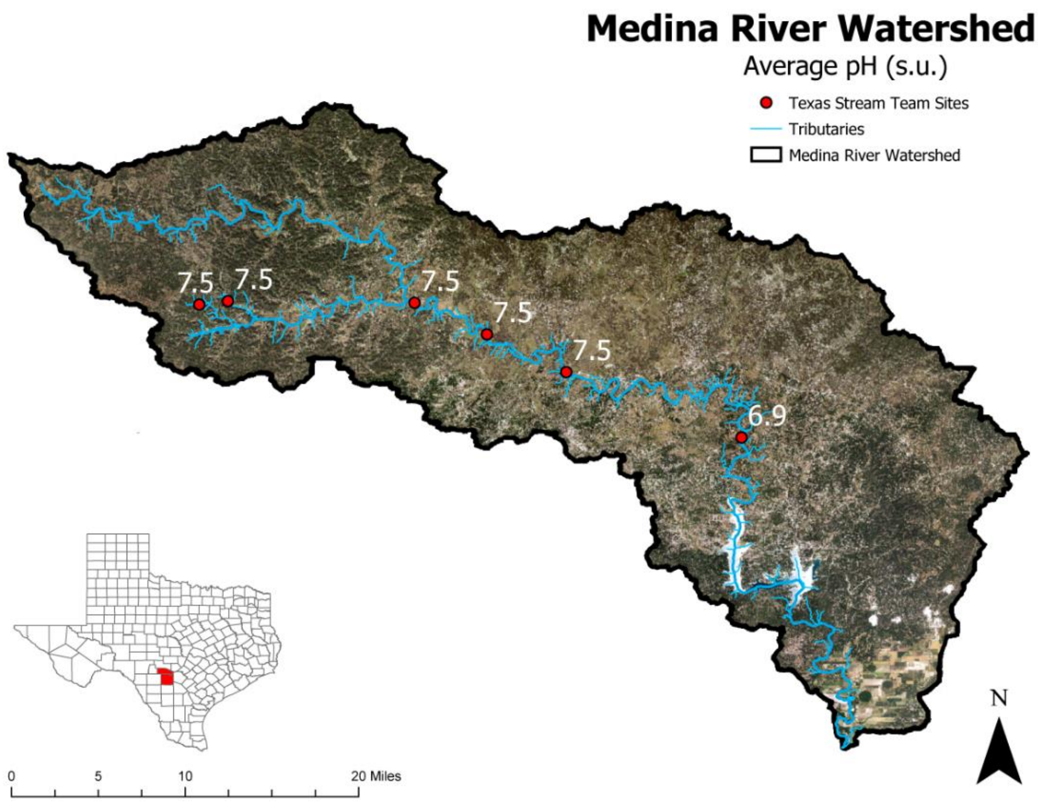

Figure 11: Map of the average pH for sites in the Medina River watershed

E. coli Bacteria

E. coli can be used as an indicator of the degree to which pathogens are present in a water body. Its presence above the TCEQ surface water quality standard for a single sample (399 CFU/100 mL) or the geometric mean (126 CFU/100 mL) indicates a possible human health risk for primary contact recreation. *E. coli* measurements taken at all sites had a geometric mean which satisfied the TCEQ surface water quality standard. Three of the six Texas Stream Team sites had single samples for *E. coli* that exceeded the number of colonies acceptable for primary contact recreation. They include Site ID# 80690 - Love Creek roughly 5 km down Love Creek Road, Site ID# 80691 - Elam Creek roughly 3 km down Elam Creek Road, and Site ID# 80575 - Medina River at HWY 16 Rangers Crossing.

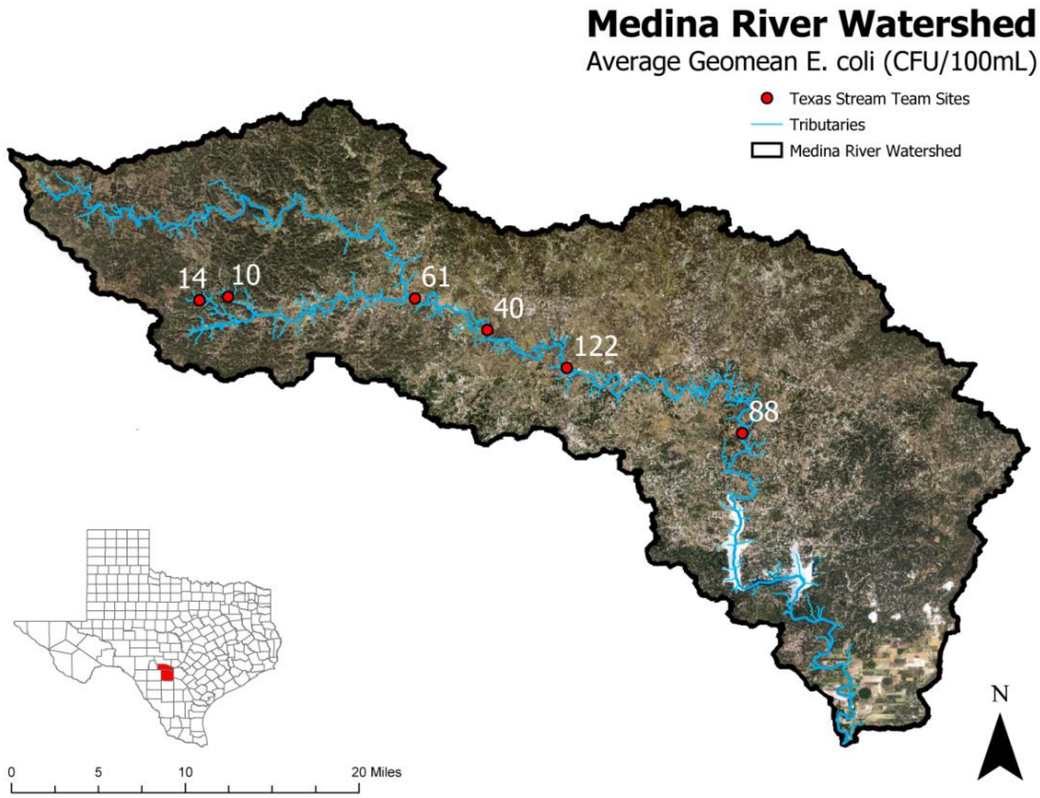

Figure 12: Map of the *E. coli* geomean for sites in the Medina River watershed

The following site-by-site summaries provide an overview for each of the featured six Texas Stream Team monitoring sites. It is important to note that there was variation in the number of times each site was tested, the time of day at which each site was tested, and the time of month the sampling occurred. While this is a quick overview of the results, it is important to keep in mind that there is natural diurnal and seasonal variation in these water quality parameters. Texas Stream Team Citizen Scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards.

Site ID# 80690 – Love Creek roughly 5 km down Love Creek Road

Site Description

This site is located on a perennial tributary of the West Prong of the Medina River within the upper portion of the river's watershed in the Texas Hill Country at a private preserve that is owned by the Texas Nature Conservancy (Fig. 2). Love Creek attracts biological interest because of the exposed upper Glen Rose formation that is found here. Numerous springs and seeps provide baseflow to Love Creek which drains canyonlands dominated by bigtooth maples and rare plant communities. This site, located at Love Creek Preserve, may be accessed only through the assistance of the Texas Nature Conservancy and/or their Volunteer Guides. Please call 210.224.8774 or visit www.nature.org/texas for more information.

Sampling Information

This site was sampled 85 times between August 9, 2011 and September 25, 2019. The time of sampling for this site ranged from 8:30 to 15:35. Nearly consistent monthly monitoring has been performed at this site since the initial monitoring event.

Table 4: Descriptive parameters for Site 80690

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	80	226 ± 40	169	273
Water Temperature (°C)	85	18.9 ± 6.3	5.5	31.5
Dissolved Oxygen (mg/L)	84	7.1 ± 1.9	2.6	10.9
pH (su)	84	7.5 ± 0.4	6.9	8.3
E. coli (CFU/100ml)	77	14 ± 135	1	1010

Site 80690 was sampled 85 times between 8/9/2011 and 9/25/2019.

Air and Water Temperature

Air temperature and water temperature was taken 85 times at this site. The air temperature fluctuated in a seasonal pattern with the highest temperature of 31.5°C in August of 2011, and the lowest temperature of 8.5°C in December of 2014. The mean water temperature was 18.9°C and the water temperature ranged from a low of 5.5°C recorded in December of 2014 to a high of 31.5°C in August of 2011.

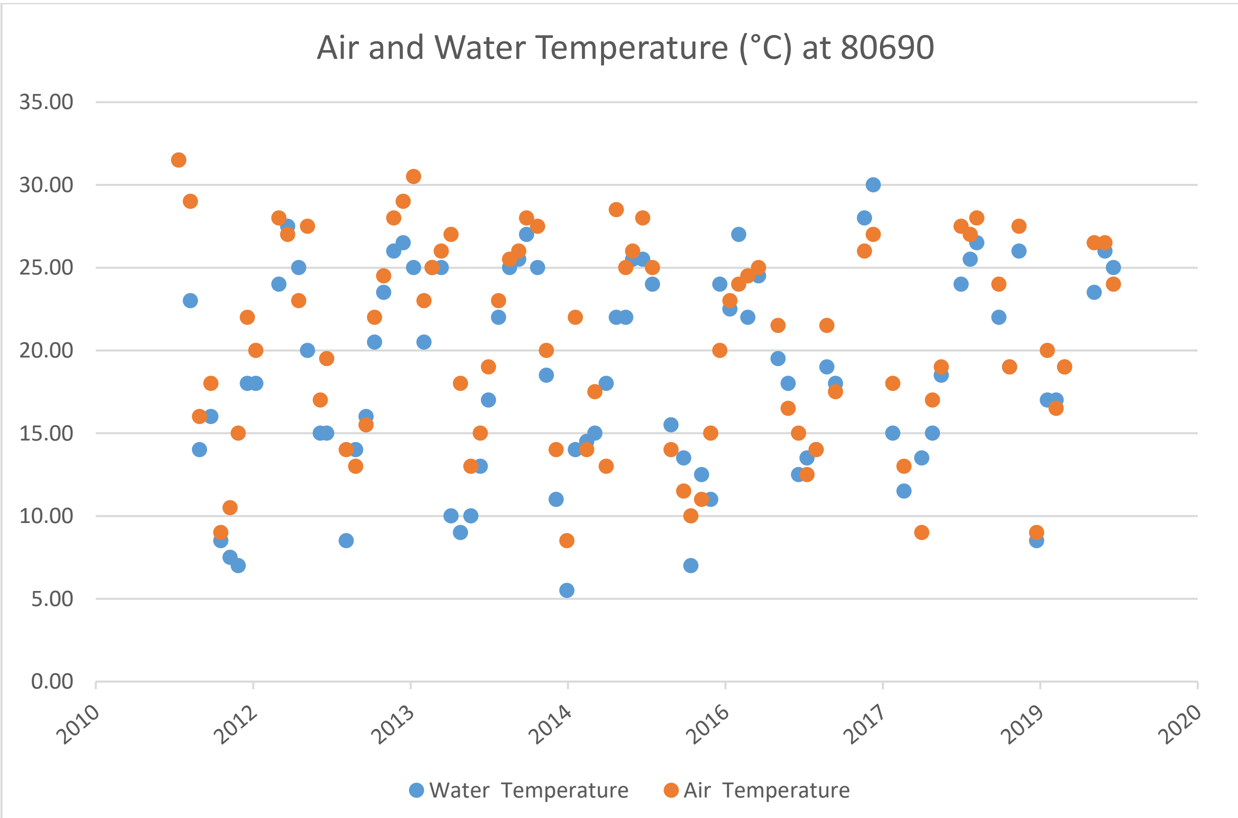

Figure 13: Air and water temperature at Site 80690

Total Dissolved Solids

Citizen scientists sampled TDS at this site 80 times between August 9, 2011 and September 25, 2019. The mean TDS concentration was 231 mg/L. The concentration of TDS ranged from a minimum of 169 mg/L in March of 2019 to a maximum of 273 mg/L in January of 2012.

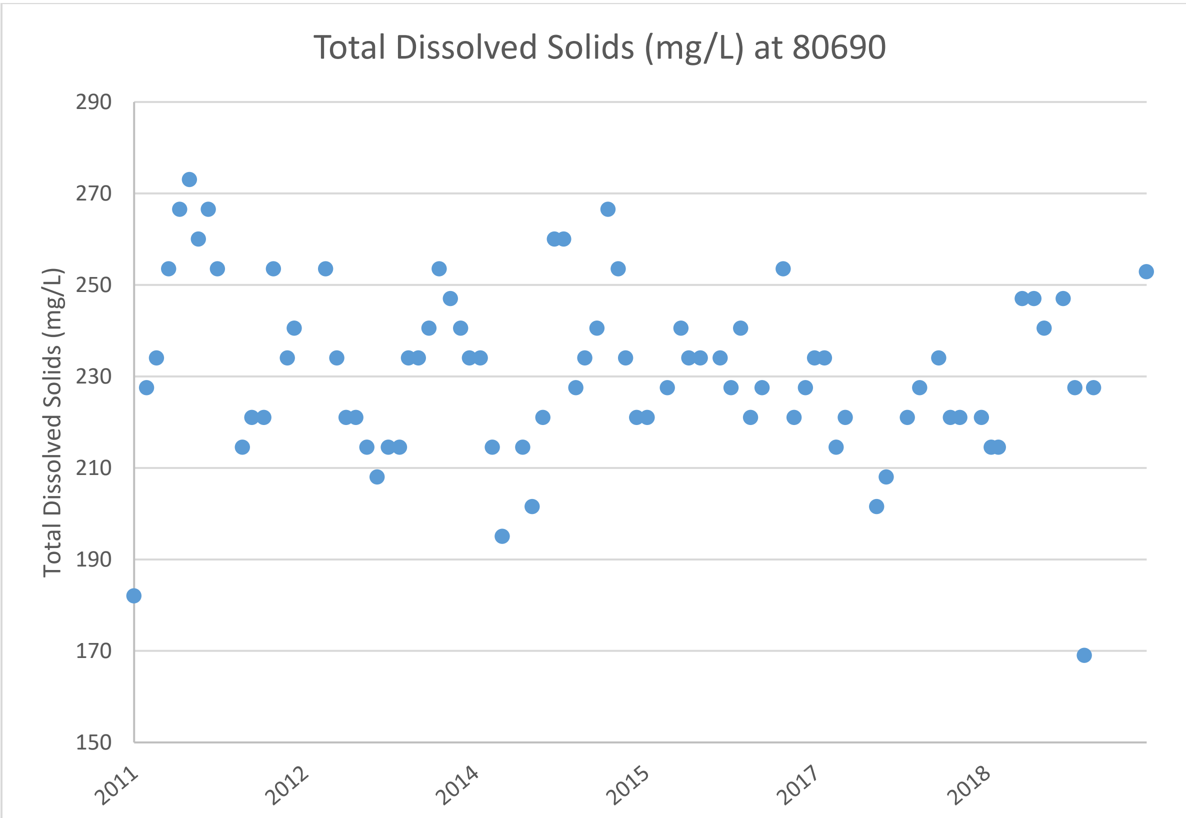

Figure 14: Total dissolved solids at Site 80690

Dissolved Oxygen

Citizen scientists took 84 DO samples at this site between August 9, 2011 and September 25, 2019. The mean DO concentration was 7.1 mg/L. DO concentrations ranged from a low of 2.6 mg/L in September of 2015 to a high of 10.9 mg/L in December of 2014.

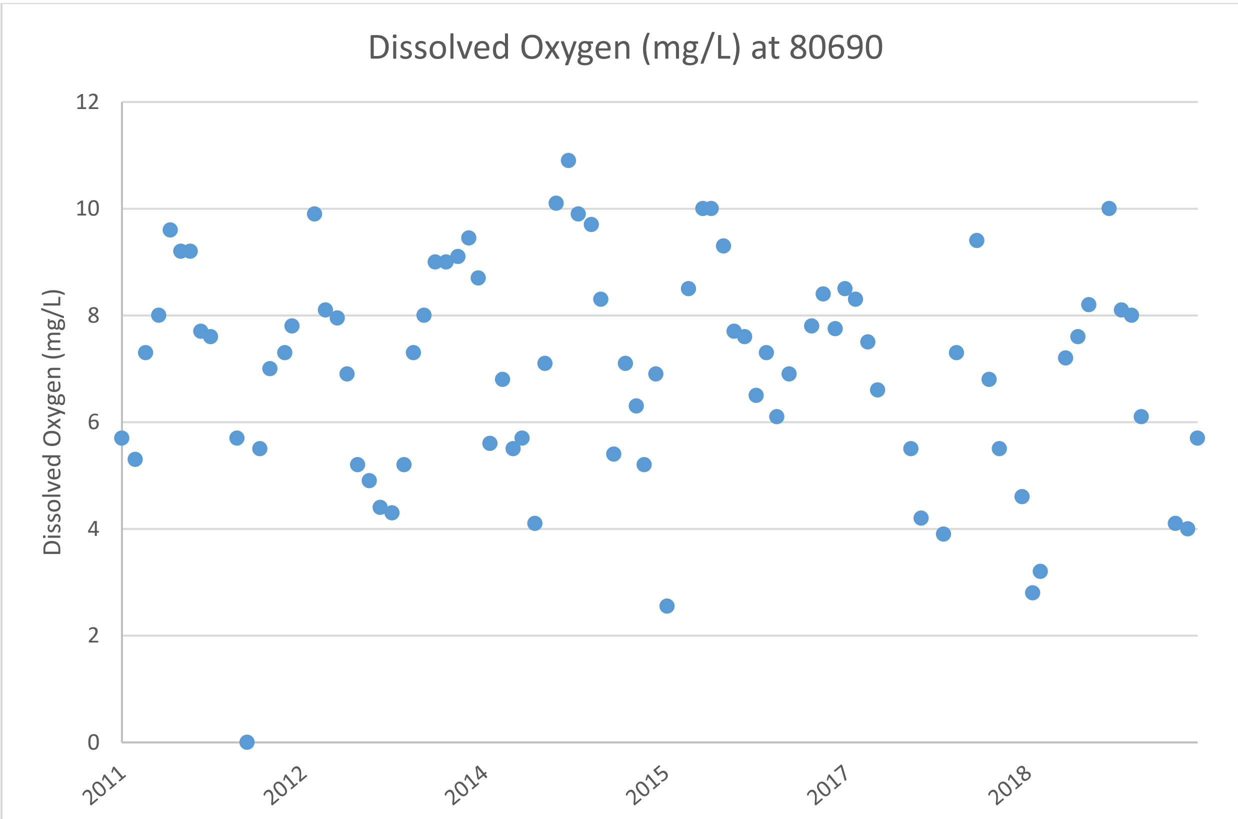

Figure 15: Dissolved oxygen at Site 80690

pH

There were 84 pH measurements taken at this site between August 9, 2011 and September 25, 2019. The mean pH was 7.5 and pH ranged from a low of 6.9 taken in April of 2012 to a high of 8.3 taken in March of 2012.

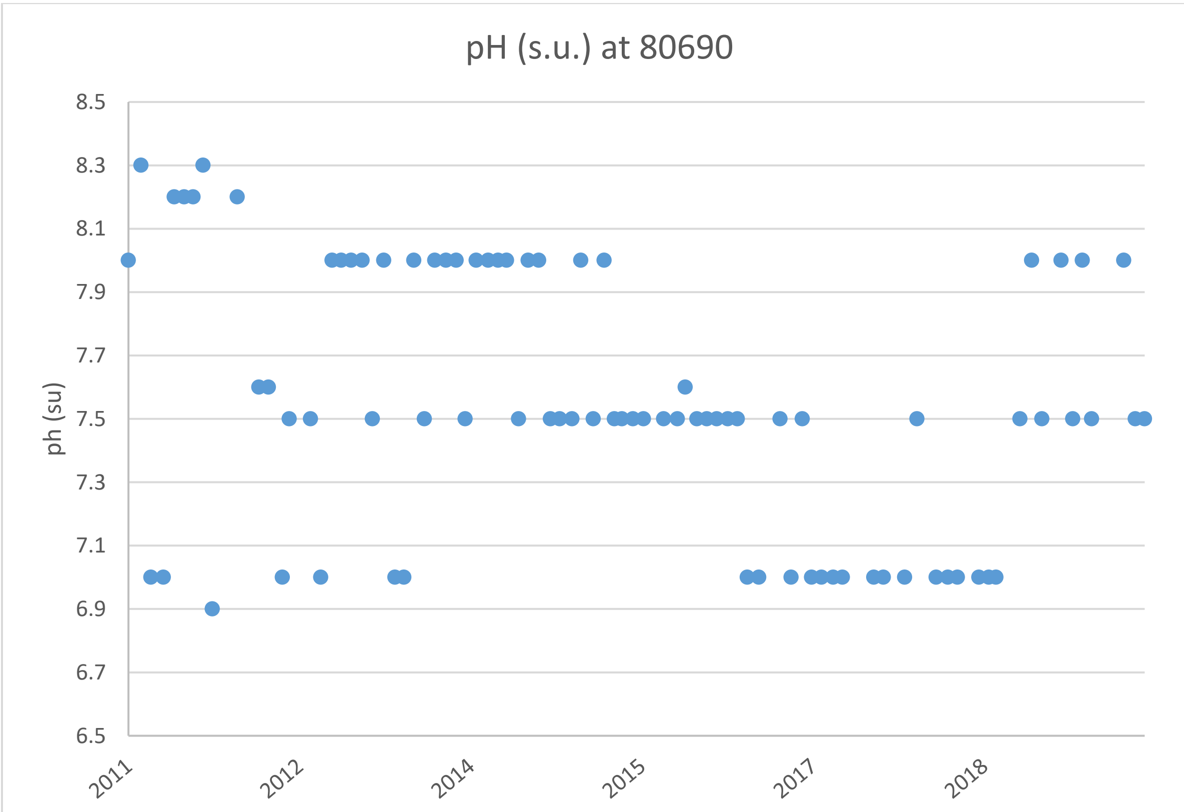

Figure 16: pH at Site 80690

E. coli

There were 77 *E. coli* measurements taken at this site between August 9, 2011 and September 25, 2019. The observed geomean was 14 CFU/100mL and ranged from 1 CFU/100mL taken on multiple occasions to a high of 1010 CFU/100mL taken in March of 2014. Results surpassed the TCEQ & EPA's standard for contact recreation (for single samples, 126 CFU/100mL) nine times out of the 77 samples.

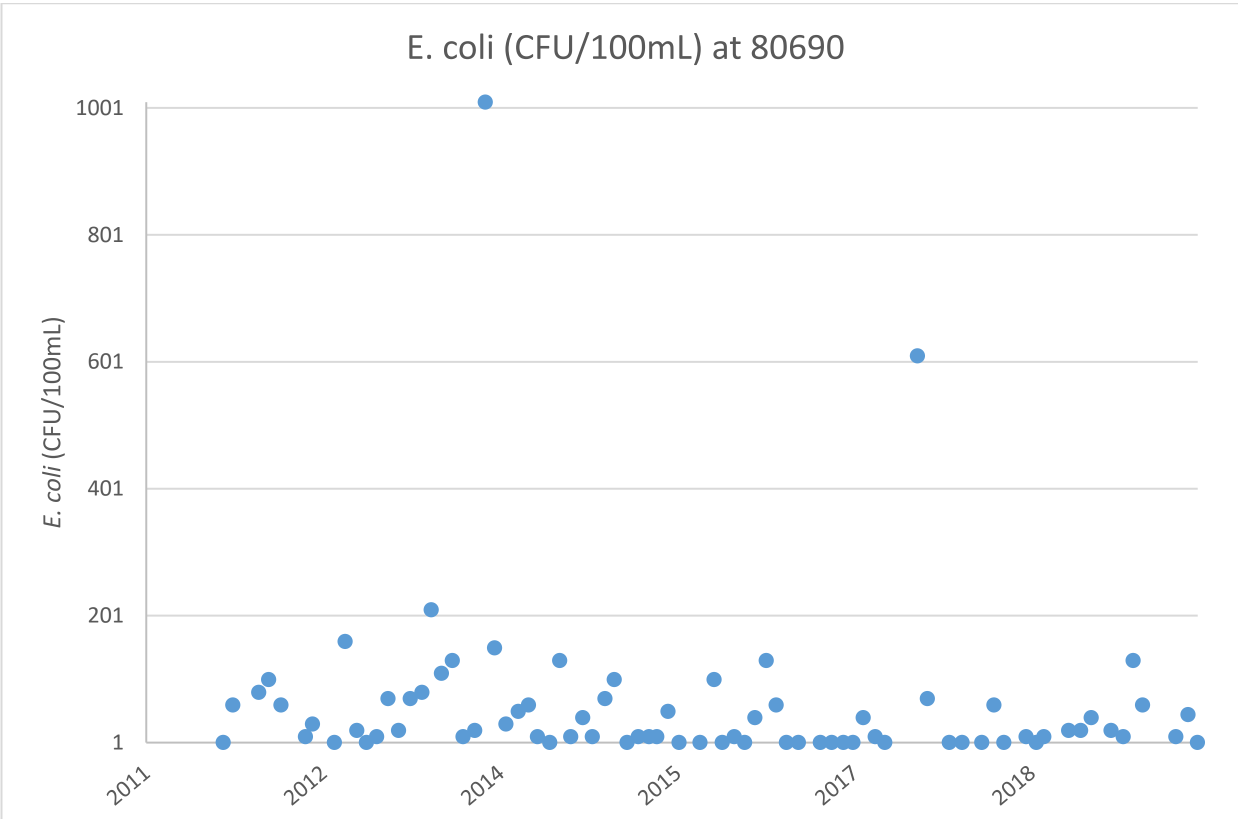

Figure 17: *E. coli* at Site 80690

Site ID# 80691 – Elam Creek roughly 5 km down Elam Creek Road

Site Description

This site is located on a perennial tributary of the West Prong of the Medina River within the upper portion of the river's watershed in the Texas Hill Country at Love Creek Preserve (Fig. 2). Like Love Creek, Elam Creek drains canyonlands dominated by bigtooth maples and rare plant communities. This site may be accessed only through the assistance of the Texas Nature Conservancy and/or their Volunteer Guides. Please call 210.224.8774 or visit www.nature.org/texas for more information.

Sampling Information

This site was sampled 88 times between August 9, 2011 and September 25, 2019. The time of sampling for this site ranged from 8:50 to 16:25. Nearly consistent monthly monitoring has been performed at this site since the initial monitoring event.

Table 5: Descriptive parameters for Site 80691

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	85	260 ± 42	215	572
Water Temperature (°C)	88	19.8 ± 6.3	7.0	29.5
Dissolved Oxygen (mg/L)	88	7.9 ± 1.3	4.3	10.8
pH (su)	88	7.5 ± 0.3	7.0	8.2
E. coli (CFU/100ml)	79	10 ± 99	1	820

Site 80691 was sampled 85 times between 8/9/2011 and 9/25/2019.

Air and Water Temperature

Air temperature and water temperature were measured 88 times at this site. The air temperature fluctuated in a seasonal pattern with the highest temperature of 30.5°C in August of 2013, and the lowest temperature of 7.0°C in December 2014. The mean water temperature was 19.8°C and the water temperature ranged from a low of 7.0°C recorded in January of 2016 to a high of 29.5°C in May of 2018.

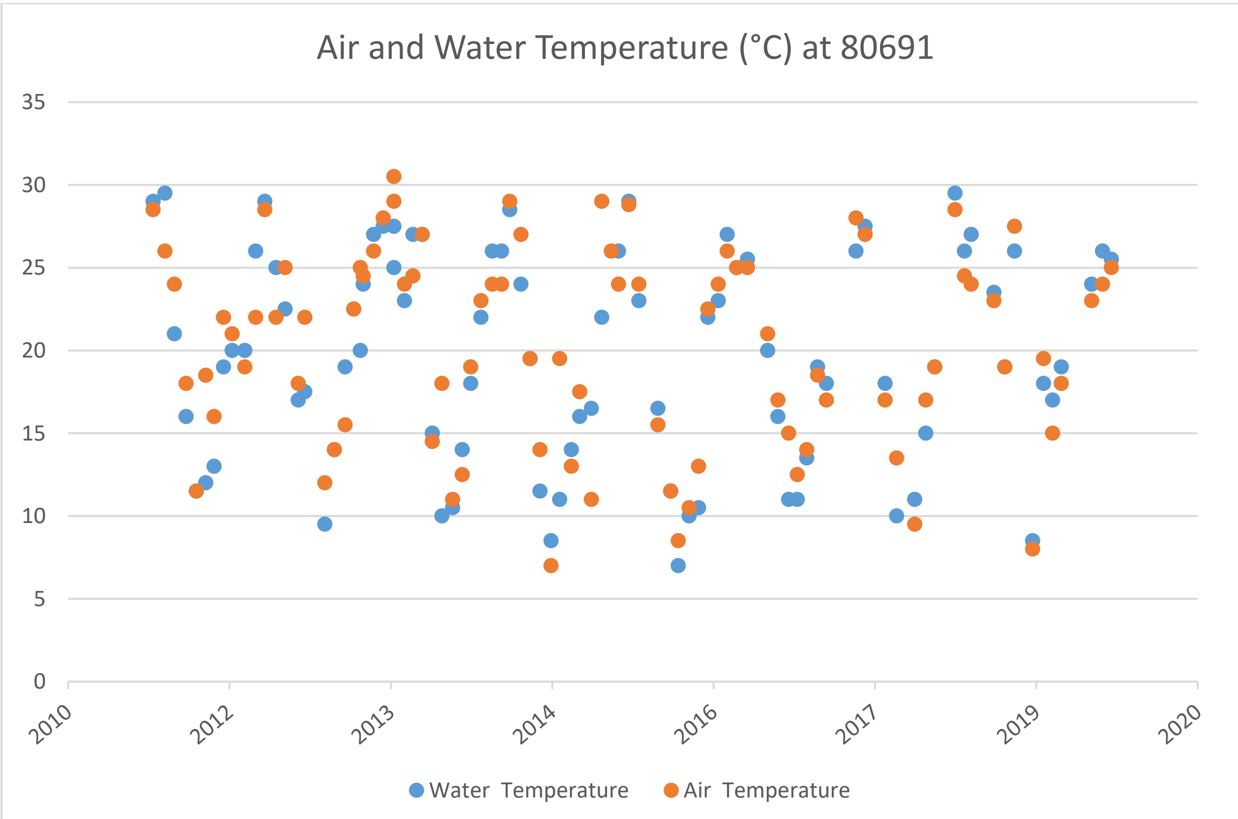

Figure 18: Air and water temperature at Site 80691

Total Dissolved Solids

Citizen scientists sampled TDS at this site 85 times between August 9, 2011 and September 25, 2019. The mean TDS concentration was 260 mg/L. The concentration of TDS ranged from a minimum of 215 mg/L in multiple instances to a maximum of 572 mg/L in December of 2013.

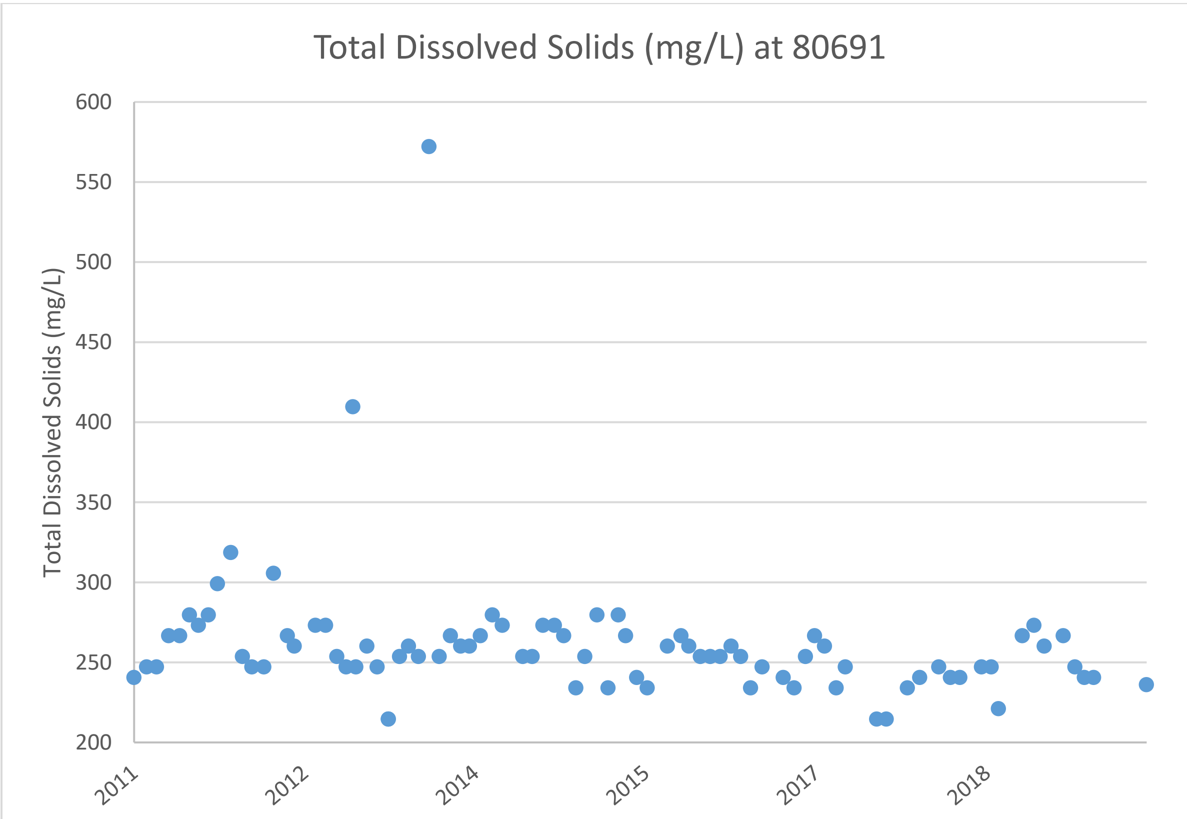

Figure 19: Total dissolved solids at Site 80691

Dissolved Oxygen

Citizen scientists took 88 DO samples at this site between August 9, 2011 and September 25, 2019. The mean DO concentration was 7.9 mg/L. DO concentrations ranged from a low of 4.3 mg/L in August of 2013 to a high of 10.8 mg/L in January of 2018.

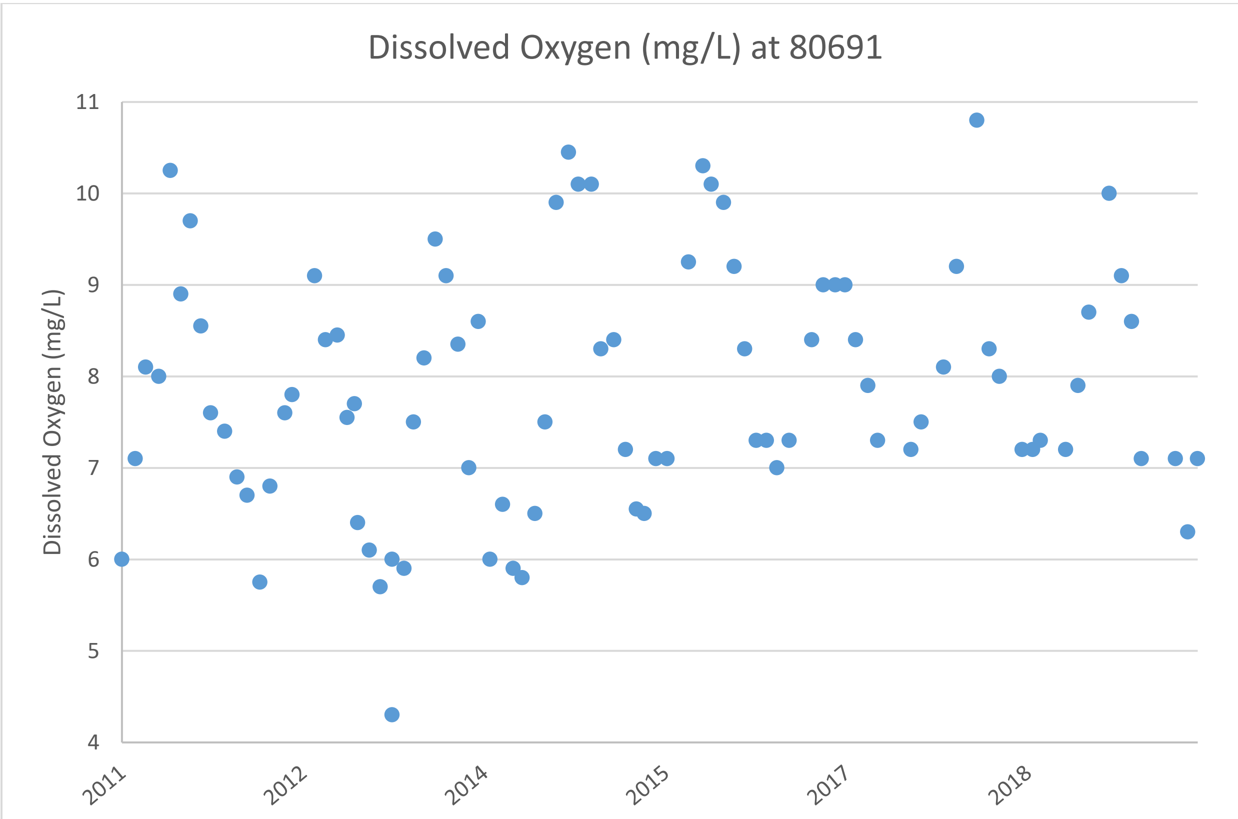

Figure 20: Dissolved oxygen at Site 80691

pH

There were 88 pH measurements taken at this site between August 9, 2011 and September 25, 2019. The mean pH was 7.5 and ranged from a low of 7.0 to a high of 8.2 in multiple instances.

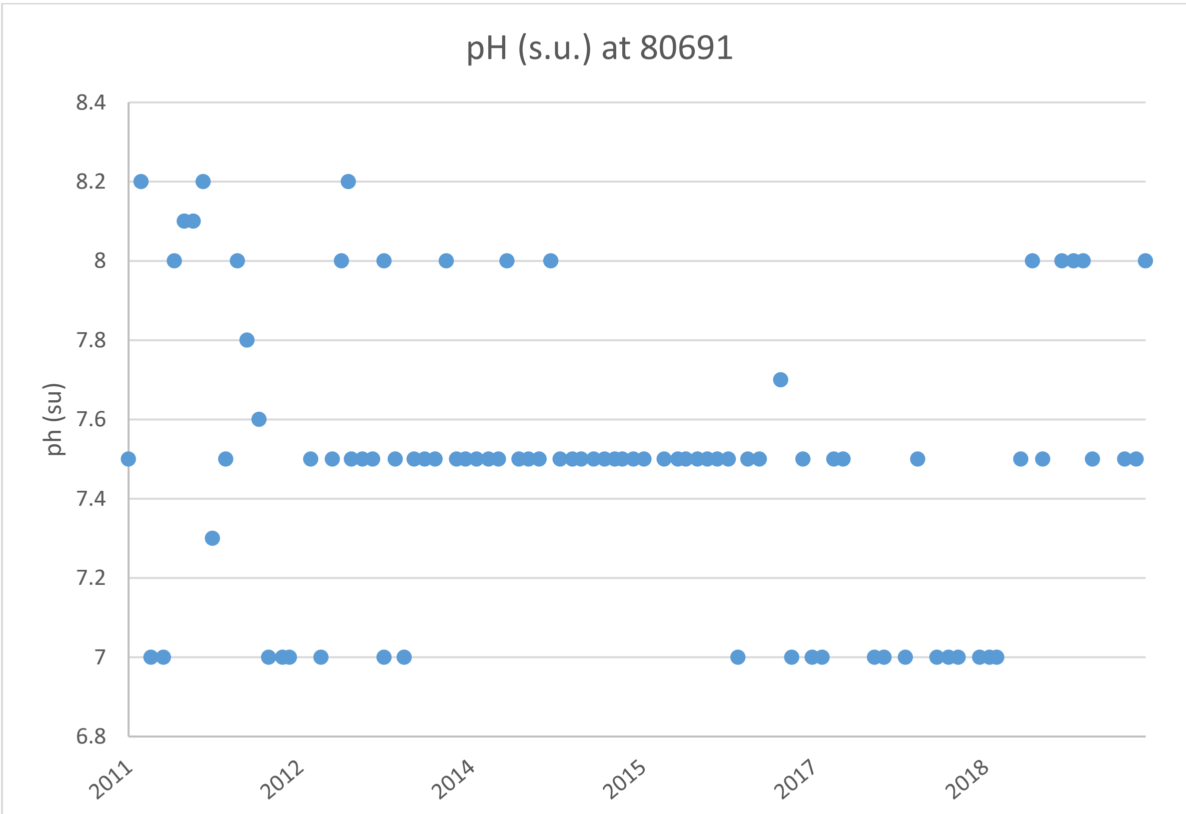

Figure 21: pH at Site 80691

E. coli

There were 79 *E. coli* measurements taken at this site between August 9, 2011 and September 25, 2019. The observed geomean was 10 CFU/100mL and ranged from 1 CFU/100mL taken on multiple occasions to a high of 820 CFU/100mL taken in May of 2015. Results surpassed the TCEQ & EPA's standard for contact recreation (for single samples, 126 CFU/100mL) six times out of the 79 samples.

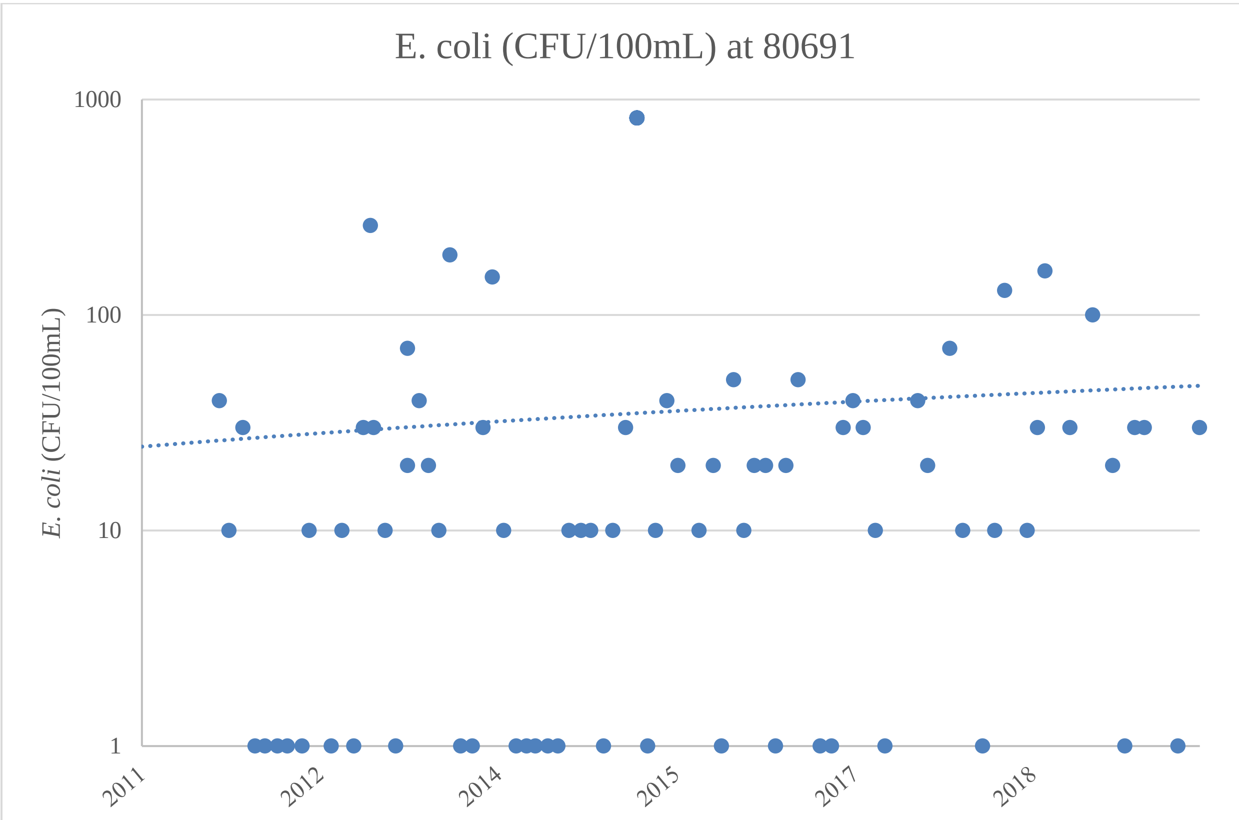

Figure 22: *E. coli* at Site 80691

Site ID# 80657 – Medina River at Patterson Ave, Medina, Texas

Site Description

This site is located on a low-water crossing of the main stem of the Medina River nearly 800 meters downstream of the confluence of the North Prong and the West Prong Medina River (Fig. 2). The perennial flow here is sustained by natural springs and access is granted through the City's Moffett Park. The river here is lined with riparian vegetation mostly dominated by cypress trees.

Sampling Information

This site was sampled 45 times between June 6, 2011 and October 3, 2015. The time of sampling for this site ranged from 8:30 to 15:30. Nearly consistent monthly monitoring was performed at this site during the monitoring period.

Table 6: Descriptive parameters for Site 80657

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	45	390 ± 24	358	462
Water Temperature (°C)	45	19.9 ± 4.3	12.0	26.5
Dissolved Oxygen (mg/L)	44	6.8 ± 1.3	4.1	9.6
pH (su)	45	7.5 ± 0.3	6.8	8.3
E. coli (CFU/100ml)	38	60 ± 53	1	290

Site 80657 was sampled 85 times between 6/6/2011and 10/3/2015.

Air and Water Temperature

Air temperature and water temperature was taken 45 times at this site. The air temperature fluctuated in a seasonal pattern with the highest air temperature of 31.5°C in June of 2011 and the lowest air temperature of 9.0°C in January of 2013. The mean water temperature was 19.9°C and the water temperature ranged from a low of 12.0°C recorded in January of 2014 to a high of 26.5°C in June of 2015.

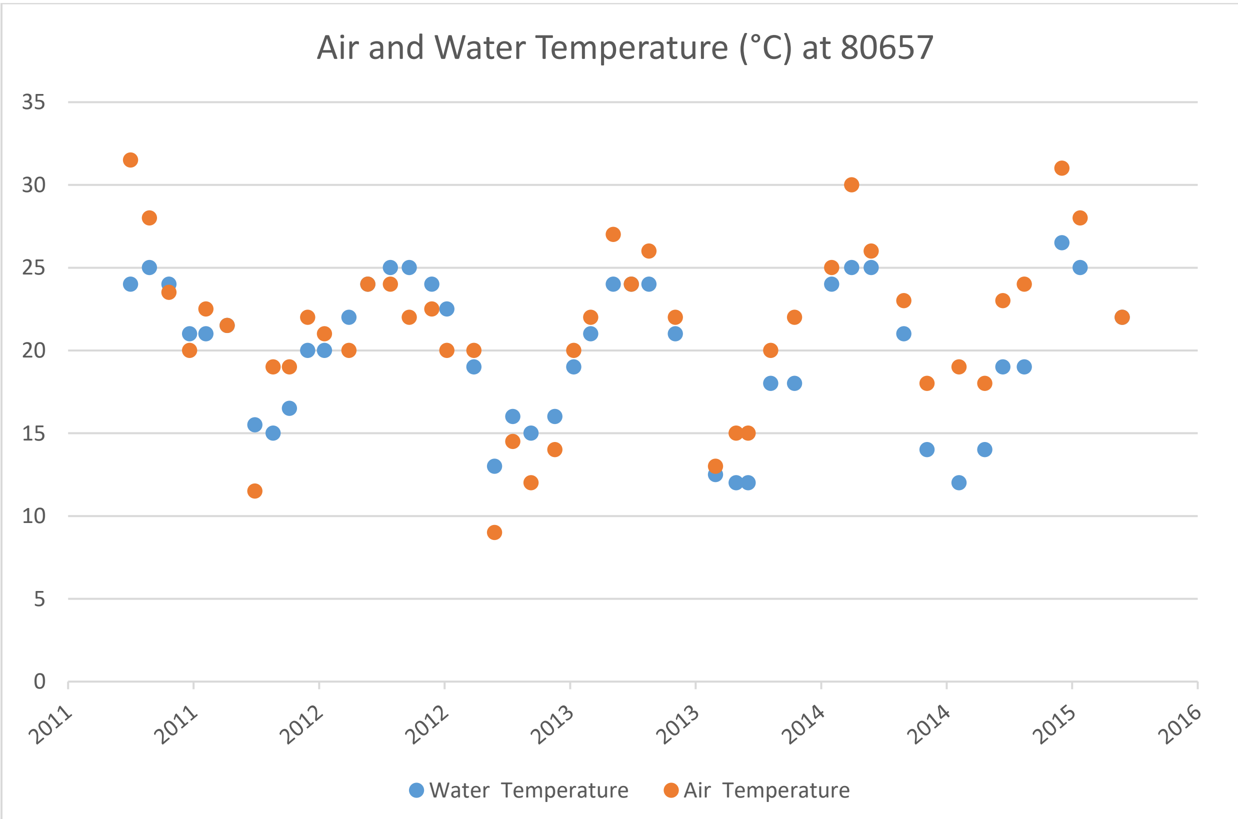

Figure 23: Air and water temperature at Site 80657

Total Dissolved Solids

Citizen scientists sampled TDS at this site 45 times between June 6, 2011 and October 3, 2015. The mean TDS concentration was 390 mg/L. The concentration of TDS ranged from a minimum of 358 mg/L in multiple instances to a maximum of 462 mg/L in February of 2015.

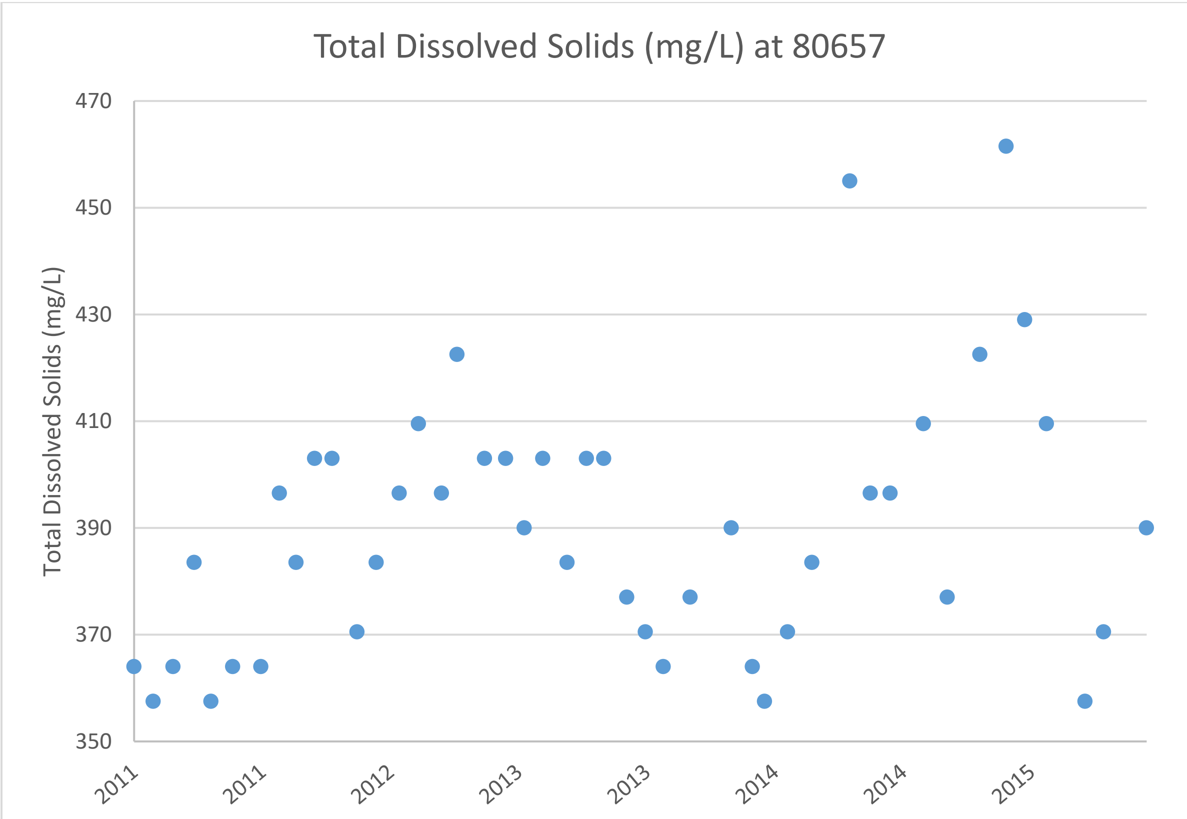

Figure 24: Total dissolved solids at Site 80657

Dissolved Oxygen

Citizen scientists collected 44 DO samples at this site between June 6, 2011 and October 3, 2015. The mean DO concentration was 6.8 mg/L. DO concentrations ranged from a low of 4.1 mg/L in August of 2011 to a high of 9.6 mg/L in December of 2013.

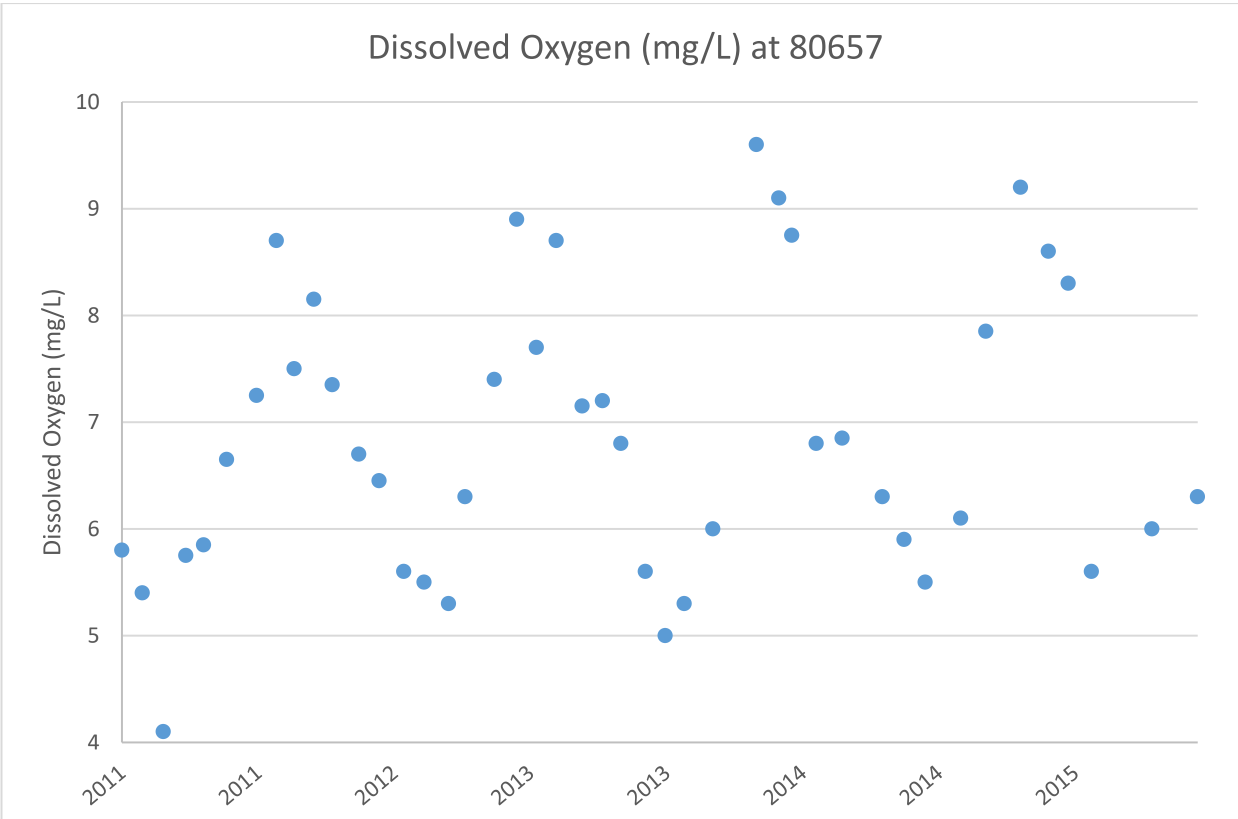

Figure 25: Dissolved oxygen at Site 80657

pH

There were 45 pH measurements taken at this site between June 6, 2011 and October 3, 2015. The mean pH was 7.5 and pH ranged from a low of 6.8 taken in October of 2011 to a high of 8.3 taken in April of 2013.

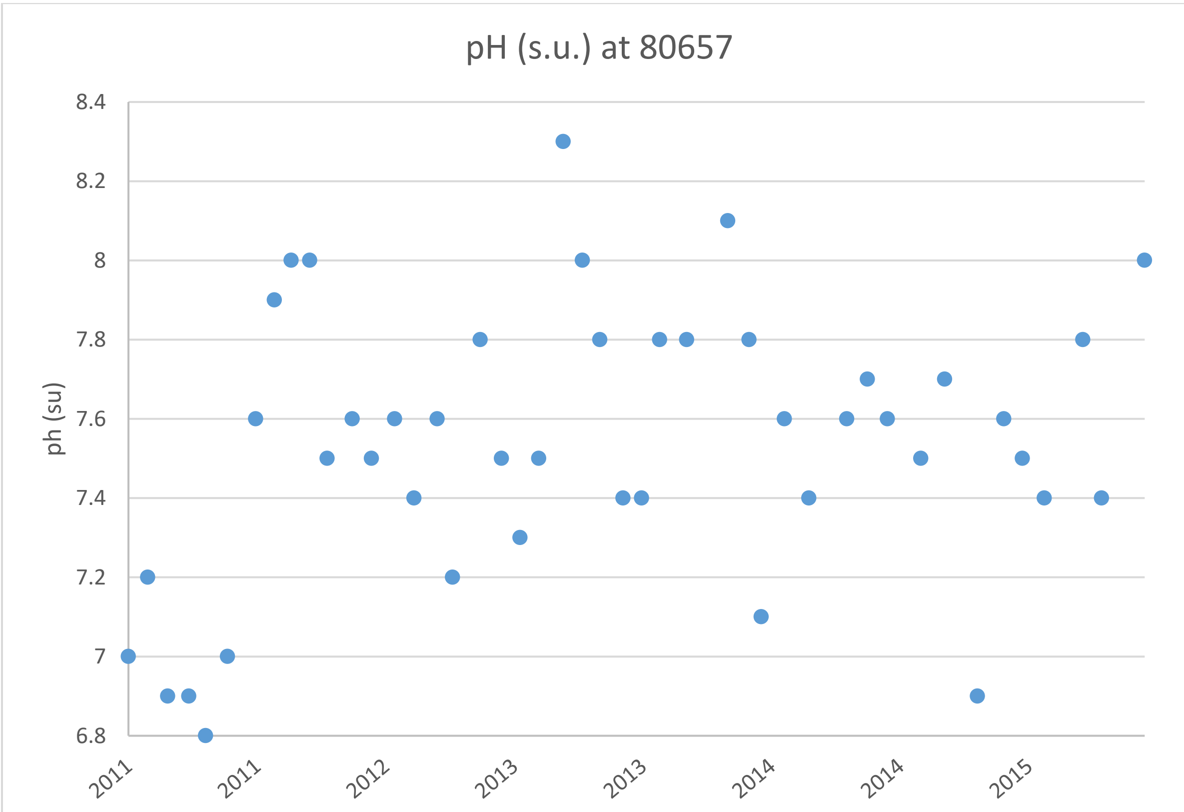

Figure 26: pH at Site 80657

E. coli

There were 38 *E. coli* measurements taken at this site between June 6, 2011 and October 3, 2015. The observed geomean was 60 CFU/100mL and ranged from 1 CFU/100mL taken on multiple occasions to a high of 290 CFU/100mL taken in February of 2015. Results surpassed the TCEQ & EPA's standard for contact recreation (for single samples, 126 CFU/100mL) eight times out of the 38 samples.

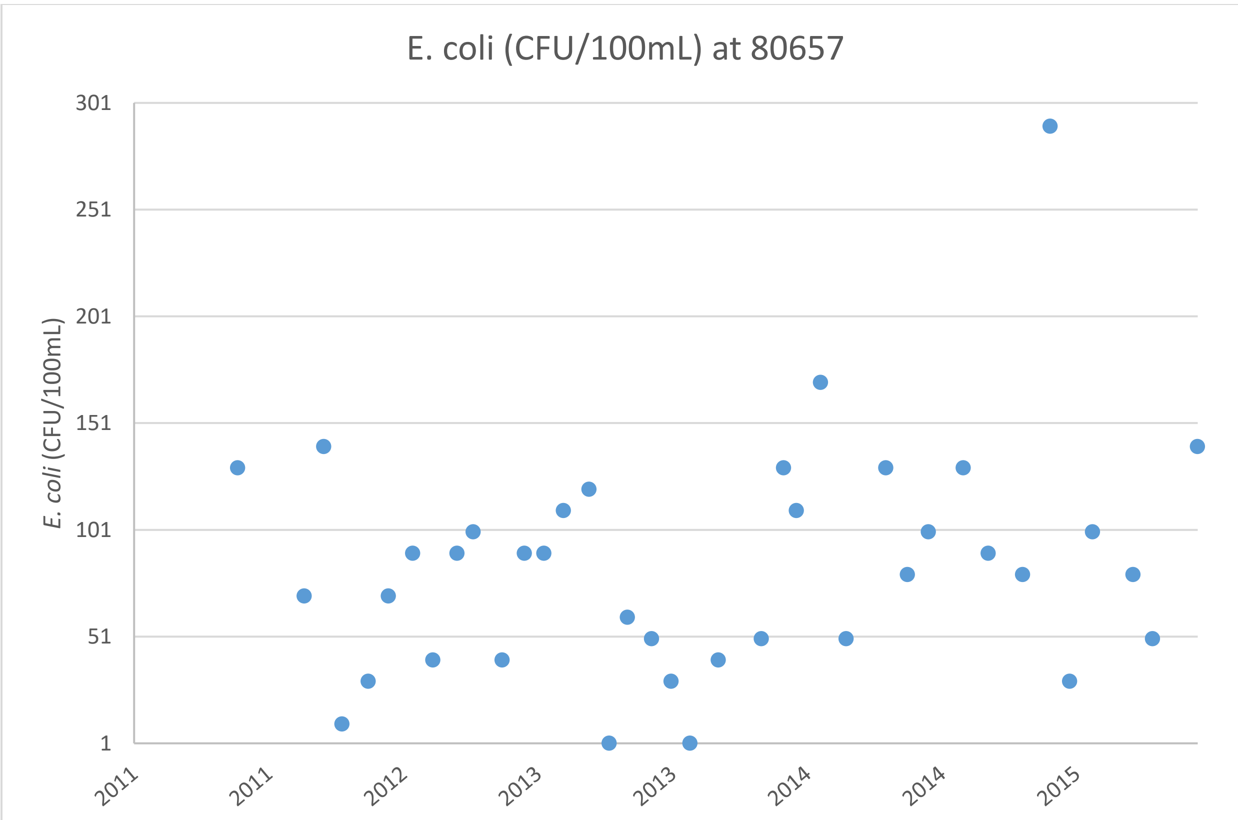

Figure 27: *E. coli* at Site 80657

Site ID# 80658 – Medina River at Bandina Ranch Road

Site Description

This site is located on a low-water crossing immediately east of the intersection of Bandina Ranch Rd and HWY 16, approximately 9.5 kilometers downstream of Medina, Texas (Fig. 2). The banks of the river here are dominated by sedges, immature sycamore trees, and cypress trees. Bandina Ranch Road leads to the Bandina Christian Youth Camp, which operates along part of the eastern side of the river here with infrastructure situated above the river's floodplain.

Sampling Information

This site was sampled 45 times between June 6, 2011 and October 3, 2015. The time of sampling for this site ranged from 9:20 to 15:30. Nearly consistent monthly monitoring was performed at this site since during the monitoring period.

Table 7: Descriptive parameters for Site 80658

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	45	462 ± 59	390	650
Water Temperature (°C)	45	20.8 ± 5.5	10.0	36.0
Dissolved Oxygen (mg/L)	45	6.2 ± 1.5	3.4	8.9
pH (su)	44	7.5 ± 0.4	6.8	8.2
E. coli (CFU/100ml)	36	38 ± 73	1	350

Site 80658 was sampled 45 times between 6/6/2011 and 10/3/2015.

Air and Water Temperature

Air temperature and water temperature was taken 45 times at this site. The air temperature fluctuated in a seasonal pattern with the highest temperature of 33.0°C in June of 2011, and the lowest temperature of 8.5°C in December of 2011. The mean water temperature was 20.8°C and the water temperature ranged from a low of 10.0°C recorded in January of 2014 to a high of 36.0°C in July of 2014.

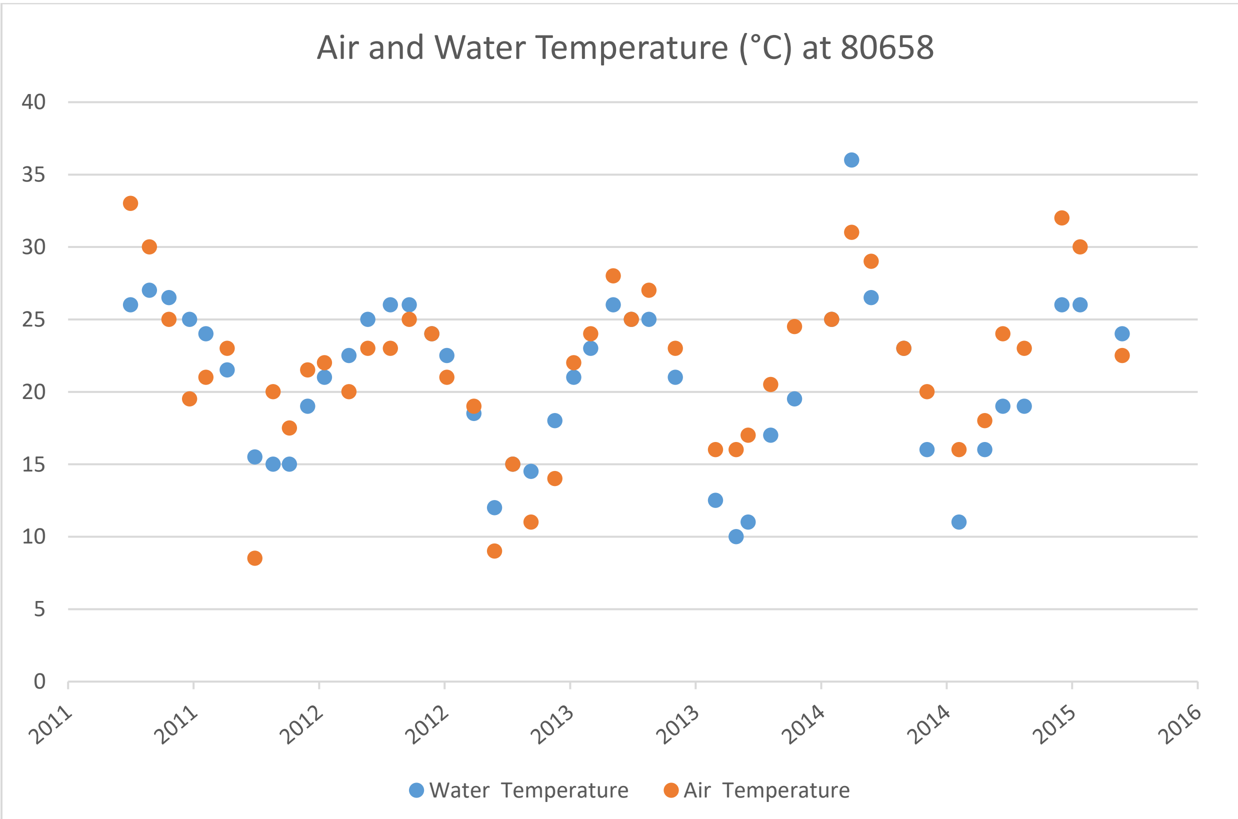

Figure 28: Air and water temperature at Site 80658

Total Dissolved Solids

Citizen scientists sampled TDS at this site 45 times between June 6, 2011 and October 3, 2015. The mean TDS concentration was 462 mg/L. The concentration of TDS ranged from a minimum of 390 mg/L in May of 2012 to a maximum of 650 mg/L in December of 2011. Measurements higher than 462 mg/L occurred during instances of low- to no-flow within the river at this location.

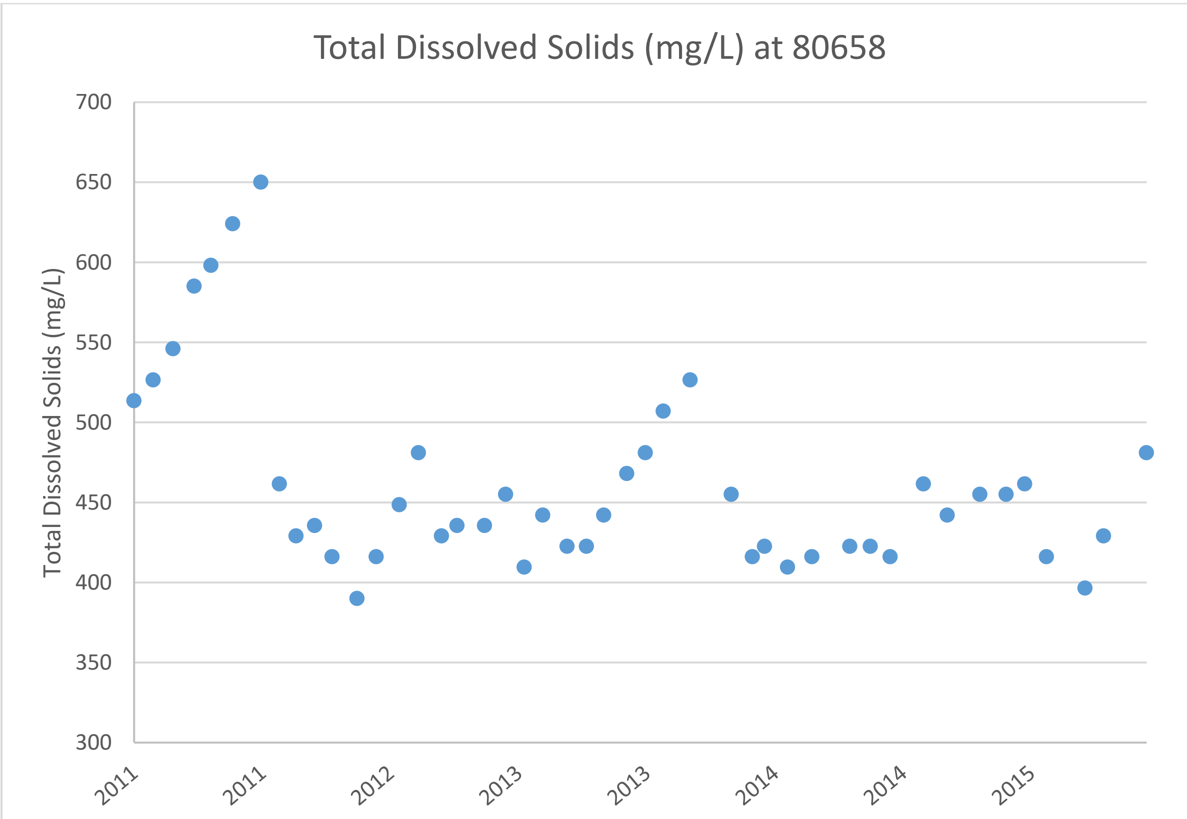

Figure 29: Total dissolved solids at Site 806958

Dissolved Oxygen

Citizen scientists took 45 DO samples at this site between June 6, 2011 and October 3, 2015. The mean DO concentration was 6.2 mg/L. DO concentrations ranged from a low of 3.4 mg/L in October of 2011 to a high of 8.9 mg/L in February of 2015.

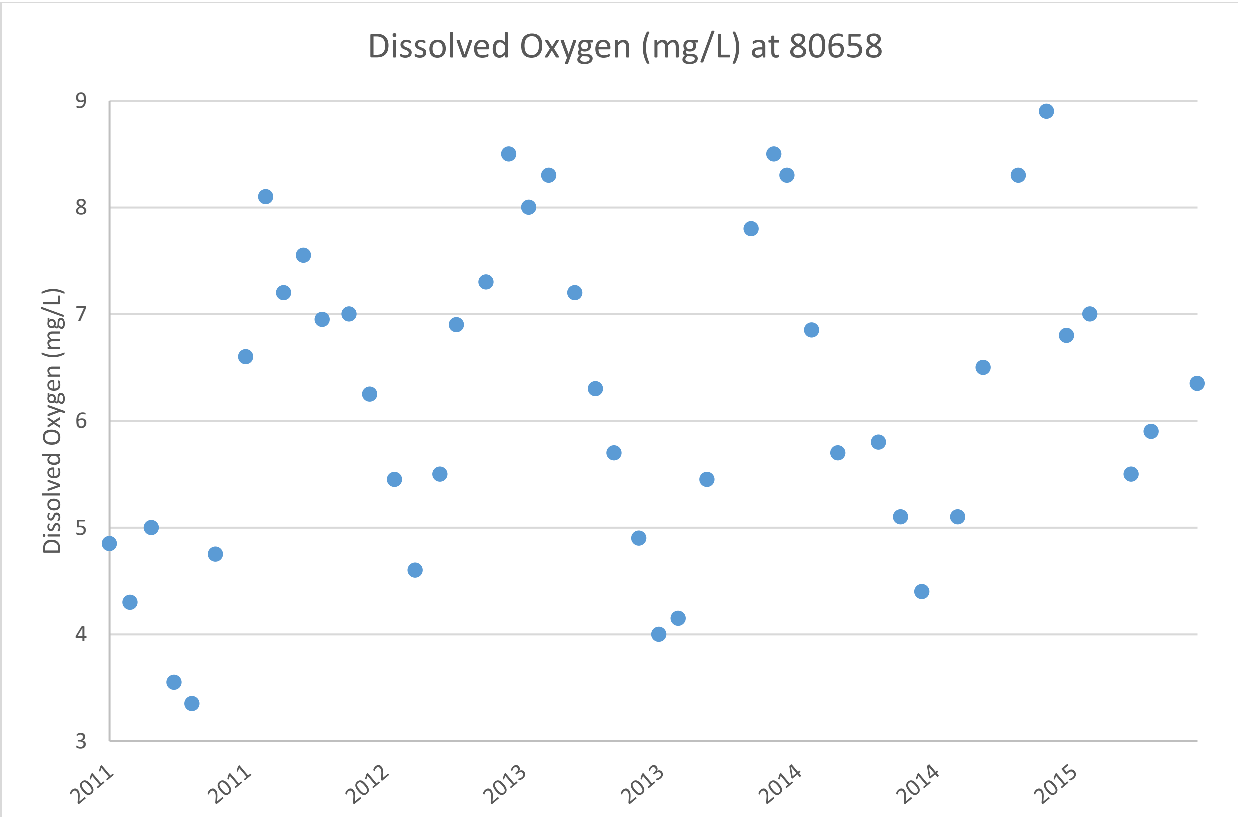

Figure 30: Dissolved oxygen at Site 80658

pH

There were 44 pH measurements taken at this site between June 6, 2011 and October 3, 2015. The mean pH was 7.5 and pH ranged from a low of 6.8 on multiple instances to a high of 8.2 taken in July of 2014.

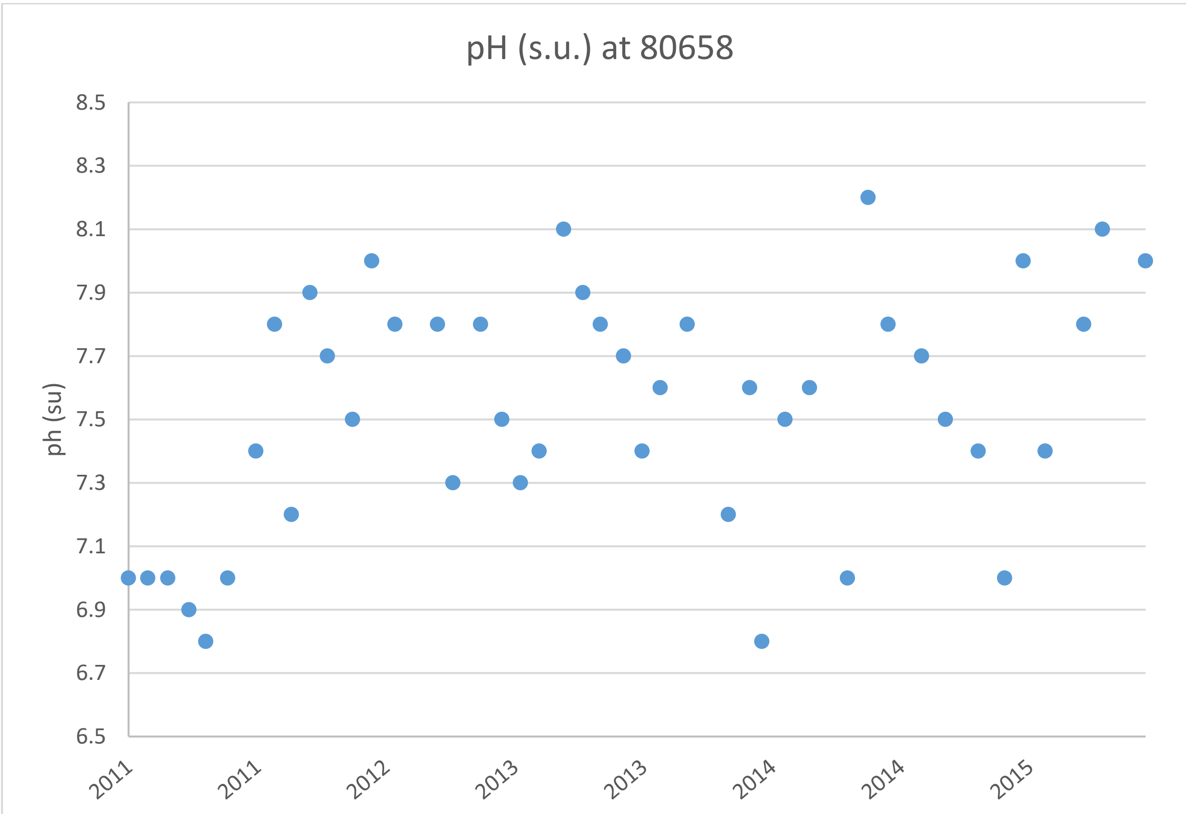

Figure 31: pH at Site 80658

E. coli

There were 36 *E. coli* measurements taken at this site between June 6, 2011 and October 3, 2015. The observed geomean was 38 CFU/100mL and ranged from 1 CFU/100mL taken on multiple occasions to a high of 350 CFU/100mL taken in May of 2012. Results surpassed the TCEQ & EPA's standard for contact recreation (for single samples, 126 CFU/100mL) five times out of the 36 samples.

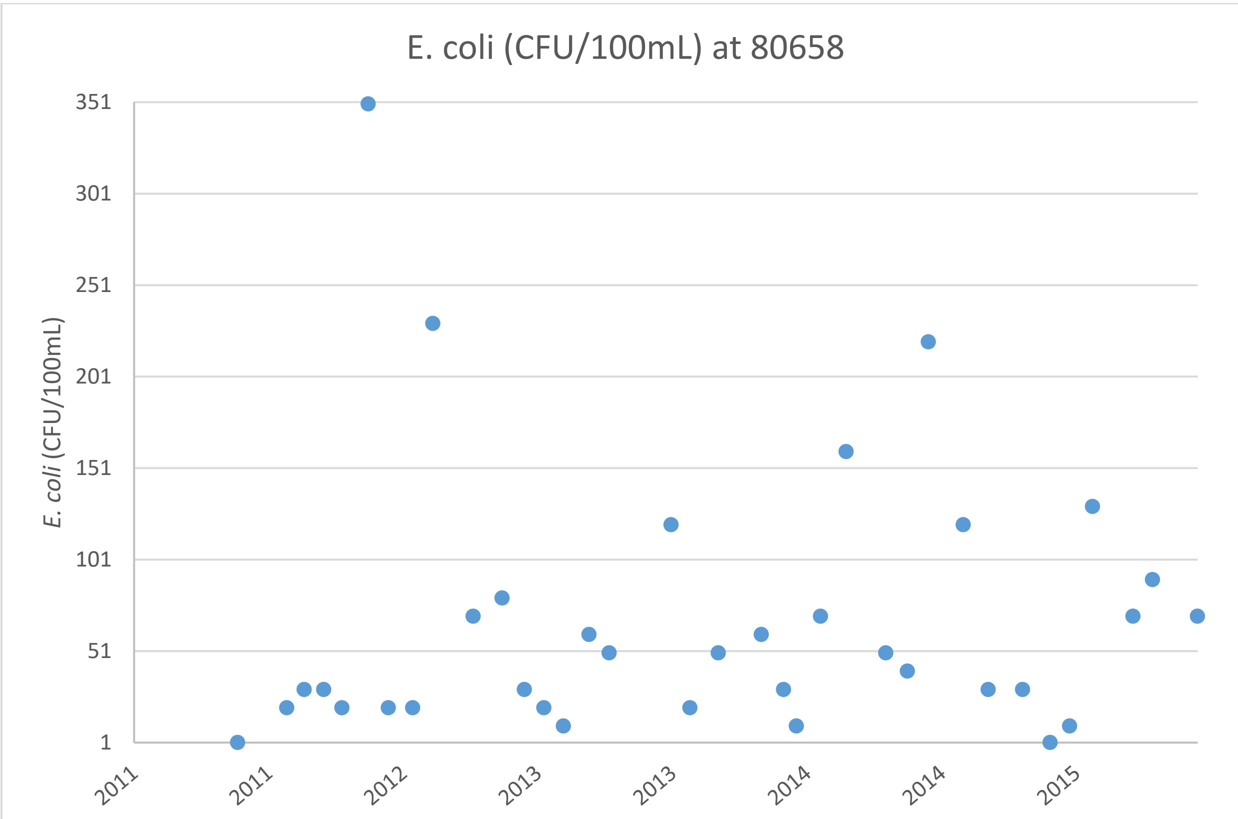

Figure 32: *E. coli* at Site 80658

Site ID# 80575 – Medina River at HWY 16 Rangers Crossing

Site Description

This site is located just above the northern crossing of HWY 16 and the Medina River and is accessed through a picnic area that is operated by the Texas Department of Transportation (Fig. 2). The picnic area offers parking and picnic arbors for the traveling public and is open 24 hours a day, 365 days a year. The banks of the river here are lined by mature stands of cypress trees. However, the riparian vegetation is extremely narrow along the river as it is flanked tightly by mow-zones, foot traffic and agricultural activity. This site is immediately upstream of an RV resort equipped with approximately 120 hook-up sites.

Sampling Information

This site was sampled 48 times between October 19, 2010 and October 3, 2015. The time of sampling for this site ranged from 9:20 to 17:30. Nearly consistent monthly monitoring was performed at this site during the monitoring period.

Table 8: Descriptive parameters for Site 80575

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	48	442 ± 35	241	475
Water Temperature (°C)	47	20.4 ± 6.3	8.0	32.0
Dissolved Oxygen (mg/L)	47	7.6 ± 1.2	5.2	10.0
pH (su)	46	7.5 ± 0.4	6.8	8.3
E. coli (CFU/100ml)	38	123 ± 135	10	800

Site 80575 was sampled 48 times between 10/19/2010 and 10/3/2015.

Air and Water Temperature

Air temperature and water temperature was taken 48 and 47 times, respectively, at this site. The air temperature fluctuated in a seasonal pattern with the highest temperature of 35.0°C in July of 2011 and the lowest temperature of 9.0°C in January of 2013. The mean water temperature was 20.4°C and the water temperature ranged from a low of 8.0°C recorded in January of 2014 to a high of 32.0°C in October of 2015.

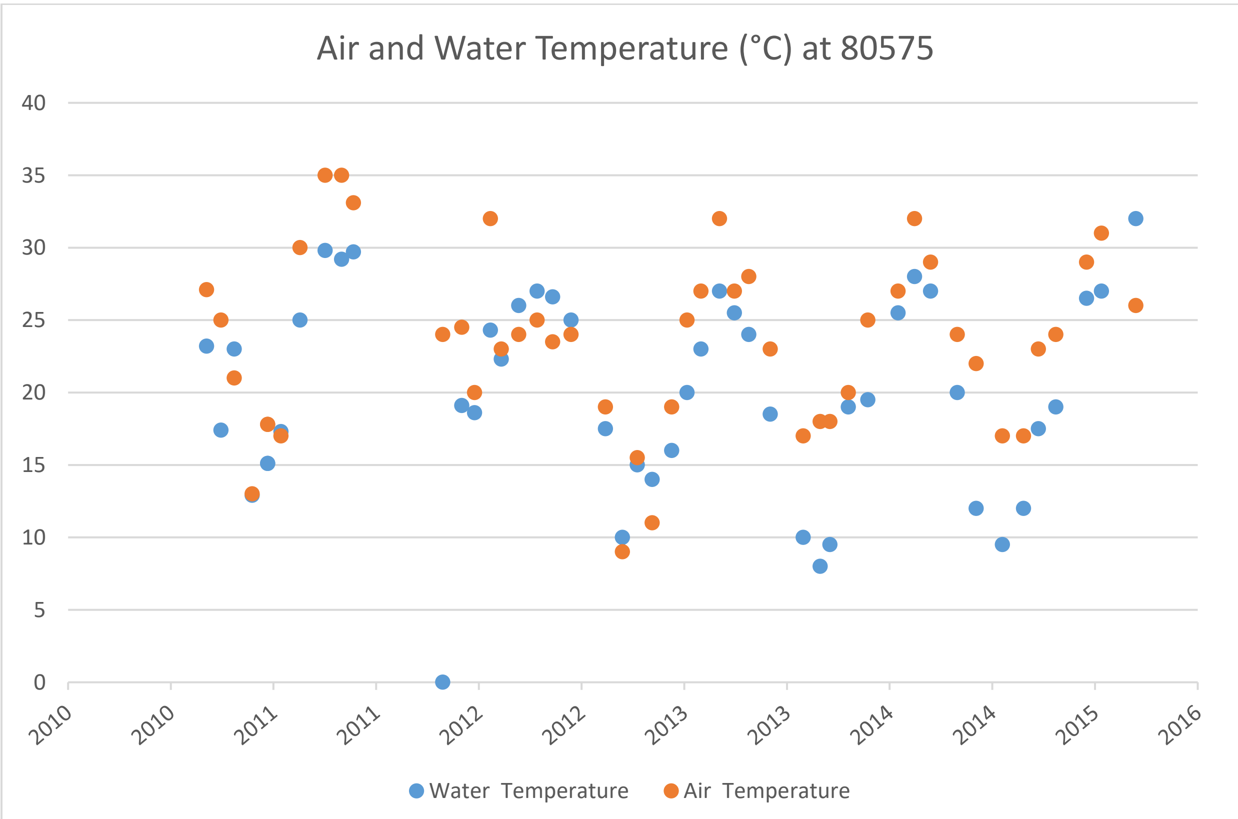

Figure 33: Air and water temperature at Site 80575

Total Dissolved Solids

Citizen scientists sampled TDS at this site 48 times between October 19, 2010 and October 3, 2015. The mean TDS concentration was 422 mg/L. The concentration of TDS ranged from a minimum of 241 mg/L in May of 2012 to a maximum of 475 mg/L in December of 2013. This site exhibited some of the highest TDS values of the Texas Stream Team sites analyzed for this report.

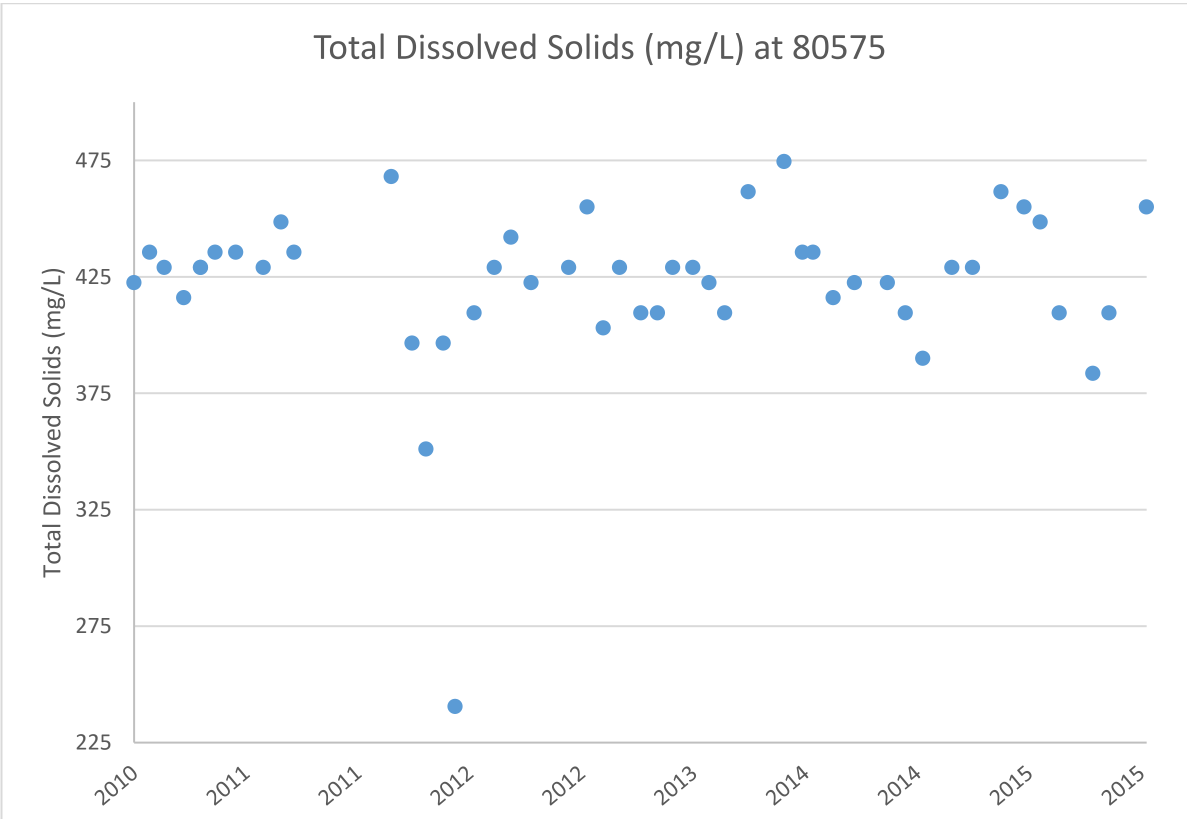

Figure 34: Total dissolved solids at Site 80575

Dissolved Oxygen

Citizen scientists took 47 DO samples at this site between October 19, 2010 and October 3, 2015. The mean DO concentration was 7.6 mg/L. DO concentrations ranged from a low of 5.2 mg/L in September of 2013 to a high of 10.0 mg/L in January of 2014.

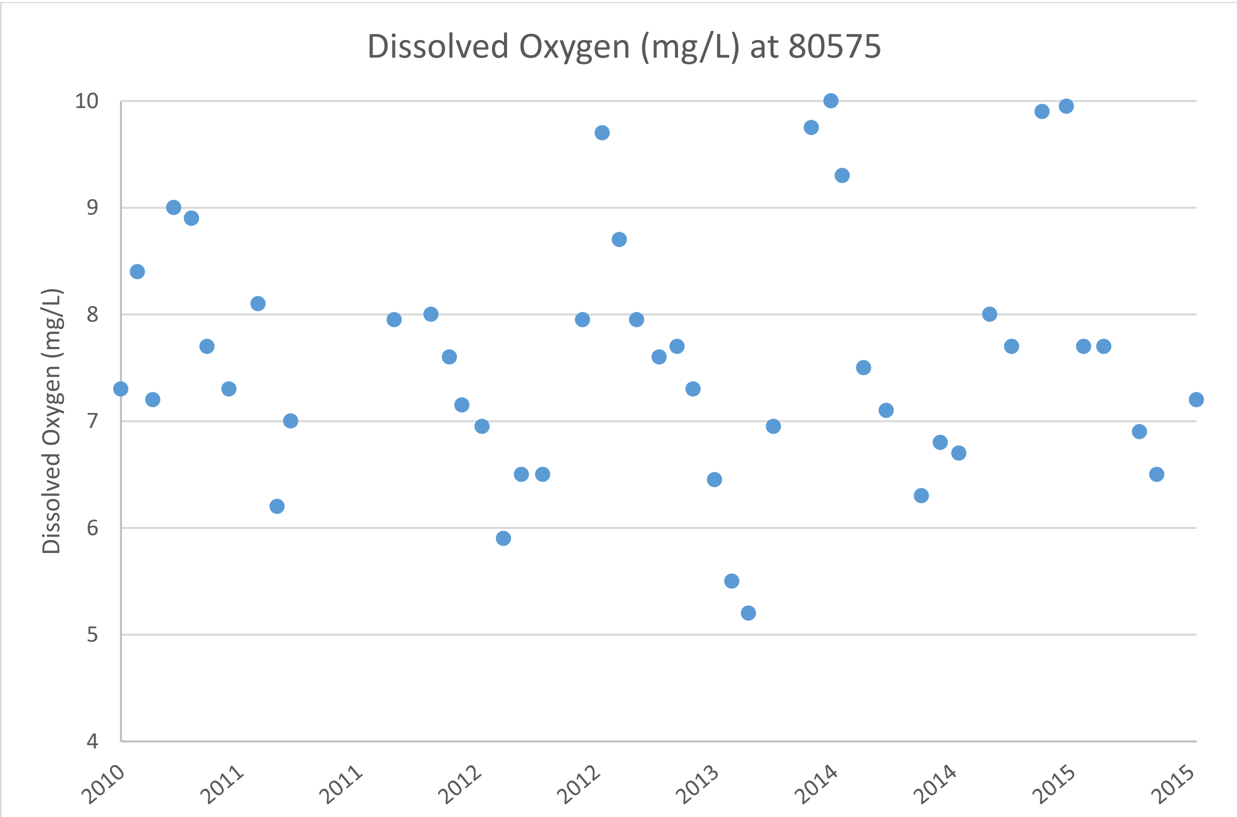

Figure 35: Dissolved oxygen at Site 80575

pH

There were 46 pH measurements taken at this site between October 19, 2010 and October 3, 2015. The mean pH was 7.5 and pH ranged from a low of 6.8 to a high of 8.3 taken on multiple instances.

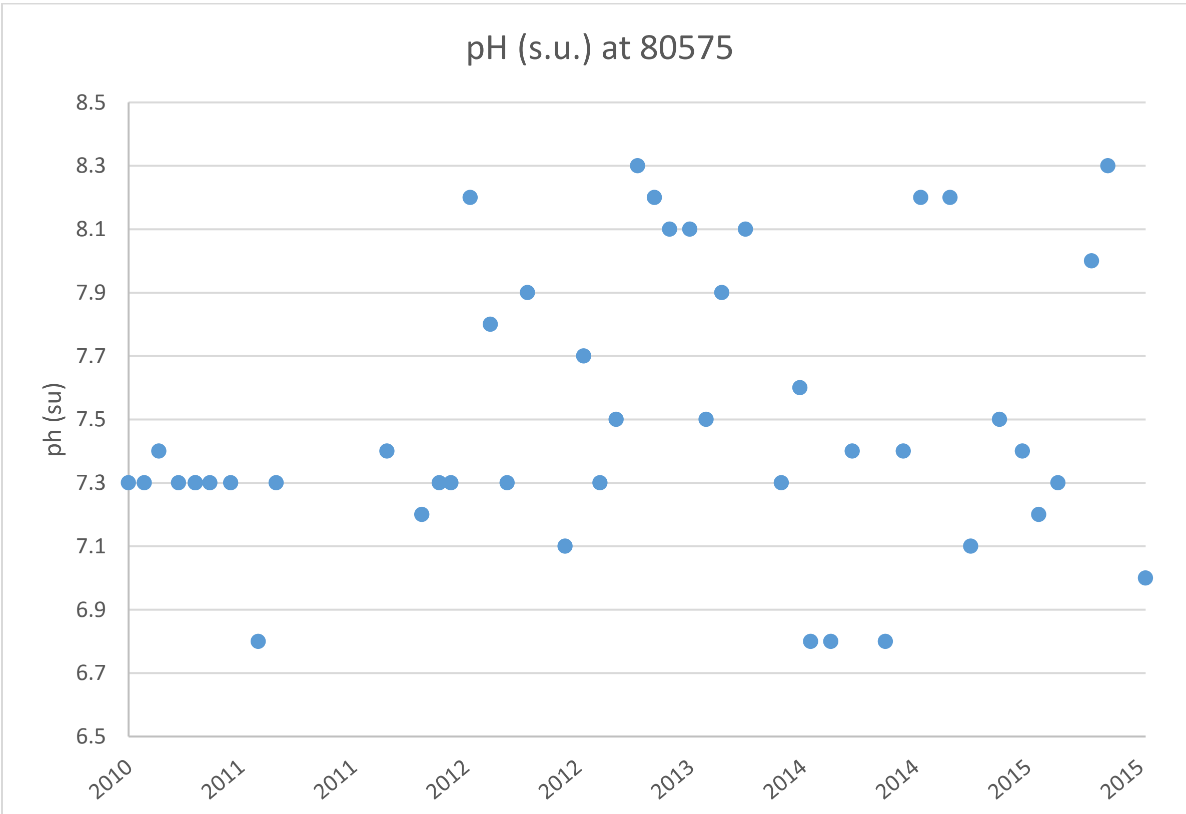

Figure 36: pH at Site 80575

E. coli

There were 38 *E. coli* measurements taken at this site between October 19, 2010 and October 3, 2015. The observed geomean was 123 CFU/100mL and ranged from 10 CFU/100mL taken on January of 2013 to a high of 800 CFU/100mL taken in August of 2011. Results surpassed the TCEQ & EPA's standard for contact recreation (for single samples, 126 CFU/100mL) 20 times out of the 38 samples. In terms of *E. coli* measurements, Site ID# 80575 is the most impacted Texas Stream Team site within this report.

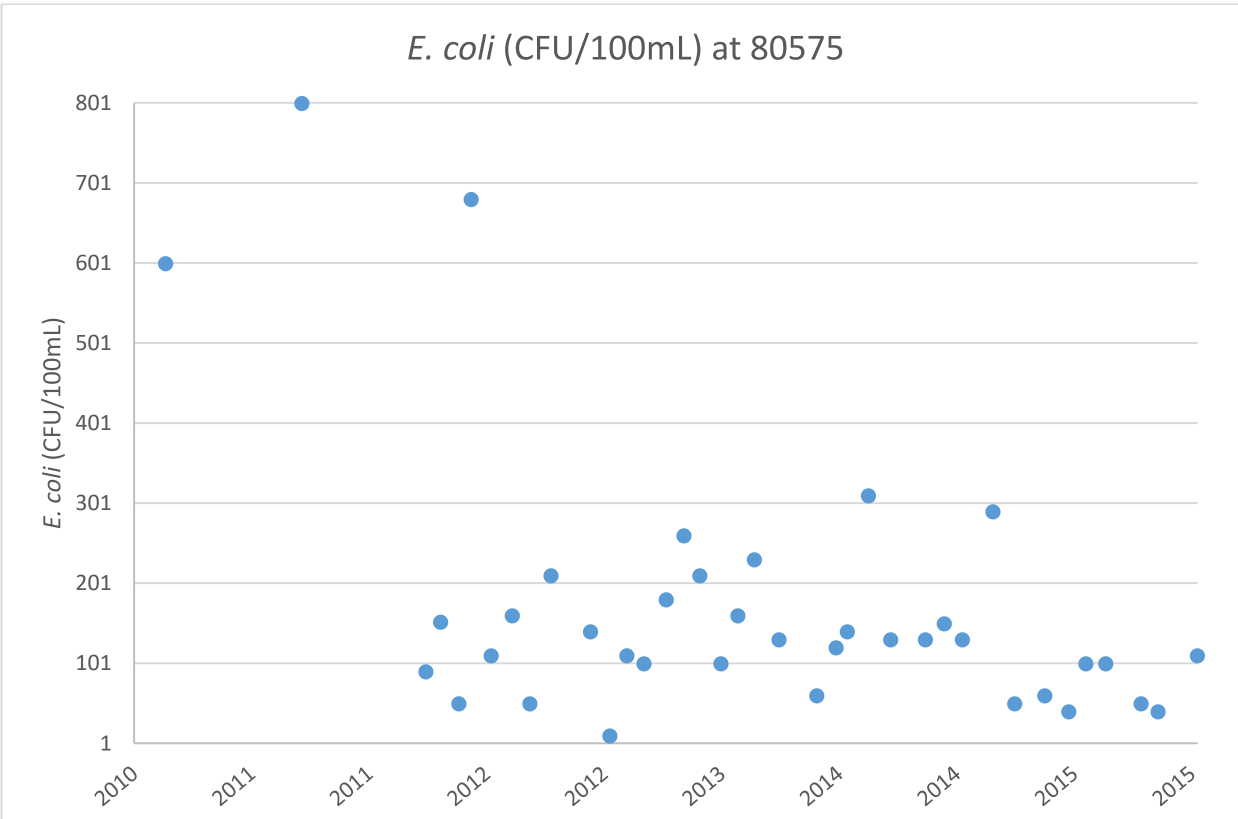

Figure 37: *E. coli* at Site 80575

Site ID# 80576 – Medina River at English Crossing

Site Description

This site is located on a low-water crossing nearly 1.6 kilometers upstream of where the river begins to form Medina Lake (Fig. 2). The immediate watershed here conforms with the mostly-undeveloped landscape of this segment of the Medina River with dense woodlands and some rangeland. This site is the same location where the U.S. Geological Survey has been maintaining a stream gage since mid-2017 with the name "08178980 Medina Rv abv English Crsg nr Pipe Creek, TX" which records discharge and gage height.

Sampling Information

This site was sampled 16 times between November 10, 2010 and May 25, 2012. The time of sampling for this site ranged from 11:30 to 18:30. Nearly consistent monthly monitoring was performed at this site during the period.

Table 9: Descriptive parameters for Site 80576

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	16	400 ± 33	351	488
Water Temperature (°C)	16	22.1 ± 5.7	12.2	32.0
Dissolved Oxygen (mg/L)	16	9.3 ± 1.8	6.9	13.9
pH (su)	16	6.9 ± 0.1	6.8	7.0
E. coli (CFU/100ml)	2	88 ± 20	70	110

Site 80576 was sampled 16 times between 11/10/2010 and 5/25/2012.

Air and Water Temperature

Air temperature and water temperature was taken 16 times at this site. The air temperature reached its highest temperature of 37.0°C in August of 2011, and the lowest temperature of 8.0°C in January of 2011. The mean water temperature was 22.1°C and the water temperature ranged from a low of 12.2°C recorded in January of 2011 to a high of 32.0°C in November of 2011.

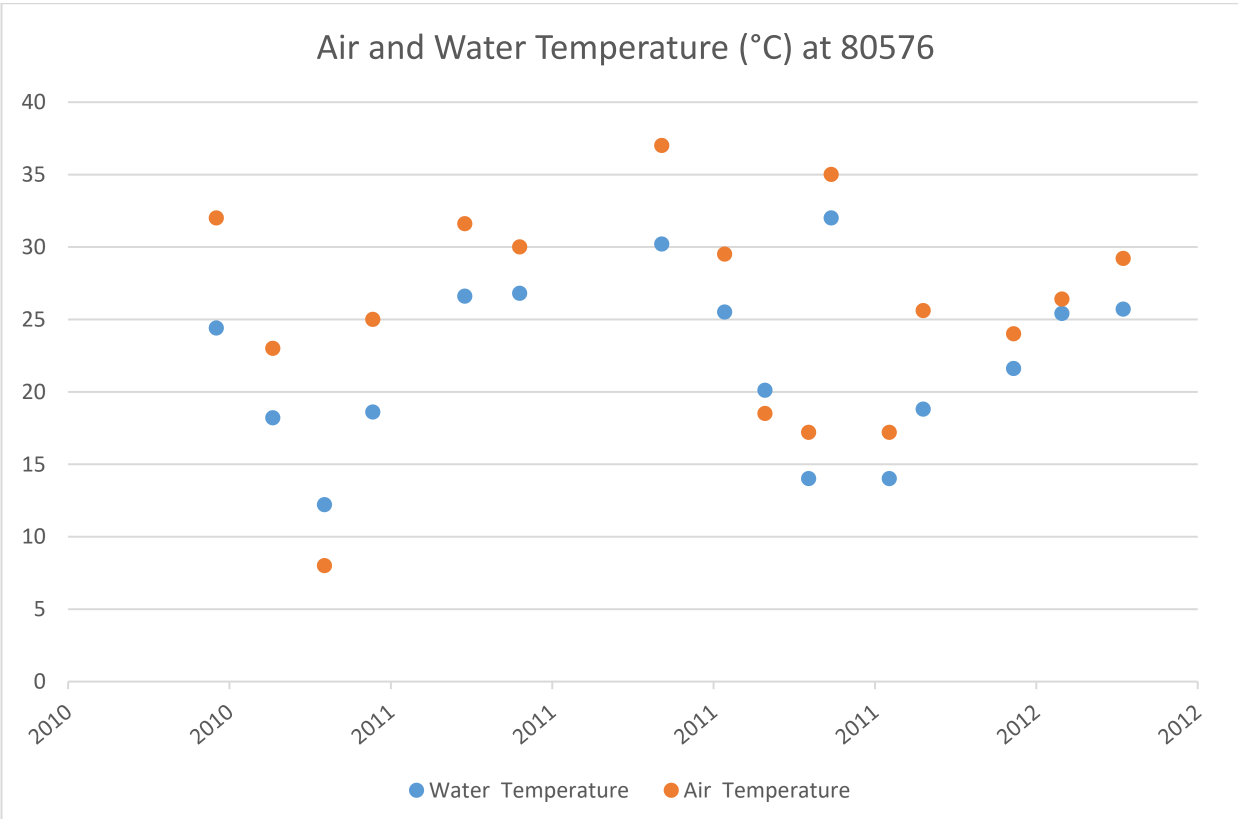

Figure 38: Air and water temperature at Site 80576

Total Dissolved Solids

Citizen scientists sampled TDS at this site 16 times between November 10, 2010 and May 25, 2012. The mean TDS concentration was 400 mg/L. The concentration of TDS ranged from a minimum of 351 mg/L in May of 2012 to a maximum of 488 mg/L in January of 2012. This site exhibited some of the highest TDS values of the Texas Stream Team sites analyzed in this report.

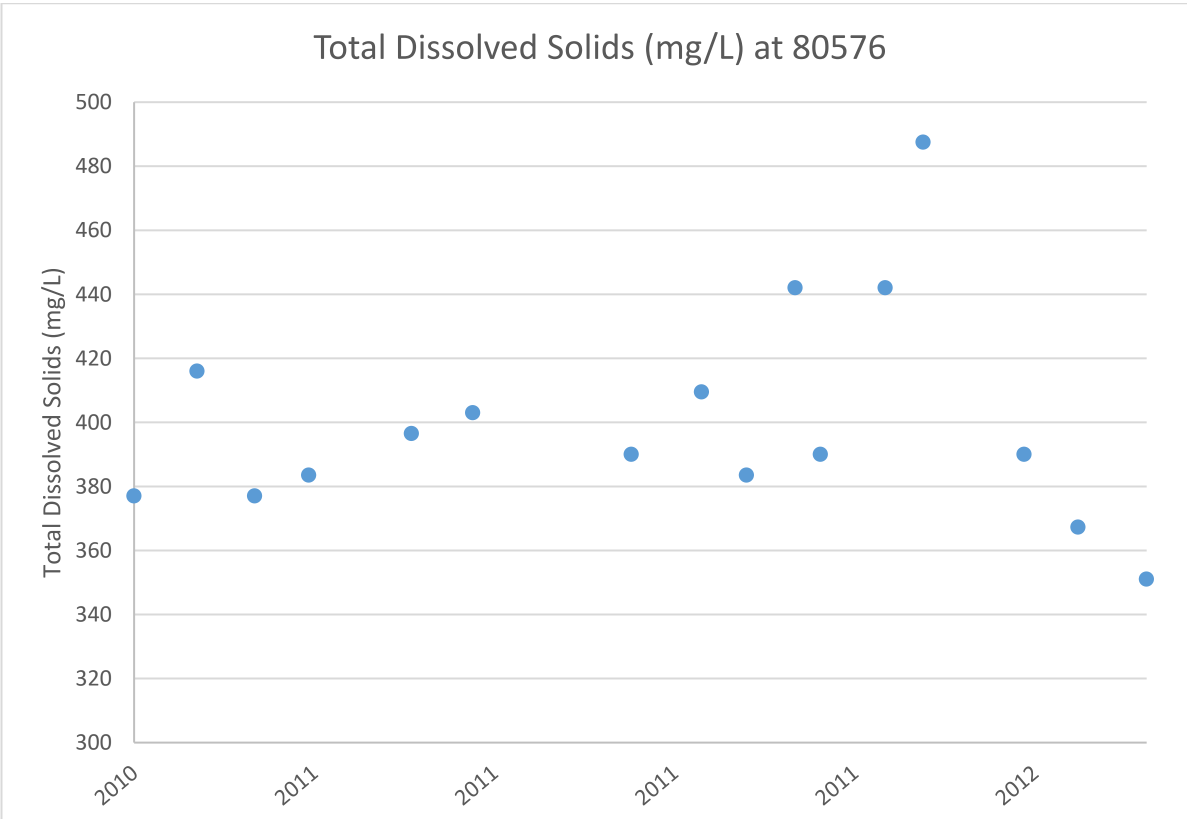

Figure 39: Total dissolved solids at Site 80576

Dissolved Oxygen

Citizen scientists took 16 DO samples at this site between November 10, 2010 and May 25, 2012. The mean DO concentration was 9.3 mg/L. DO concentrations ranged from a low of 6.9 mg/L in May of 2011 to a high of 13.9 mg/L in January of 2012.

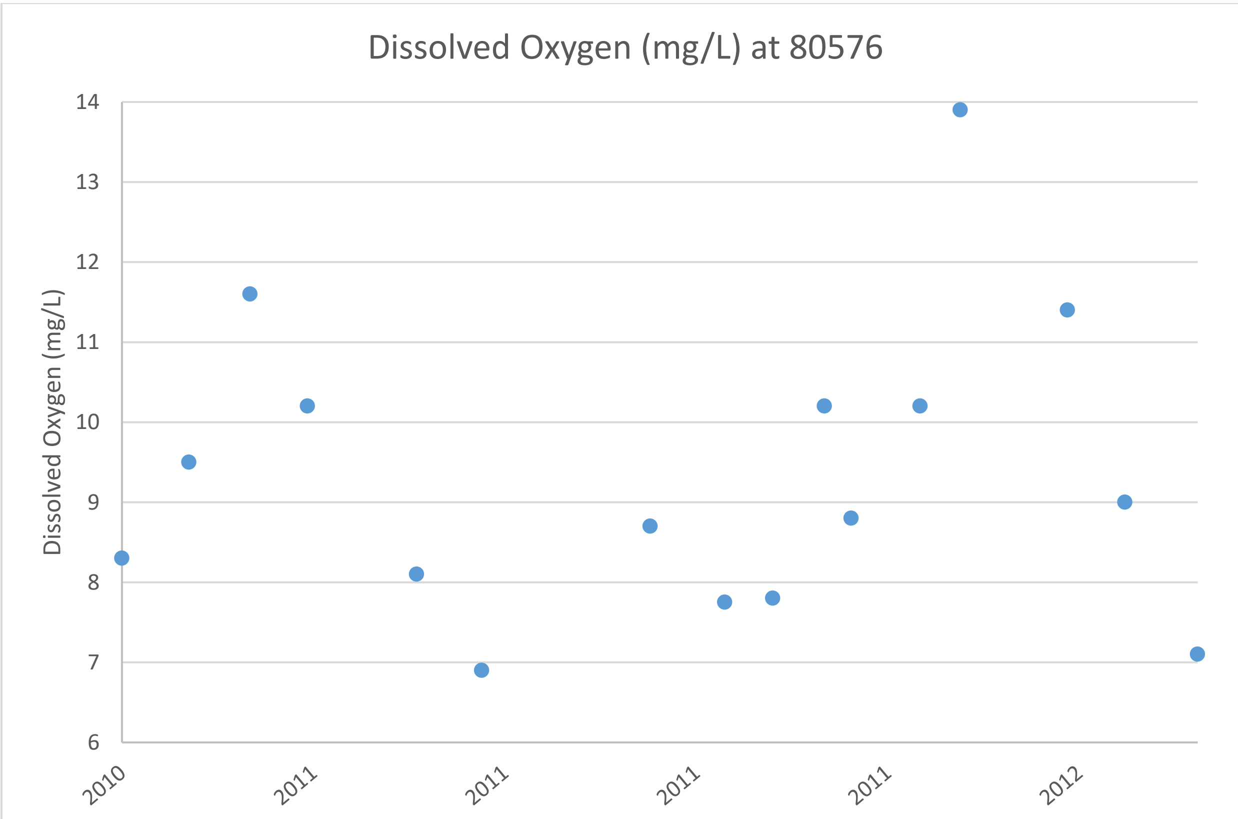

Figure 40: Dissolved oxygen at Site 80576

pH

There were 16 pH measurements taken at this site between November 10, 2010 and May 25, 2012. The mean pH was 6.9 and pH ranged from a low of 6.8 to a high of 7.0 taken in multiple instances.

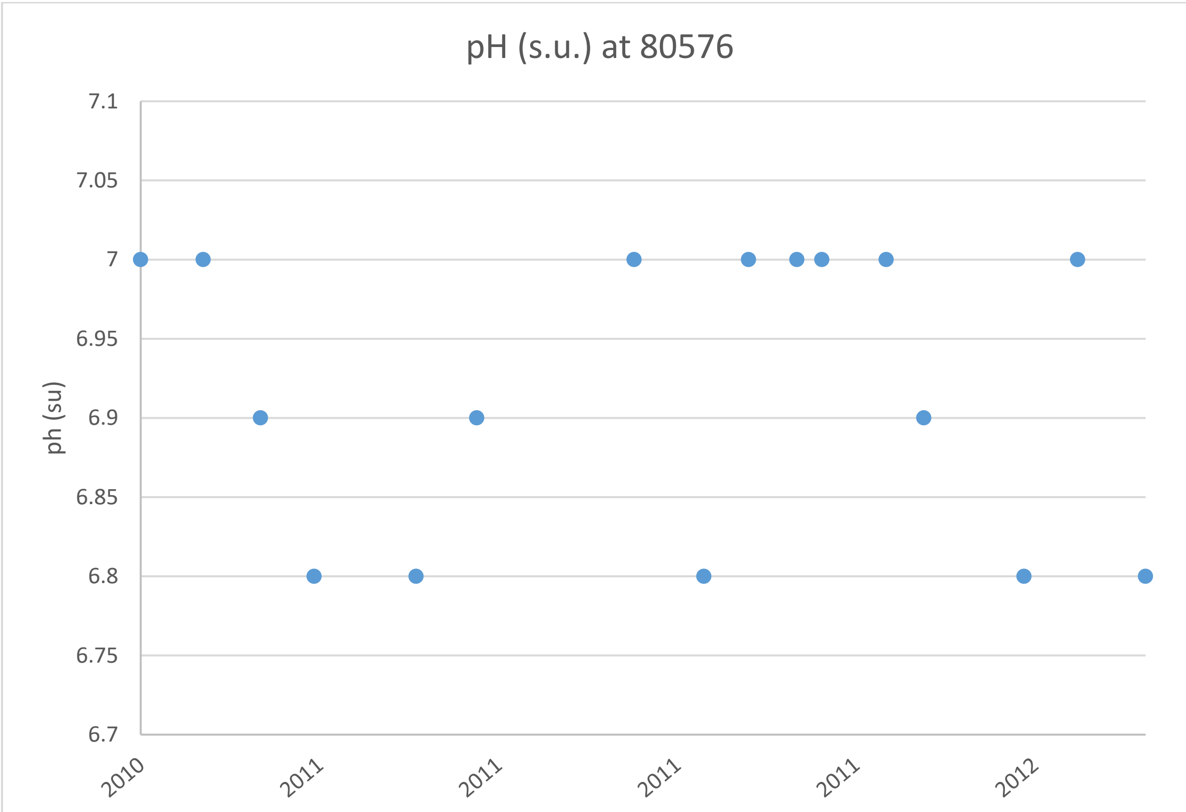

Figure 41: pH at Site 80576

E. coli

There were only two *E. coli* measurements taken at this site between November 10, 2010 and May 25, 2012. Those values were 70 CFU/100mL collected in April of 2012 and 110 CFU/100mL collected in March of 2012. Results did not surpass the TCEQ's standard for contact recreation for single samples (126 CFU/100mL).

WATERSHED SUMMARY

Texas Stream Team citizen scientists monitored several water quality parameters from six different sites in the Medina River above Medina Lake (Segment 1905) from 2010 to the present including air and water temperature, TDS, DO, pH, and *E. coli*. Data from the six monitoring sites were analyzed to provide an overview of findings during the period of record.

Highlights of the results include:

- An upstream to downstream water temperature gradient from colder to warmer was apparent, likely a result of the proximity of the spring water source at the upstream sites. The temperature water quality standard (31.0 °C) was exceeded at the downstream sites where more urbanization is prominent than at the upstream sites.
- Total dissolved solid measurements had a bimodal spatial distribution, with the two upper sites (80690 and 80691) revealing lower TDS values than the lower four sites within the watershed. This was likely a result of the proximity to the spring water source which typically exhibits lower TDS.
- Dissolved oxygen was consistently above the water quality standard at most sites with higher overall values at the two upper (80690 and 80691) and two lower (80575 and 80576) sites (>7.1 mg/L) within the watershed. The lower DO values (<6.8 mg/L) appeared at the two middle sites (80657 and 80658) along the continuum from upstream to downstream, which are also the sites located either in the city or just downstream of the city of Medina. Some values fell below the minimum water quality standard (4.0 mg/L) at the most upstream site (80690) and the site downstream of the city of Medina (80658).
- The pH values were all within the range of values associated with the water quality standard (6.5-9.0). No values dropped below or above that range.
- *E. coli* values exceeded both the geomean and single sample standard on several occasions at most sites, except the most downstream site (80576), but it had a very limited data set (2 data points). The highest geomean (123) with the greatest standard deviation ($\pm$169) was observed at site 80575 in the lower portion of the segment with 20 of the 38 samples exceeding the geometric mean criterion (126 CFU/100mL).

The Texas Stream Team citizen scientist monitoring group, Bandera Stream Team, will continue to monitor the water quality of the Medina River watershed. Texas Stream Team will continue to support citizen scientists to collect and test samples for water quality. Additionally, the Texas Stream Team and the Bandera Stream Team will continue to create new monitoring sites and re-activate existing sites as necessary.

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APPENDIX

Appendix 1: Endangered, threatened and rare species within the Medina River watershed

AMPHIBIANS	Southern Dusky Salamander	Critically Imperiled
	Cascade Caverns Salamander	Threatened
	Texas Salamander	Critically Imperiled, Imperiled*
	Comal Blind Salamander	Threatened
	Valdina Farms Sinkhole Salamander	Vulnerable, Apparently Secure*
	Blanco River Springs Salamander	Vulnerable*
	Black-Spotted Newt	Threatened
	Woodhouse's Toad	SU
	Strecker's Chorus Frog	Vulnerable*
	Mexican Treefrog	Threatened
BIRDS	Reddish Egret	Threatened
	White-Faced Ibis	Threatened
	Wood Stork	Threatened
	Bald Eagle	Threatened
	Zone-Tailed Hawk	Threatened
	Gray Hawk	Threatened
	Whooping Crane	Endangered
	Piping Plover	Threatened
	Mountain Plover	Imperiled*
	Eskimo Curlew	Endangered
	Franklin's Gull	S2N*
	Interior Least Tern	Endangered
	Western Burrowing Owl	Imperiled*
	Black-Capped Vireo	Endangered
	Tropical Parula	Threatened
	Golden-Cheeked Warbler	Endangered
FISHES	Frio Roundnose Minnow	Imperiled*
	Medina Roundnose Minnow	Apparently Secured*
	Texas Shiner	Apparently Secured*
	Plateau Shiner	Critically Imperiled, Imperiled*
	Headwater Catfish	Imperiled*
	Widemouth Blindcat	Threatened
	Toothless Blindcat	Threatened
	Guadalupe Bass	Vulnerable*
	River Darter	Apparently Secured*
	Guadalupe Darter	Unranked
MAMMALS	Cave Myotis Bat	Apparently Secured*
	Tricolored Bat	Vulnerable, Apparently Secured*
	Big Brown Bat	Secure
	Eastern Red Bat	Apparently Secured*
	Hoary Bat	Apparently Secured*
	Townsend's Big-Eared Bat	Vulnerable*
	Mexican Free-Tailed Bat	Secured*
	Big Free-Tailed Bat	Vulnerable
	Swamp Rabbit	Secured*
	Thirteen-Lined Ground Squirrel	Secured*
	Black-Tailed Prairie Dog	Vulnerable*
	Llano Pocket Gopher	Imperiled*
	Frio Pocket Gopher	Imperiled*

	Woodland Vole	Vulnerable*
	Black Bear	Threatened
	White-Nosed Coati	Threatened
	Long-Tailed Weasel	Secured*
	Mink	Apparently Secured*
	American Badger	Secured*
	Eastern Spotted Skunk	Critically Imperiled, Vulnerable*
	Plains Spotted Skunk	Critically Imperiled, Vulnerable
	Western Spotted Skunk	Secure*
	Western Hog-Nosed Skunk	Apparently Secured*
	Mountain Lion	Imperiled, Vulnerable*
	Ocelot	Endangered
REPTILES	Cagle's Map Turtle	Threatened
	Eastern Box Turtle	Vulnerable*
	Western Box Turtle	Vulnerable*
	Texas Tortoise	Threatened
	American Alligator	Apparently Secured*
	Slender Glass Lizard	Vulnerable*
	Spot-Tailed Earless Lizard	Imperiled*
	Northern Spot-Tailed Earless Lizard	Imperiled*
	Southern Spot-Tailed Earless Lizard	Imperiled*
	Keeled Earless Lizard	Vulnerable
	Texas Horned Lizard	Threatened
	Texas Indigo Snake	Threatened
	Western Hognose Snake	Apparently Secured*
	Common Garter Snake	Imperiled*
	Texas Garter Snake	Critically Imperiled*
	Timber (Canebrake) Rattlesnake	Threatened
	Western Rattlesnake	Secure
CRUSTACEANS	Cascade Cave Amphipod	Critically Imperiled*
	Ezell's Cave Amphipod	Vulnerable*
	Balcones Cave Amphipod	Imperiled*
	Nueces Crayfish	Critically Imperiled*
	Mexiweckelia Hardeni	Imperiled*
	Seborgia Hershleri	Imperiled*
	A Cave Obligate Isopod	Imperiled*
	Brackenridgia Reddelli	Critically Imperiled*
INSECTS	Cotinis Boylei	Imperiled*
	A Ground Beetle (Rhadine Exilis)	Critically Imperiled*
	A Ground Beetle (Rhadine Infernalis)	Critically Imperiled*
	Rhadine Speca	Imperiled*
	Rhadine Bullis	Imperiled*
	Helotes Mold Beetle	Critically Imperiled*
	A Cave Obligate Beetle	Unranked*
	Lymantes Nadineae	Unranked*
	Myrmecoderus Laevipennis	Unranked*
	Cotalpa Conclamara	Unranked*
	A Mayfly	Critically Imperiled*
	American Bumblebee	Unranked*
	Bombus Variabilis	Unranked*
	Megachile Parksi	Unranked*
	Manfreda Giant-Skipper	Critically Imperiled*
	Oxyelophila Callista	Unranked*

	Sage Sphinx Moth	Critically Imperiled*
	Cisthene Conjuncta	Critically Imperiled*
	Pygarctia Lorula	Imperiled
	A Katydid	Unranked
	Pediodectes Mitchelli	Unranked
	Dichopetala Catinata	Unranked
	Dichopetala Seeversi	Unranked
	Hydroptila Melia	Imperiled*
	Ochrotrichia Capitana	Imperiled*
	Neotrichia Juani	Critically Imperiled*
	Nectopsyche Texana	Imperiled*
	Texas Austrotinodes Caddisfly	Imperiled*
ARACHNIDS	Government Canyon Bat Cave Spider	Critically Imperiled*
	Cokendolpher Cave Harvestman	Critically Imperiled*
	Texella Hardeni	Critically Imperiled*
	Tartarocreagris Amblyopa	Critically Imperiled*
	Tartarocreagris Reyesi	Critically Imperiled*
	Madla Cave Meshweaver	Critically Imperiled*
	Robber Baron Cave Meshweaver	Critically Imperiled*
	Braken Bat Cave Meshweaver	Critically Imperiled*
	Government Canyon Bat Cave Meshweaver	Critically Imperiled*
	Cicurina Bandera	Imperiled*
	Cicurina Mckenziei	Critically Imperiled*
	Cicurina Medina	Critically Imperiled*
	Cicurina Obscura	Critically Imperiled*
	Cicurina Pastura	Critically Imperiled*
	Cicurina Sprousei	Critically Imperiled*
	Cicurina Stowersi	Critically Imperiled*
	Speodesmus Reddelli	Unranked*
	Eidmannella Nasuta	Critically Imperiled*
MOLLUSKS	Texas Fatmucket	Threatened
	Golden Orb	Threatened
	Cyclonaias Necki	Unranked*
	False Spike Mussel	Threatened
	Holospira Goldfussi	Imperiled*
	Millerelix Gracilis	Imperiled*
	Horseshoe Liptooth	Critically Imperiled*
	Marstonia Comalensis	Critically Imperiled*
	Elimia Comalensis	Imperiled*
	Mimic Cavesnail	Critically Imperiled*
	Phreatodrobia Conica	Imperiled*
	Phreatodrobia Micra	Imperiled*
PLANTS	Plateau Milkvine	Vulnerable*
	Gravelbar Brickellbush	Vulnerable, Apparently Secure*
	Narrowleaf Brickellbush	Vulnerable*
	Spreading Leastdaisy	Vulnerable, Apparently Secure*
	Awnless Leastdaisy	Vulnerable*
	South Texas False Cudweed	Vulnerable*
	Sandhill Woolywhite	Imperiled*

	Barbed Rattlesnake-Root	Vulnerable*
	Canyon Rattlesnake-Root	Imperiled*
	Burridge Greenthread	Vulnerable*
	Texas Barberry	Vulnerable*
	Heller's Marbleseed	Vulnerable*
	Engelmann's Bladderpod	Vulnerable*
	Bracted Twistflower	Critically Imperiled*
	Tobusch Fishhook Cactus	Endangered
	Basin Bellflower	Imperiled*
	Bristle Nailwort	Imperiled*
	Lundell's Whitlow-Wort	Critically Imperiled*
	Tree Dodder	Vulnerable*
	Hill Country Wild-Mercury	Imperiled, Vulnerable*
	Low Spurge	Vulnerable*
	Darkstem Noseburn	Vulnerable*
	Texas Amorpha	Vulnerable*
	Wright's Milkvetch	Vulnerable*
	Drummond's Rushpea	Vulnerable*
	South Texas Rushpea	Critically Imperiled*
	Hall's Prairie Clover	Vulnerable*
	Sabinal Prairie Clover	Possibly Extirpated*
	Net-Leaf Bundleflower	Vulnerable*
	Watson's Milk-Pea	Critically Imperiled*
	Canyon Bean	Imperiled*
	Turnip-Root Scurfea	Vulnerable, Apparently Secure*
	Canyon Mock-Orange	Vulnerable*
	Texas Mock-Orange	Imperiled*
	Texas Beebalm	Vulnerable*
	Correll's False Dragon-Head	Imperiled*
	Big Red Sage	Critically Imperiled*
	Plateau Loosestrife	Vulnerable, Apparently Secure*
	Longstalk Heimia	Imperiled*
	Woolly Butterfly-Weed	Vulnerable*
	Parks' Jointweed	Imperiled*
	Scarlet Leather-Flower	Vulnerable, Apparently Secure*
	Texas Almond	Vulnerable, Apparently Secure*
	Texas Peachbush	Vulnerable, Apparently Secure*
	Osage Plains False Foxglove	Imperiled*
	Guadalupe Beardtongue	Vulnerable*
	Heller's Beardtongue	Imperiled*
	Threeflower Penstemon	Vulnerable*
	Texas Seymeria	Vulnerable*
	Hairy Sycamore-Leaf Snowbell	Vulnerable*
	Sycamore-Leaf Snowbell	Vulnerable*
	Bigflower Cornsalad	Vulnerable*
	Siler's Huaco	Vulnerable*
	Canyon Sedge	Vulnerable, Apparently Secure*
	South Texas Spikesedge	Vulnerable*
	Elmendorf's Onion	Imperiled*

	Glass Mountains Coral-Root	Vulnerable*
	Texas Fescue	Vulnerable*
	Buckley Tridens	Vulnerable, Apparently Secure*

*NatureServe subnational (state) conservation ranks.