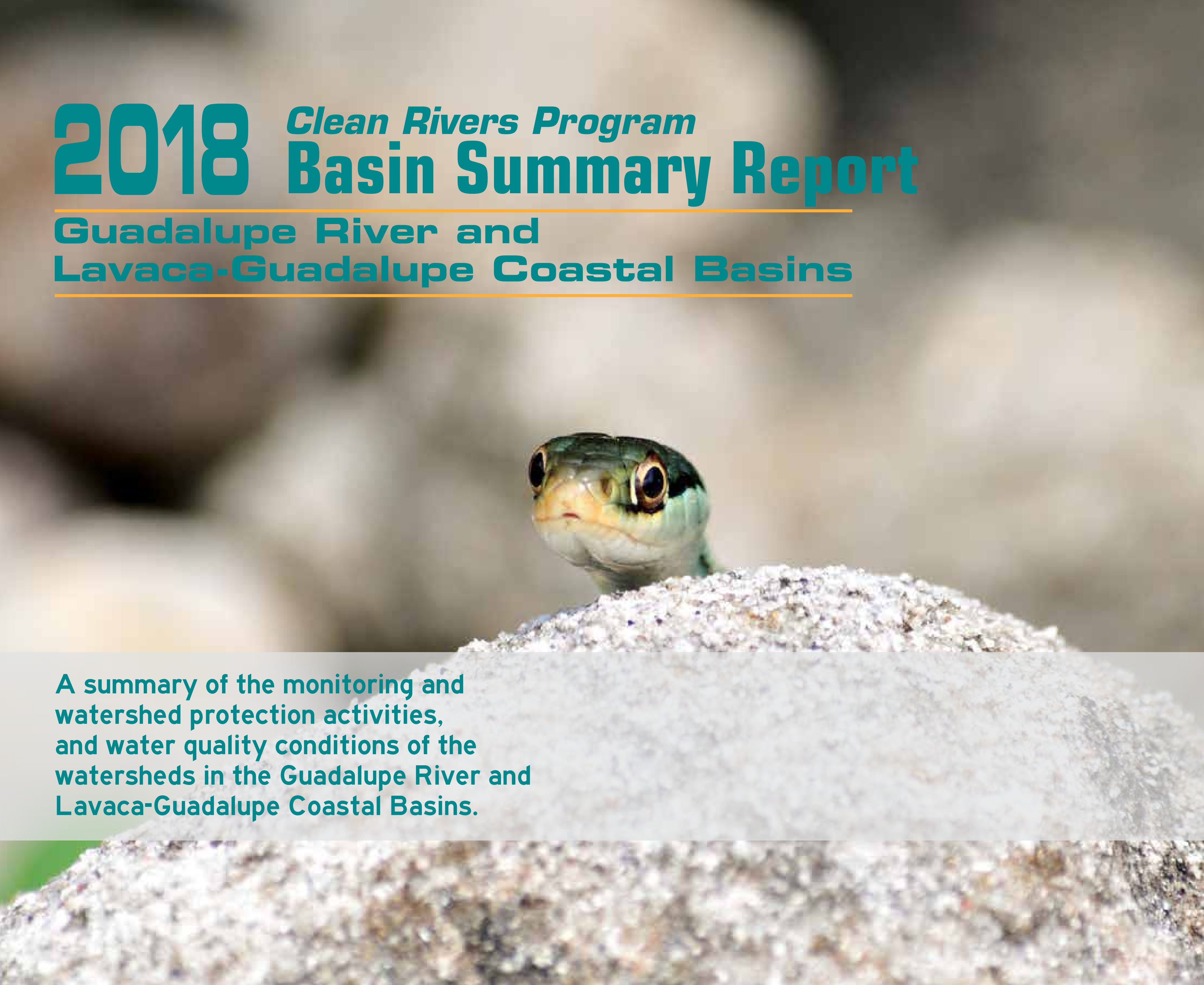
2018 *Clean Rivers Program* Basin Summary Report

Guadalupe River and Lavaca-Guadalupe Coastal Basins



A summary of the monitoring and watershed protection activities, and water quality conditions of the watersheds in the Guadalupe River and Lavaca-Guadalupe Coastal Basins.

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EXECUTIVE SUMMARY

The 2018 Basin Summary Report for the Guadalupe River Basin and Lavaca-Guadalupe Coastal Basin summarizes the monitoring, watershed protection activities, and water quality conditions of the watersheds in the respective basins. Historical data was reviewed for possible trends that would indicate degrading or improving water quality conditions. Section 26.0135 of the Texas Water Code dictates the information found in this report.

BASIN DESCRIPTION

The Guadalupe River Basin varies from the steep, limestone Hill Country that is prone to flash flooding, to the flat, rolling terrain of the lower basin. Turbulent flows of the upper watershed streams result in substrates primarily composed of bedrock and large gravel and the streams are shallow and swift. The tributaries of the middle and lower Guadalupe River have sandy substrates. The lower basin substrates are silty, and the streams carry logs and debris from upstream, often collecting in log jams at the lower end of the river. The middle portion of the river basin consists of waterbodies that referred to as lakes but are really run-of-river impoundments. In four out of five years, these lakes respond like rivers with short residence times, rather than true lakes or reservoirs with long residence times and stratification. The Guadalupe basin has two primary reservoirs, Canyon Lake and Coleto Creek Reservoir. Canyon Lake will stratify in most years, with one "turnover" that occurs in the fall. Coleto Creek Reservoir is used as cooling water for a power plant, which creates excellent habitat for aquatic vegetation and fish.

The Guadalupe River Basin is home to several endangered species. The Texas Wild Rice and the fountain darter are found in the Comal and San Marcos Springs and Rivers along with other species unique to springs and underground caves. Water quality, quantity and consistency of spring flow are critical to their habitat. The whooping crane that winters in the Aransas National Wildlife Refuge along San Antonio Bay is making a comeback. Freshwater inflows, or the lack of inflows due to diversions of water upstream, can affect the habitat and biology of this species, often considered the poster child for protection of endangered species. The Senate Bill 3 stakeholder process has recommended instream flows for the Guadalupe River and inflows into the bays and estuaries in the lower basin. The Texas Commission on Environmental Quality (TCEQ) considered these recommendations when setting the environmental flow requirements for the river. An ongoing Texas Instream Flow Program Study (Senate Bill 2) is also being conducted on the Lower Guadalupe River by the Texas Water Development Board (TWDB), Texas Parks and Wildlife Department (TPWD), TCEQ and Guadalupe-Blanco River Authority (GBRA) in order to scientifically assess how much water should flow in this portion of the river in order to maintain a healthy and sound ecological environment.

The land use of the basin includes Hill Country ranches primarily used for hunting; farms and ranches, raising row crops, cattle, goats and poultry; and, urbanized areas around the growing cities of Kerrville, Boerne, New Braunfels, Seguin, San Marcos, Lockhart, Luling, Gonzales, Cuero, Victoria, and Port Lavaca. The highest population growth is occurring along the major thoroughfares, US 281, IH 35 and SH 130, located in the central portion of the basin. Most of the industrial facilities are located in the lower basin, near the Victoria Barge Canal and ports along the coast. Recreation is an important "industry" in the upper to mid basin and reservoirs, utilizing the clear water and flows for swimming, tubing, canoeing/kayaking and fishing. Numerous summer camps can also be found on the banks of the upper Guadalupe River. Utilization of surface water for cooling occurs at power plants in Victoria and Goliad counties.

WATERSHED CONCERNS

The watershed segment summaries found in this report include discussions on stakeholders concerns. Those concerns may vary somewhat from watershed to watershed, but most have common issues. Stakeholders are concerned about the impact of human activities on water quality and how those activities will influence both the recreational and aesthetic value of the watershed. The human activities range from recreational pressure to waste discharges and disposal, or lack thereof, to urban development. Recreational activities produce trash that, if not disposed of properly, floats downstream and becomes a nuisance. The wastewater discharges that exist throughout the river basin range in level of treatment and in permitted volume. The permits are issued to municipalities for domestic waste treatment, to industries for their waste streams, and to power plants that use surface water for cooling. The level of waste treatment is improving in many of the newly-developing areas, to include nutrient removal. Reuse of wastewater is a beneficial use because it turns the treated wastewater effluent into a resource. This helps conserve water resources, but an unintended consequence of reuse is the reduction in return flows to the river which can be a factor in water quality and quantity of the river, bay and estuary. Septic tanks that are improperly installed, maintained or are failing can be a source of pollution by contributing bacteria and nutrients to the watershed. Additionally, control of illegal dumping at stream crossings is a high priority to stakeholders.

Impacts from urban development are concerns up and down the basin. The impervious cover associated with new houses and roads increases rainfall runoff. This runoff can be a source of "nonpoint source pollution" (pollution not associated with a permitted discharge pipe). The pollutants that might be captured and bio-degraded by soils,

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are readily washed over cement and pavement, directly into the surface water. Additionally, impervious cover reduces groundwater recharge and in turn, reduces the base flow of the streams.

In Kerr County, the stakeholders are concerned about dense stands of ashe juniper and its propensity to intercept rainwater and prevent it from reaching the soil surface. This reduces groundwater recharge which is critical to the base flow of the river in Kerr County. The Eagle Ford Shale underlies much of South Texas, including DeWitt and Gonzales counties, which are located in the heart of the Guadalupe River Basin. The Eagle Ford Shale play is a hydrocarbon-producing geologic formation capable of producing both natural gas and oil. Hydraulic fracturing is a process to stimulate wells and recover natural gas and oil from unconventional reserves trapped underground. Landowners in these counties are concerned with the impact that the hydraulic fracturing may have on their groundwater, as well as the potential for pollution from activities entering the surface water in the runoff or from spills. In Goliad County, the stakeholders are also concerned about impacts from oil and gas production, and most recently, the in-situ mining for uranium.

MONITORING WATER QUALITY

Most sampling locations have been routinely monitored for a number of years and provide an excellent historical perspective of water quality. Only consistently collected long-term data is used for the trend analysis presented in this document. Monitoring entities include the Texas Commission on Environmental Quality, the Guadalupe-Blanco River Authority, the Upper Guadalupe River Authority, the Wimberley Valley Watershed Association and the US Geological Survey. The Hays County Development Services Department initiated a monitoring program within their jurisdiction in 2012. Funding for the Hays County program was discontinued in 2013 and has been diverted to other projects.

TRENDS IN WATER QUALITY

Water quality in most locations does not appear to be degrading. The historical data confirmed the impairments or concerns that were listed in the 2014 Texas Integrated Report. The concentrations of E. coli continue to be of concern at most locations throughout the basin, but significant changes over time were not found in most locations. Concentrations of chloride and sulfate anions were increasing and dissolved oxygen was decreasing at several locations throughout the basin. The changes in concentrations of these parameters closely correlates with changes in streamflow, which is often associated with rainfall runoff, or lack thereof. The drought conditions in the basin from 2009-11, impacted the water quality as many parameters such as dissolved solids became more concentrated during base flow. The hottest, driest, one year period of record in the state occurred between 2010 and 2011.

The Upper Guadalupe River in Kerr County remains listed as impaired due to bacteria in a small section in Kerrville. A total maximum daily load (TMDL) study was completed in 2007 and in 2011. The Upper Guadalupe River Authority partnered with the City of Kerrville, Kerr County, and the Texas Department of Transportation to implement the Bacteria Reduction Plan for the Upper Guadalupe River and contributing tributaries. The plan includes strategies to address the primary sources of bacteria pollution that have been identified in this section of the Guadalupe River including bird nesting on bridges, large flocks of domestic waterfowl congregating in the lakes, faulty septic systems, and pollution from general urban runoff. These efforts have resulted in improved water quality and the removal of two assessment units from the state list of impaired water bodies in 2012 and 2014. The Quinlan Creek and Town Creek tributaries have been recently incorporated into a TMDL to address bacteria impairments. Other segments in the Upper Guadalupe River basin are have concerns for depressed dissolved oxygen and biological habitat.

Canyon Reservoir remains listed as impaired due to a fish consumption

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advisory for mercury in fish tissue of the striped bass and long-nosed gar.

The Dry Comal Creek has been listed for contact recreation impairments due to bacteria concentrations above the contact recreation standard since 2010. This creek is a tributary of the highly recreated Comal River. Stakeholders are concerned that bacteria loading from the Dry Comal may have an impact on the Comal River. The City of New Braunfels has formed a stakeholder group and initiated a watershed protection plan with the TCEQ in order to address this issue in both watersheds.

Ammonia nitrogen concentrations are a concern on Plum Creek, especially at the upper site that is downstream of the discharges of the cities of Kyle and Buda and other smaller wastewater plants. The magnitude of the concentrations added to the concern. Sources of the ammonia nitrogen could be the wastewater effluent that dominates the flow at this location, but septic tanks and fertilizer may also be sources. Plum Creek is impaired for contact recreation due to elevated bacteria concentrations and concerns for nitrate nitrogen and total phosphorus.

Peach, Sandies and Elm Creeks are in various stages of total maximum daily load (TMDL) development for excessive bacteria and depressed dissolved oxygen concentrations. The Peach Creek TMDL has been completed but no implementation plan has been initiated. The TMDL found that the impairment was most likely coming from non-point sources, such as failing septic tanks, livestock and wildlife. Sandies and Elm Creeks have completed the majority of the data collection, but models have not been developed that would establish the sources of the impairments or the recommended total maximum daily loads. Stakeholders in these watersheds have expressed concern that an inappropriate amount of emphasis is being placed on the necessity of the stream to meet bacteria standards for contact recreation because of the low potential for exposure to bacteria by swimmers immersed in water in these small tributaries. TCEQ has developed a process to assess the attainability of the recreational standards on these small creeks. A Recreational Use Attainability Analysis (RUAA) can be performed on waterbodies to evaluate and determine which category of recreational use is appropriate (e.g. primary, secondary one or two) based on historical and existing stream usage. Stakeholders and the TCEQ determined that the most appropriate strategy for addressing the impairments in Sandies and Elm Creeks were aquatic life and contact recreational use attainability analyses. These analyses are being conducted by the TCEQ to determine appropriate water quality standards.

Overall, the quality of the Guadalupe River and its tributaries is good. The involvement of stakeholders and the ongoing water quality protection efforts in the basin indicate the extensive commitment to maintaining the health of the Guadalupe basin.

INTRODUCTION

The Basin Summary report is designed to provide a comprehensive review of water quality data with a detailed discussion of data analysis findings for the Guadalupe River and Lavaca Coastal Basin. The report serves to develop a greater understanding of water quality conditions, as well as changes and trends in the river basin. It also serves to enhance the ability to make decisions regarding water quality issues. The report is completed every five years. In addition to the water quality data review, the report contains highlights of events, monitoring activities, and identifies issues and concerns in the Guadalupe River Basin and Lavaca Coastal Basin under the Clean Rivers Program (CRP) as well as opportunities for the public to have input into the program. The CRP is managed by the Texas Commission on Environmental Quality and funded entirely by fees assessed to wastewater and water rights permit holders. The Guadalupe-Blanco River Authority (GBRA), together with the Upper Guadalupe River Authority (UGRA), carry out the water quality management efforts in these basins under contract with the Texas Commission on Environmental Quality (TCEQ).

OBJECTIVES AND GOALS OF THE CLEAN RIVERS PROGRAM

The Texas Legislature passed the Clean Rivers Act in 1991 which requires water quality assessments for each river basin in Texas. In accordance with the Act, the TCEQ administers the Clean Rivers Program in partnership with river authorities, municipal water authorities, councils of governments and other regional entities. The goal of the program is to maintain and improve water quality within each river basin through these partnerships.

The TCEQ, GBRA and UGRA gather data from the Guadalupe River, its sub-watersheds and coastal basins in a watershed management approach in order to identify and evaluate water quality issues, establish priorities for corrective action, work to implement those actions, and adapt to changing priorities. Examination of long-term data allows comparison between current and historical water quality data, and statistical analysis can indicate any trends in improvement or deterioration of water quality parameters.

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COORDINATION AND COOPERATION WITH OTHER ENTITIES IN THE BASIN

GBRA and UGRA coordinate with other entities interested in monitoring in the Guadalupe River Basin. Those entities include the TCEQ, United States Geologic Survey (USGS), Texas Parks and Wildlife Department (TPWD), Texas State Soil and Water Conservation Board (TSSWCB), the Wimberley Valley Watershed Association (WVWA) and Texas Stream Team. Annually, all cooperators monitoring in the basin meet to coordinate their activities. This coordination minimizes duplication, focuses monitoring and resources where needed and helps prevent voids in coverage across the basin.

The WVWA is an important partner in the Guadalupe River basin. This entity has determined that managing water resources is of paramount importance for the continued health and welfare of the local citizens and economy. WVWA funds the Blanco River – Cypress Creek Water Quality Monitoring Program. The purpose of the program is to be proactive in protecting the Wimberley area water resources. The objectives of the monitoring program are to detect and describe spatial and temporal changes, determine impacts of point and nonpoint sources, and assess compliance with established water quality standards for Cypress Creek and the Blanco River. The monitoring program is conducted under the Guadalupe River Basin Clean Rivers Program Quality Assurance Project Plan (QAPP). By following the strict quality control guidelines spelled out in the QAPP, the data can be contributed to the TCEQ Surface Water Quality Database for use in stream assessments.

The Guadalupe River Basin Clean Rivers Program supports Texas Stream Team monitoring groups in the basin. GBRA supplies replacement chemicals and provides training for monitoring and quality assurance to the volunteer monitors in the basin. Currently there are groups monitoring on the Guadalupe River and Geronimo Creek near Seguin, Cypress Creek in Wimberley, the San Marcos River, the Blanco River and tributaries, the Comal River and Canyon Reservoir, and Plum Creek and its tributaries.

Another example of the role that CRP plays in the basin is the contribution of quality-assured data used in the watershed planning efforts going on in the river basin. The water quality data collected by the Clean Rivers Program is used by TCEQ to assess streams to determine if they are meeting the stream standards for their designated uses. Secondly, the data is used to determine the need and extent that watersheds could benefit from watershed protection plans. There are four watershed protection plans in various stages of development in the Guadalupe River Basin.

The Plum Creek Watershed Protection Plan (PCWPP) was accepted by the U. S. Environmental Protection Agency in 2008. The PCWPP was the result of a stakeholder driven process and provided the foundation for ecological restoration of Plum Creek and its tributaries. Plum Creek is located in Hays and Caldwell counties in one of the most rapidly growing areas in the state. Based on routine water quality sampling, TCEQ listed portions of Plum Creek for high E. coli bacteria in 2004. The elevated bacteria concentrations indicated that the creek no longer supported the designated use for contact recreation. Additional segments of the creek were identified as having high nutrient concentrations. The Plum Creek Watershed Partnership developed a watershed protection plan. Based on the pollutant sources in the watershed, the plan detailed both the management measures and the timeline that will help meet the goal of restoring the water quality of the stream. GBRA continues to monitor three routine sites on the main stem as a part of the Clean Rivers Program. The data generated for these sites can be used to assess the success of the implementation of the management measures identified in the plan.

The Geronimo and Alligator Creeks Watershed Partnership's Watershed Protection Plan accepted by the USEPA in 2012. Like the Plum Creek plan, the Geronimo and Alligator Creek Watershed Protection Plan can be used to restore the environmental health of the creeks. Geronimo Creek and its tributary, Alligator Creek, are located in Comal and Guadalupe Counties in an area like many in the basin transitioning from a rural to urban landscape. The Watershed Protection Plan outlined a series of implementation measures that will reduce nonpoint source pollutant loading from urban storm water sources, such as pet waste, and from wildlife and non-domestic animals such as feral hogs. The plan recommends the development of water quality management plans on the agricultural operations in the watershed. GBRA continues to monitor monthly at the CRP station that originally identified the bacterial impairment of the stream and continues to monitor the site to provide data to assess the effectiveness of implementation measures.

The Cypress Creek Watershed Protection Plan was developed by stakeholders under the facilitation of the Meadows Center for Water and the Environment at Texas State University. The plan was accepted by the EPA in 2016. The goal of the plan is to protect and preserve the water quality of Cypress Creek that flows through the city of Wimberley for present and future generations. Based on routine monitoring that is conducted by the Clean Rivers Program and by the WVWA, Cypress Creek is still attaining its designated uses and has not been identified as an impaired water body. The Cypress Creek Project is proactive, working to preserve the water quality, rather than restore it from an impaired condition. The plan is focused upon preserving springs flows and reducing non-point source pollution.

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The project is financed by grants from the Texas Commission on Environmental Quality through the Environmental Protection Agency Region VI.

Two other watershed protection plans are under development in the Guadalupe River Basin. The Meadows Center for Water and the Environment has been developing a watershed protection plan for the Upper San Marcos River. No current impairments or concerns exist in this watershed. The City of New Braunfels is facilitating the development of a plan for the Dry Comal Creek and Comal River to reduce bacteria loading in these watersheds.

OVERVIEW OF THE GUADALUPE RIVER BASIN

The Guadalupe River Basin is located in south central Texas, with the headwaters in the Hill Country. The river is 432 miles long and flows southeastward through a drainage area of 6,061 square miles. The land mass that makes up the basin is divided into two distinct regions by the Balcones Escarpment. The northern region consists of the Edwards Plateau of the Great Plains Province. The area has variable topography, with rolling hills divided by limestone-walled valleys. The southern region is referred to as the Gulf Coastal Plains area and consists of gently sloping prairie. The basin's principle tributaries are the North and South Fork of the Guadalupe River, Johnson Creek, the Comal River, the Blanco River, the San Marcos River, Geronimo Creek, Plum Creek, Peach Creek, Sandies Creek and Coleto Creek. The springs that feed the Comal and San Marcos Rivers have an average monthly discharge of 382 cubic feet per second and 187 cubic feet per second respectively. The Comal River is more subject to drought conditions and has ceased to flow during the severe drought of the 1950's. The San Marcos River is much more environmentally stable.

The geology of the area consists primarily of sedimentary material that was deposited during the latter Mesozoic era from approximately 100 million years ago to 65 million years ago and the current Cenozoic Era. The principle geologic structures in the basin are the Balcones and Luling fault zones. The Balcones Fault Zone consists of a series of semi-parallel faults, about 14.9 miles, extending from Hays County southwestward to Bexar County. The Luling Fault Zone extends from Caldwell County to Medina County and is 9.9 to 19.8 miles southeast of the Balcones Fault Zone. The displacement varies from less than three feet to a combined displacement of over 1500 feet. The Trinity group of limestones and Edwards limestone covers the Edwards Plateau.

The Guadalupe River Basin and Lavaca-Guadalupe Coastal Basin are located within four ecoregions. The delineation of ecoregions is based on geographic conditions that cause or reflect differences in ecosystem patterns. These conditions include geology, physiography, vegetation, climate, soils, land use, wildlife and hydrology. The basin lies within the Edwards Plateau (Ecoregion 30), the Texas Blackland Prairie (Ecoregion 32), East Central Texas Plains (Ecoregion 33) and the Western Gulf Coastal Plain (Ecoregion 34). In the technical section of this report, specific information on the land use, climate, soil, and key factors that impact water quality are described on the sub-watersheds of the basin.

The Edwards Plateau Ecoregion is characterized by springfed perennial streams and is predominantly rangeland. The Texas Blackland Prairie Ecoregion has timber along the stream, including oak, pecan, cypress, cedar elm and mesquite. In its native state, it was largely a grassy plain, but most of the area has been cultivated and only small areas of meadowland remain. The East Central Texas Plains Ecoregion is characterized by subtropical dryland vegetation made up of small trees, shrubs, cacti, weeds and grasses. Principal plants include mesquite, live oak, post oak, blackbrush acacia, and huisache. Long-continued grazing has contributed to the dense cover of brush. The gulf coast and marshes of the Western Gulf Coastal Plains are divided into two subunits: marsh and salt grasses at the tidewater and bluestems and tall grasses more inland. Oaks, elms and other hardwoods grow along the streams. The area is abundant with fertile farmland.

The climate of the region is mild and normal temperatures seldom fall below 32oF in the winter. The basin averages 32 inches of rainfall per year, when considering rainfall data in 2017. The rainfall amounts vary with season, with the minimum occurring in the winter and the maximum in the late spring and early fall. The cool season begins in November and extends through March. According to the latest USGS Water-Data Report from 2013, the annual average runoff in the northern part of the river basin is 161,400 acre-feet per year, 1,476,000 acre-feet per year in the middle portion, and 1,396,000 acre-feet in the lower basin. These discharge volumes represent the amount of water reaching the stream, in the form of runoff, annually at the cities of Comfort, Gonzales and Victoria respectively.

The main stream impoundments located in the river basin include UGRA Lake; Flat Rock Lake; Canyon Reservoir; Lakes Dunlap, McQueeney, Placid, Meadow, Gonzales and Wood; Green Lake and Coleto Creek Reservoir. Canyon Reservoir, built in the 1960s, is the largest impoundment in the river basin and has 8,230 surface acres at the 909 feet above mean sea level conservation storage capacity. It is a multipurpose reservoir designed to serve flood control and water supply functions. It is also used for recreation. UGRA Lake, Flat Rock Lake and Lakes Dunlap, McQueeney, Placid, Meadow, Gonzales and Wood are run-of-river impoundments, used for water supply and hydroelectric power generation.

As populations in the basin grow, the potential for associated anthropogenic impacts increase. Along with urbanization comes increases in impervious cover, larger volumes of wastewater discharged to the stream and greater demands on water supplies, reducing the base flow of the river. The population of the counties in the basin was estimated to be 673,944 in 2010, with the heaviest concentrations in Victoria, Comal, Hays, Kendall and Guadalupe Counties. The fastest growing counties in the region are located in the Guadalupe River Basin: Hays, Comal, Guadalupe, Kendall and Caldwell Counties. These counties are experiencing explosive growth as the populations of the cities of San Antonio and Austin spill over to the communities in the river basin. Additionally, other significant changes have occurred in the watershed that have caused the population and the landscape to change. The oil and gas exploration in DeWitt and Gonzales Counties has caused the population and construction activities to rise in these counties. According to the University of Texas at San Antonio (UTSA) Center for Community and Business Research the increased revenue from the Eagle Ford Shale will lead to the creation of approximately 117,000 full-time jobs by 2021. State Highway 130, the tollway that gives traffic an alternative to Interstate Highway 35, connecting Austin and San Antonio, is predicted to see a large amount of commercial and residential growth over the next ten years.

Agriculture, in the form of crops and livestock production, is the primary industry in the basin, with the manufacture of steel, gravel, plastics and chemicals contributing to the economy of the basin as well. Oil and gas production can be found in all counties but especially in the mid-Basin. The Eagle Ford Shale Play, located in DeWitt and Gonzales counties, has become one of the richest oil and gas deposits in Texas because of the exploration technology called hydraulic fracturing or “fracking.” Fracking is the process to stimulate wells and recover natural gas and oil by creating fractures that extend from a well bore into formations and allow the product to be extracted more easily.

SUMMARY OF WATER QUALITY CHARACTERISTICS

The water quality of the Guadalupe River is highly influenced by the ground water that makes up its baseflow. The largest contribution to the baseflow is the Edwards Aquifer, with additional volume from the Cow Creek, Trinity, Leona, Carrizo, and Gulf Coast Aquifers. Each aquifer is unique in its water quality, discharge points and volume. The headwaters of the Guadalupe are located in Kerr County, and originate from springs in the North and South Forks. The discharge of the Edwards Aquifer at the Comal Springs and San Marcos Springs form two small, crystal clear lakes, which support aquatic vegetation and wildlife, including the fountain darter and Texas Wild Rice, two endangered species. Springs that come from the Leona formation, which is high in nitrate-nitrogen, are suspect to be a partial source of the nutrient concern and dissolved solids in Plum and Geronimo Creek.

The Guadalupe River flows through Kerr and Kendall counties and into Canyon Reservoir, the largest reservoir in the basin, located in Comal County. Canyon Lake impounds water for water supply, flood control, and recreation. The water exits the reservoir through a bottom penstock and is used for hydroelectric generation. A more complete description of the releases from the reservoir is given in the technical section. In most years, the lake stratifies in the late summer months and, after the first strong cold front of the winter, usually in October, the lake will experience a lake “turnover”. During times of lake stratification, the bottom release from the reservoir is low in temperature and dissolved oxygen. The water is aerated as it leaves either the hydroelectric plant or penstock. The cold water conditions of Canyon Reservoir’s bottom release have been utilized by TPWD and Trout Unlimited for a put and take trout sport fishery.

Downstream of Canyon Reservoir, the Guadalupe River flows over bedrock substrate and through swift water runs. The river is shallow, with few pools until it nears the city of New Braunfels, where it confluences with the Comal River and enters the first of six hydroelectric impoundments. The flow through the impoundments is diverted through turbines to generate hydroelectric power. These impoundments are nutrient-rich, with nitrogen and phosphorus contributions from wastewater discharges and organic sediments. The impoundments exhibit the water quality conditions of a flowing stream in years of high flow. In years of medium to high flows, the impoundments have low chlorophyll concentrations and no stratification. In years of low flow conditions, the impoundments provide the residence time needed for the assimilation of nutrients that promote higher chlorophyll production. During periods of low flow the impoundments also exhibit weak thermal stratification. Historically, these impoundments have been subject to infestations of non-native aquatic vegetation and algal blooms during periods of normal and low flow conditions.

From Kerr County to Refugio County, the Guadalupe River receives treated wastewater discharges. The cities of Kerrville, Boerne, Buda, New Braunfels, Kyle, San Marcos, Lockhart, Luling, Seguin, Gonzales, Cuero, and Victoria, along with other small wastewater treatment plants, discharge treated wastewater, Most of these plants provide at least secondary treatment of the wastewater to reduce total suspended solids (TSS) dissolved organic material. In several locations, the Guadalupe River or one of its tributaries is used for cooling water. In the upper part of the watershed, a power plant diverts flow from the Guadalupe River to mix with treated wastewater and use as cooling

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water. This is a zero discharge facility and no water is returned to the stream. Near the city of Victoria, a portion of the flow in the Guadalupe River is diverted to serve as once-through cooling water for a power plant, and then returned to the stream. The Coleto Creek Reservoir also serves as cooling water for the power plant located in Goliad County. In these last two locations, the water is returned warmer than the receiving stream. Coleto Creek Reservoir was designed to hold the water long enough to dissipate the heat. The warm water conditions are conducive for the growth of aquatic vegetation. The volume and temperature of the release from the power plant near Victoria is regulated by a discharge permit that is protective of the receiving stream.

At the lower end of the basin, the Guadalupe River confluences with the San Antonio River. The Guadalupe River Diversion Canal and Fabridam are located below the confluence with the San Antonio River. The fabridam is made up of two large inflatable bags that are used to prevent salt water intrusion from the bay during times of low river flows. A canal system diverts fresh water for irrigation and municipal water supply.

WATER QUALITY MONITORING

The Guadalupe-Blanco River Authority and the Upper Guadalupe River Authority have been monitoring under the Clean Rivers Program since 1996. Prior to the partnership with TCEQ in the CRP, both entities had routine monitoring programs. Other entities contributing data to the historical database include the Texas Commission on Environmental Quality's Surface Water Quality Monitoring, the Texas State Soil and Water Conservation Board (TSSWCB) and the United States Geological Survey (USGS).

These monitoring programs collect and analyze data under an approved Quality Assurance Project Plan (QAPP). The QAPP is used to plan, organize and define the quality assurance process for the program. Quality assurance is the integrated system of management activities that ensures that data generated is of the type and quality needed for its uses. Those uses include planning, assessment and water quality management. Elements of the program that are controlled by the QAPP include measurement performance specifications, appropriate methods, field and laboratory quality control, data management, and verification and validation of the data. Additionally, oversight of the laboratory quality system and process of corrective actions are described in the QAPP. The current QAPP is available for review on the GBRA CRP webpage.

Table 1 is the summary of water quality sampling currently being performed in the basin. The sections in this report are divided by sub-watershed or segment and will discuss the historical trends observed in the data review and factors that may be impacting water quality within each sub-watershed.

The Texas State Soil and Water Conservation Board is funding water quality monitoring programs on Plum Creek and Geronimo and Alligator Creeks in support of the implementation of the watershed protection plan developed on these creeks. These plans were developed using data collected by the Clean Rivers Program and the TCEQ's Surface Water Quality Monitoring program and in the case of the Geronimo Creek plan, with additional monitoring done in advance of the plan development. Using the existing monitoring of the three sites on Plum Creek and one site on the Geronimo Creek by TCEQ and GBRA's CRP as match, TSSWCB has funded additional monitoring in these watersheds with Clean Water Act Section 319(h) funds. GBRA, under an EPA-approved QAPP, is performing both routine and targeted monitoring and monitoring springs and storm water within the watersheds. The data are submitted to the TCEQ and may be included in the biennial assessments.

These monitoring programs are done under a Quality Assurance Project Plan (QAPP). The QAPP is used to plan, organize and define the quality assurance process for the program. Quality assurance is the integrated system of management activities that ensures that data generated is of the type and quality needed for its uses. Those uses include planning, assessment and water quality management. Elements of the program that are controlled by the QAPP include measurement performance specifications, appropriate methods, field and laboratory quality control, data management, and verification and validation of the data. Additionally, oversight of the laboratory quality system and process of corrective actions are described in the QAPP. The current QAPP is available for review on the GBRA CRP webpage.

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DESCRIPTION OF THE WATER QUALITY ASSESSMENT PROCESS

In compliance with sections 305(b) and 303(d) of the Federal Clean Water Act, the TCEQ evaluates water bodies in the state and identifies those that do not meet the uses and criteria defined in the Texas Surface Water Quality Standards. EPA has established guidance that directs TCEQ to document and submit the assessment results to EPA biennially, in even numbered years. The 2014 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) summarizes the condition of the state's surface waters, including concerns for public health, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources (TCEQ, 2013). It describes the status of water quality in all surface water bodies in the state that were evaluated for the assessment period. The data used in the assessment comes from various sources, including the Guadalupe River Basin CRP partners, TCEQ's Surface Water Quality Monitoring program and other contributors. Given the regulatory implications associated with the use of the water quality data, the data used in the assessment process must be collected using consistent and scientifically rigorous sampling and laboratory methods. Data collected under an accepted quality assurance project plan that describes the integrated system of management activities ensures that data generated is of the type and

quality needed for its uses is assessed. The 2014 Guidance for Assessing and Reporting Surface Water Quality in Texas dictates which data will be evaluated in the biennial Texas Integrated Report. Data that are not collected under a TCEQ-approved quality assurance plan, if submitted, must be accompanied by documentation of quality assurance for evaluation by TCEQ water quality staff. Data without appropriate quality assurance documentation will be considered as anecdotal evidence to support or refute assessment results, but will not be used in statistical evaluations. On July 1, 2008 requirements regarding laboratory accreditation went into effect. Data analyzed after that must comply with the National Environmental Laboratory Accreditation Conference (NELAC) standard to be used to generate the Integrated Report (See 30 TAC, Chapter 25). Both the GBRA and UGRA laboratories are accredited by the Texas Environmental Laboratory Accreditation Program administered by the TCEQ.

The quality of the water described in the assessment report is a snapshot of conditions during the specific time period considered in the assessment. The 2014 assessment covers the period of record from 12/1/2005 to 11/30/2012. Assessors have the option of including more recently collected data than 12/01/2012, if available. The TCEQ assessment process has been developed by TCEQ staff through a stakeholder process. River authorities and CRP partners are invited to participate in the development and review of the assessment guidance.

Water quality standards are comprised of two parts, designated uses and the associated criteria for stream conditions necessary to support that use. The uses of a water body include aquatic life use, providing a suitable environment for fish and other aquatic organisms; and contact recreation use, providing water that is safe for swimming and other recreational activities. The criteria for each use may be described numerically or expressed in terms of desirable conditions. Uses and criteria are assigned to a segment. A segment is a water body or a portion of a water body with a specific location, defined dimensions, and designated or presumed uses. If the criteria of a segment are not met, then the segment is designated as impaired. If nonattainment of the criterion is imminent, then the segment is designated as having a concern.

After assessments are completed, water bodies are designated as impaired if the stream does not meet the numeric stream standard or as a concern if the conditions match those scenarios described above. Overall, the quality of the Guadalupe River Basin is good. According to the 2014 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d), nine waterbodies in the Guadalupe River Basin were found to be impaired for recreational use, aquatic life use, or fish consumption use (Table 2). Eighteen waterbodies were found to have at least one concern for general use, aquatic life use, or recreational uses. The most common impairments and concerns

CONTINUED ON PAGE 12

in the basin were for bacteria, depressed dissolved oxygen, and nitrate nitrogen concentrations.

PUBLIC PARTNERSHIPS

The GBRA sustains a number of communication mechanisms to support the CRP in the Guadalupe Basin, striving to maintain active communication with the public to pursue the goals of public involvement and education in water quality issues. GBRA develops opportunities for direct public participation to ensure that community concerns are addressed. These include quarterly GBRA River Run, website updates, issuing press releases regarding various water topics, and providing presentations to the public.

THE GUADALUPE RIVER BASIN STEERING COMMITTEE

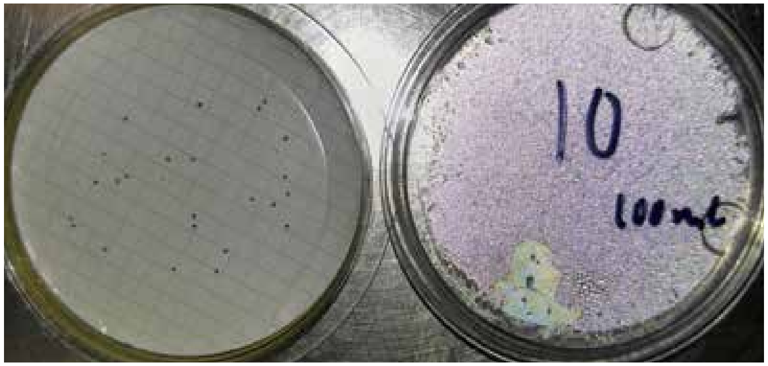
A major communication vehicle for the CRP is the Basin Steering Committee. Composed of community leaders and interested citizens from throughout the basin, this group meets annually to review activities and advise the program on priorities for monitoring and special studies. The Steering Committee membership includes: representation from municipalities, counties, industries, homeowner organizations, Texas Soil and Water Conservation Board, Texas Parks and Wildlife Department, Texas Department of Agriculture, Texas Railroad Commission, League of Women Voters, chambers of commerce, and local/regional environmental organizations. Steering Committee meetings are OPEN TO THE PUBLIC with the primary purpose of reviewing and approving achievable basin water quality objectives and priorities, considering available technology and economic impacts, and guiding work plans and the allocation of available resources. Notice of the Steering Committee meetings is made available by emailed notices, as well as on the meeting page of the GBRA website (www.gbra.org).

SPECIAL SUB-COMMITTEES FOR LOCAL WATER QUALITY ISSUES

In addition to the Basin Steering Committee for the CRP, the GBRA has established the Hydroelectric Lake Citizens Advisory Committee and the Coleto Creek Reservoir Advisory Committee. These groups are given the opportunity to hear, question and give input on activities to control nuisance, non-native aquatic vegetation each year as well as lake operations and safety. The committees have representatives from homeowners associations, potable water systems, bass clubs, boating sales companies, industries, as well as the Texas Parks and Wildlife Department and Texas Department of Agriculture. These committees also receive invitations to the CRP steering committee meetings.

REGIONAL LAB

The Regional Laboratory located at the General Offices of GBRA in Seguin provides technical assistance and support to GBRA's operations, as well as municipalities, water districts, industries, engineering firms and other organizations as they comply with federal, state and local regulatory requirements that protect water quality. The Regional Laboratory has received its accreditation from the Texas Environmental Laboratory Accreditation Program. The Regional Lab is equipped to perform physical, chemical and biological analyses of water from natural streams, potable water and wastewater treatment plants, groundwater wells and treatment residuals, utilizing current technology and equipment. The Regional Laboratory serves as a contract laboratory for the CRP. In addition to its broad water quality planning initiatives and participation in environmental and water quality monitoring programs within the river basin, the laboratory also sponsors and trains Texas Stream Team water quality monitors, a statewide volunteer program created under the Texas Clean Rivers Act of 1994 to involve citizens in the testing and protection of water resources. The lab also conducts presentations for schools, civic and other organizations on water quality, environmental issues, Texas Stream Team and other water-related subjects. The laboratory maintains strong working relationships with federal, state and local government agencies responsible for water quality, as well as corporations and individuals capable of affecting water quality.



PUBLIC EDUCATION EFFORTS

GBRA's award-winning fourth-grade program, Journey through the Guadalupe River Basin maintains a strong presence in schools throughout the river basin. This Texas Essential Knowledge and Skills (TEKS) correlated program takes an interdisciplinary approach to the subject of water, placing an emphasis on watersheds and water quality, specific to the Guadalupe River Basin. In addition, the curriculum touches on the water cycle, water uses in the basin, population growth, and water conservation. GBRA continues to offer teacher trainings for this program.

Waters to the Sea, Guadalupe River

SUBWATERSHED CONCERNS AND ISSUES

is a multi-media middle school program used throughout the river basin. This interactive learning program highlights relationships between human activities and water resources within the Guadalupe watershed from the river's headwaters to San Antonio Bay. The program addresses Texas science and social studies education standards through numerous short videos, animations, simulations, and multimedia interactives that draw from the region's rich history. Modules will focus on themes ranging from traditional Native American uses of natural resources, to the importance of water for agriculture, to the impacts of urban growth on surface water runoff, to the importance of wetlands at the bay.

Education staff makes a concerted effort in both the Plum Creek and Geronimo Creek watersheds. Water quality education and monitoring are introduced to fourth and fifth grade students in these target watersheds. School year 2017-2018 was the twelfth consecutive year GBRA Education staff led efforts in public elementary schools in the Plum Creek watershed. Working side by side with teachers and students, GBRA staff spent three weeks in classrooms presenting information using a tabletop watershed model to discuss watersheds, nonpoint source pollution and the Plum Creek project directly with the students. All needed supplies were donated to the schools including water monitoring test kits, watershed map posters and student workbooks. A total of 1,100 students and 30 teachers conducted water quality testing in the spring. Using the Texas Stream Team methods as a model for their monitoring, students have tested water from Plum Creek for the following parameters: temperature, dissolved oxygen, pH, turbidity, nitrates, and phosphates and bacteria. The results of the student monitoring indicate a slight decrease in dissolved oxygen and increases in phosphates and nitrates as the creek moves from the urban area in the northern portion of the watershed to the more rural southern area. Efforts in the Geronimo Creek watershed are implemented through programming at the Irma Lewis Seguin Outdoor Learning Center. Primarily fourth and fifth grade students are provided the opportunity to explore water quality through a variety of activities, including macroinvertebrate collection and identification, riparian studies and water quality testing.

OVERVIEW OF THE TECHNICAL SUMMARY

The technical summary section provides a review of the water quality conditions in the Guadalupe River Basin. Also included in this section is a discussion of the latest biennial assessment of the surface water quality done by TCEQ. In an evaluation of the water quality data, stations and parameters for which the data met sample number and sampling duration criteria were statistically examined to identify and verify trends. Also considered

in the evaluation of the data were the results of biological analyses if available, land uses, soils and vegetation, and point source discharges. The factors at play in each sub-watershed are considered in order to identify and prioritize concerns or impairments and their most probable causes, recommend future monitoring activities, implementation of control or remediation actions, public outreach, or other appropriate measures. The origin of the data and the analytic procedures used to evaluate the data are explained in the section, Description of Water Quality Assessment Process. The Watershed Summaries section provides an overview of existing data, a discussion on the water quality concerns identified during the screening process and an assessment of the trends seen in the water quality data.

The screening and assessment of water quality conditions in this Basin Summary Report is organized by watershed, segment and station. A watershed is the total area drained by a particular stream. The Guadalupe River basin is broken into 15 watersheds for this report. For assessment and trend analysis, the watersheds were broken down further into sub-watersheds and then further by segment. Segments are contiguous reaches that exhibit similar physical, chemical and biological characteristics for which a uniform set of standards apply. Most segments have one monitoring location. But in those

CONTINUED ON PAGE 14

cases where there are multiple sampling locations, the data sets were combined to observe differences within the segment, and/or to strengthen the analyses by increasing the number of data points used in the assessment. If two or more sites within one segment were statistically different for any water quality data type, the data was not combined for more than a comparison between sites and the difference was noted.

For evaluation of trends over time, water quality data available from the TCEQ's Surface Water Quality Monitoring Information System was divided by station and then by parameter. The historical period of data examined varied by station, but generally encompassed all available data collected between December of 2002 and June of 2017. This time frame was examined in order include the data used from the previous 2013 Basin Summary Report in the evaluation of trending changes. The historical period examined utilized substantially similar collection and laboratory texting methodologies. For a given station and parameter the number of data points used in the initial trend analyses was at least 20 points over the historical period, with at least three measurements per year, in five or more years. The data sets that met the data criteria were compared over time to observe any trends using statistical tools in Excel. Each data set was evaluated for normality by comparing skewness and kurtosis to a normal distribution using the Jarque-Bera goodness-of-fit test. Linear regressions were performed to confirm the significance of the trend. Additionally, a graph and narrative were created to explain any significant trends. A trend was identified as significant by evaluating the F-test of overall significance for each regression model. The probability value or "p value" generated by the F-test was compared to a predetermined p-critical value. The default p-critical value that was utilized for this analysis was 0.05, but a 0.10 p value was also utilized at some stations in order to evaluate specific parameters of concern. If the "p value" was less than the predetermined p-critical value then the regression model was determined to be significant. A "p value" less than the p-critical value indicates that there is a high chance that at least some of the regression coefficients for the model are not equal to zero and that the regression model has some degree of validity.

When looking for potential changes in water quality conditions, water quality parameters are compared over time. The statistical comparisons and graphs of these comparisons can show if there are overall upward or downward trends at a location or in a segment. The graphed data can be represented with or without a line that connects the data points. The line may make it easier to see seasonal patterns in the water quality data. It should be recognized that if the data points are connected by a line in time comparisons, the line between the points does not represent the true conditions of the stream between the times that the data was actually collected.

Table 1. Monitoring parameter and frequencies conducted by monitoring partners in the Guadalupe River Basin in 2018

Sampling Entity	Field Parameters	Conventional Parameters	Bacteria	Biological and Habitat	24 Hr. Dissolved Oxygen
GBRA	19 sites, monthly; 12 sites, quarterly	19 sites, monthly; 12 sites, quarterly	19 sites, monthly; 12 sites, quarterly	2 sites, twice yearly	1 site, twice yearly
UGRA	6 sites, monthly; 11 sites, quarterly	11 sites, quarterly	6 sites, monthly; 11 sites, quarterly		1 site, twice yearly
TCEQ	9 sites, quarterly	9 sites, quarterly	9 sites, quarterly		
WVWA	9 sites, quarterly	9 sites, quarterly	9 sites, quarterly		2 sites, twice yearly

SUBWATERSHED CONCERNS AND ISSUES

Table 2. Summary of Findings from the 2014 Texas Integrated Report of Surface Water Quality in the Guadalupe River Basin.
(Assessed using data inclusive of December 1, 2005 through November 30, 2012)

SEGMENT NUMBER	WATER BODY	Impairment or Concern	Impairment or Concern removed in 2014	Category	Year Listed
1701	Victoria Barge Canal	Nirtrate-Nitrogen And Chlorophyll - A		Note 1	2000
1801	Guadalupe River Tidal	Nirtrate-Nitrogen		Note 1	2002
1802	Guadalupe River Below San Antonio	Nirtrate-Nitrogen		Note 1	2002
1803	Guadalupe River Below San Marcos River	Nirtrate-Nitrogen	Bacteria	Note 1	2014
1803A	Elm Creek	**Depressed Dissolved Oxygen** Chlorophyll - A		**5b**; Note 1	1999
1803B	Sadies Creek	**Depressed Dissolved Oxygen; Impared Fish And Macrobenthic Communities; Bacteria;** Impared Biological Habitat; Chlorophyll - A		**5b**; Note 1	1999
1803C	Peach creek	**Depressed Dissolved Oxygen; Bacteria;** Impared Fish Community; Total Phosphorus And Chlorophyll - A		**5b**	2002
1803D	Salty Creek	Not Assesed			
1803E	Little Elm Creek	Not Assesed			
1803F	Denton Creek	Not Assesed	Bacteria		
1803G	Sandy Fork	Not Assesed	Bacteria		
1804	Guadalupe River Below Comal River	No Impairments Or Concerns			
1804A	Geronimo Creek	**Bacteria;** Nirtrate-Nitrogen		**5b**; Note 1	2006
1804C	Alligator Creek	No Impairments Or Concerns			
1804D	Bear Creek	Bacteria;		Note 1	2014
1805	Canyon Lake	**Mercury In Edible Fish Tissue;** Amonia-Nitrogen		**5c**; Note 1	2006
1806	Guadalupe River above Canyon Lake	Impaired Biological Habitat	Bacteria	Note 1	1999
1806A	Camp Meeting Creek	Depressed Dissolved oxygen		Note 1	2004
1806D	Quinian Creek	**Bacteria;** Depressed Dissolved oxygen		**5a**; Note 1	2010
1806E	Town Creek	**Bacteria;** Depressed Dissolved oxygen		**5a**; Note 1	2010
1807	Coleto Creek	No Impairments Or Concerns			
1807A	Perdido Creek	No Impairments Or Concerns			
1808	Lower San Marcos	No Impairments Or Concerns			
1809	Lower Blanco River	No Impairments Or Concerns			
1810	Plum Creek	**Bacteria;** Depressed Dissolved Oxygen; Impaired Biological Habitat; Nirtrate-Nitrogen; Total phosphorous		**4b**; Note 1	2004
1810A	Town Branch	Bacteria; Depressed Dissolved Oxygen; Nirtrate-Nitrogen		Note 1	2014
1811	Comal River	No Impairments Or Concerns			
1811	Dry Comal Creek	**Bacteria;**		**5c**	2010
1812	Guadalupe River Below Canyon Dam	No Impairments Or Concerns			
1813	Upper Blanco River	No Impairments Or Concerns	Depressed Dissolved oxygen		
1814	Upper San Marcos River	No Impairments Or Concerns	Total Dissolved Solids		
1815	Cypress Creek	Depressed Dissolved Oxygen; Impaired biological habitat			2006
1816	Johnson Creek	No Impairments Or Concerns			
1817	North Fork Guadalupe River	No Impairments Or Concerns			
1818	South Fork Guadalupe River	Depressed Dissolved Oxygen;			2014

Bolded text indicates an impairment of the water quality standard.

Note 1: A water quality concern was identified rather than an impairment of a designated use. Concerns are identified for bodies of water nearnonattainment of water quality standards (CN) or not meeting numerical screening levels (CS).

Category 4: Standard is not attained or nonattainment is predicted in the near future due to one or more parameters, but no TMDLs are required.

4b – Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future.

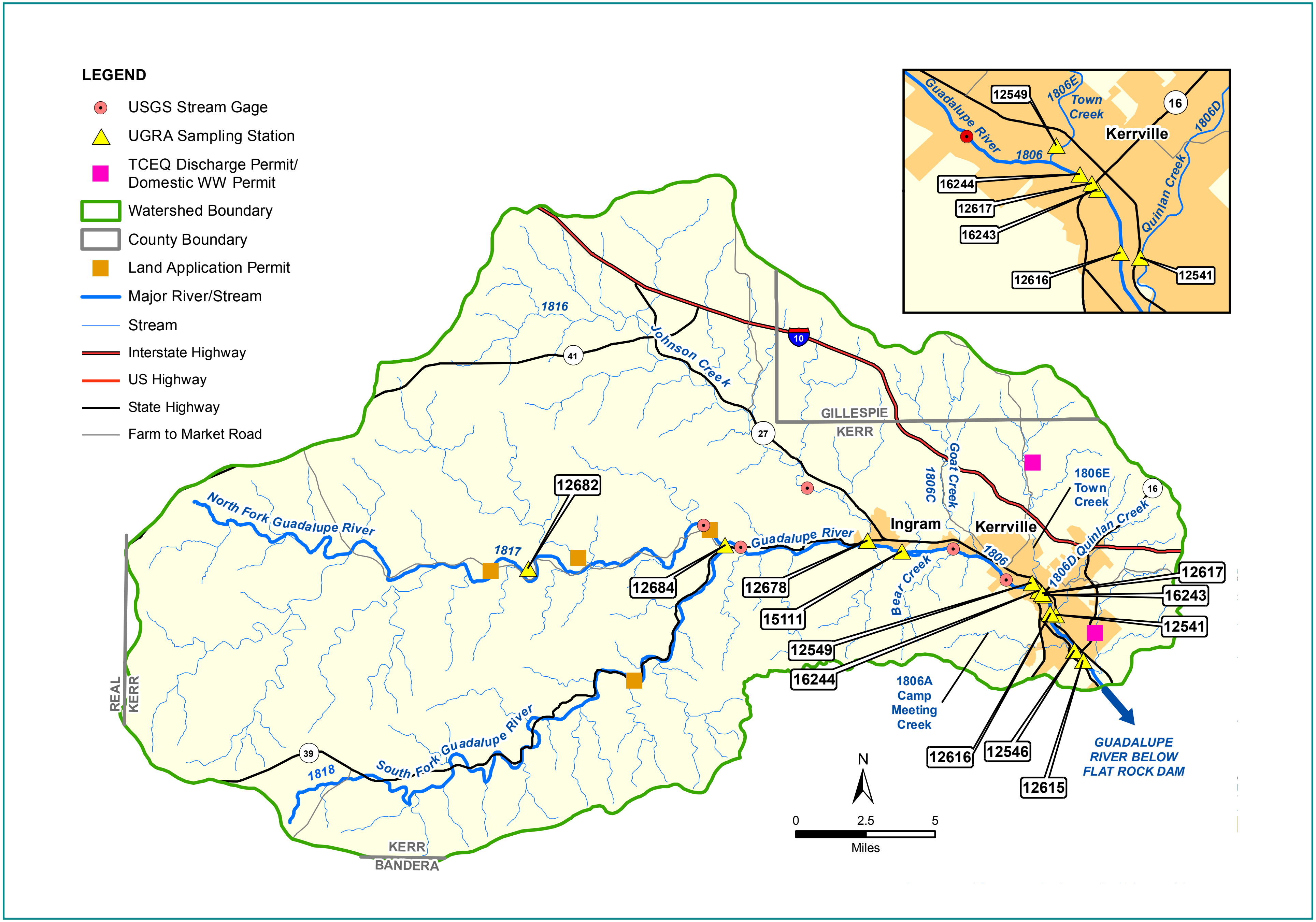
Category 5: Standard is not attained or nonattainment is predicted in the near future for one or more parameters.

5a – TMDLs are underway, scheduled, or may be scheduled for one or more parameters.

5b – Review of the standards for one or more parameters will be conducted before a management strategy is selected, including a possible revision to the water quality standards.

5c – Additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.

GUADALUPE RIVER ABOVE FLAT ROCK DAM



GUADALUPE RIVER ABOVE FLAT ROCK DAM

The upper Guadalupe River watershed above Flat Rock Dam consists of several segments including the North Fork (1817) and South Fork Guadalupe River (1818), Johnson Creek (1816), and a portion of the upper Guadalupe River segment (1806). This summary report will discuss the upper Guadalupe River segment 1806 as two sub-watersheds in order to better describe the effects of a TMDL implementation plan that has been put into place upstream of Flat Rock Dam in the City of Kerrville. The TCEQ has divided Segment 1806 into eight assessment units (AUs). The five AUs that describe the upper sub-watershed above Flat Rock Dam are 1806_07 which covers the upper 10 miles of segment, 1806_06 from FM 394 to 1 mile downstream, 1806_05 from the confluence with Camp Meeting Creek to 2 miles upstream, 1806_04 from 1 mile upstream Flat Rock Dam to the confluence with Camp Meeting Creek, and 1806_03 from Flat Rock Dam in Kerrville to 1 mile upstream. These five AUs represent only the upper 16 miles of this segment. For information regarding the remaining three AUs in this segment please refer to the section of this report covering the Guadalupe River below Flat Rock Dam.

High levels of E. coli bacteria prompted the Texas Commission on Environmental Quality (TCEQ) to add the Guadalupe River Above Canyon Lake (Segment 1806) to the state's 2002 Clean Water Act (CWA) section 303(d) list of impaired waters. Assessment units 1806_06 and 1806_04, had bacteria levels that exceeded the primary contact recreation standard geometric mean of 126 colony forming units of E. coli per 100 mL (cfu/100 mL) of water. The TCEQ assessed a geometric mean of 193 cfu/100 mL of E. coli at AU 1806_06 and 231 cfu/100 mL at AU 1806_04. Both of the listed assessment units were contained within the urbanized portions of the City of Kerrville. The 1806_04 AU is located downstream of the confluence with Goat Creek at FM 394 (Francisco Lemos Street) and receives the discharge from Town Creek. The 1806_06 AU is immediately downstream of the confluence with Camp Meeting Creek and flows into Flat Rock Lake. The two mile long AU 1806_05 that falls between the two impaired AUs was found to be fully supporting of primary contact recreation standard. Since that time, the Upper Guadalupe River Authority (UGRA) has worked with TCEQ to develop a locally driven solution to reduce the bacteria concentrations to a level consistent with state standards for recreation.

In 2004, the TCEQ initiated a Total Maximum Daily Load (TMDL) project to conduct public outreach, identify sources, and establish loads. The TMDL and subsequent Implementation Plan (I-Plan) were adopted and approved by the TCEQ in 2007 and 2011 respectively. The TCEQ provided UGRA with CWA section 319(h) funding to implement the I-Plan in partnership with the City of Kerrville, Kerr County, and the Texas Department of Transportation (TXDOT). To address the bacteria impairment, the I-Plan included implementing best management practices to control bacteria from animal waste, improving infrastructure, and conducting education and outreach in the watershed. As a result of the collaborative effort of individuals and organizations, the water

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Guadalupe River Above Flat Rock Dam
Drainage Area: 537 square miles
Length: 17 miles
Tributaries: North Fork (1817) and South Fork (1818) of the Guadalupe River, Johnson Creek (1816), Kelly Creek, Indian Creek, Goat Creek (1806C), Bear Creek, Town Creek(1806E), Quinlan Creek (1806D), Camp Meeting Creek (1806A), Third Creek
Aquifer: Trinity, Edwards Plateau
River Segments: 1816, 1817, 1818, 1806, 1806A, 1806C, 1806D, 1806E
Cities and Communities: Hunt, Ingram, Kerrville
Counties: Kerr, Gillespie
EcoRegion: Edwards Plateau
Climate: Average annual rainfall 32.08 inches, Average annual temperature 65.1°F
Vegetation Cover: Evergreen Forest 33.25%, Deciduous Forest 7.16%, Shrubland 52.81%; Grassland 2.11%; Woody Wetlands: 0.01% Cultivated Crops 0.02% ; Pasture Hay 0.06%
Land Uses: ranching, farming, tourism, light manufacturing
Development: Low Intensity 0.8% ; Medium Intensity 0.3%; High Intensity 0.1%; Open Space 3.0%
Water Body Uses: aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: Domestic 2, Land Application 6, Industrial 0

quality in AU 1806_04 and 1806_06 has improved and TCEQ removed these AUs from the state's impaired waters list in 2012 and 2014, respectively.

Many of the bacteria reduction strategies have been maintained and continue to be implemented. Routine water quality monitoring both through the Clean Rivers Program and UGRA funded efforts continue to track E. coli levels to ensure this restoration process remains a success. In FY18 UGRA received CWA section 319(h) funding to update and revise the Implementation Plan for the Upper Guadalupe River. This process has reengaged the original stakeholders to assess the progress done to date and possibly plan for the implementation of additional strategies to maintain the bacteria reductions.

UGRA performs routine sampling at 10 stations within the portion of 1806 above Flat Rock Lake. There are three USGS gages within this portion of 1806, one just below the confluence of the North and South Forks in Hunt, one near the Bear Creek Road Crossing immediately west of Kerrville, and one just downstream of Nimitz Dam in Kerrville. During the period of this report (2003-2016), a decreasing trend in flow influenced water quality at nearly all locations in segment 1806 due to the intense drought from 2011-2014. Average annual rainfall was only 21 inches during the drought compared to the long term annual average of 30 inches for Kerr County.

The 2014 Texas Integrated Report assessed a concern for impaired biological habit in this AU. The data used to asses this concern was collected from four biological monitoring screening events conducted at station 15111. All four events were collected by the Guadalupe-Blanco River Authority (GBRA) and UGRA staff in the years of 2006, 2008, 2009, and 2010. The monitoring event collected in 2006 utilized historical Receiving Water Assessment (RWA) sampling protocols that were published by the TCEQ in 1999. The assessed monitoring events from 2008, 2009 and 2010 were collected utilizing the Aquatic Life Monitoring (ALM) protocols defined in the TCEQ Surface Water Quality Monitoring Procedures Manual Volume 2 that was published in June of 2007. In order to evaluate designated aquatic life uses, bioassessments of aquatic assemblages must be collected during a TCEQ defined Index Period that encompasses the period of time from March 15th to October 15th of a given year. An ALM event also includes monitoring during the TCEQ defined critical period from July 1st to September 30th, when streamflow and dissolved oxygen levels are usually at their lowest levels. This segment of the Guadalupe River is assessed against the designated Excellent Aquatic Life Use. The TCEQ utilizes an Index of Biotic Integrity (IBI) tool that was developed from multiple biological statistics to quantitatively assess the health of a biological community in an ecological region. The TCEQ averaged the index of biotic integrity (IBI) scores from each of the four collection events for the assessment categories of fish community, microbenthic community, and biological habitat. No concerns were noted for the fish community and macroinvertebrate community at this time. The average of the habitat IBI scores for these four events was assessed at 23.5 with a coefficient of variance of 2.45. This score was slightly below an exceptional habitat IBI score of 26. A more recent aquatic life monitoring event was conducted by GBRA and UGRA at station 15111 in 2015 utilizing the current iteration of SWQM Procedures updated in 2014. The 2015 event confirmed that the previously assessed habitat concern continues to persist with an average Habitat IBI score of 19.5 and a coefficient of variance of 3.63. These habitat IBI scores were particularly influenced by flow conditions at the time of the assessment. This event also found that the fish community IBI average of 38.5 with a coefficient of variance of 5.51 was below the designated exceptional IBI score of 52, but the average IBI of 37 for macroinvertebrate community was greater than the exceptional IBI criteria of 36. The 2015 ALM was heavily affected by drought conditions and the stream flows for both the critical period (15.4 cfs) and index period (3.7 cfs) events were well below the statistically determined low flow for seven consecutive days within a two year interval of recurrence (7Q2) of 27.1 cfs for this segment. The stream flow conditions during the 2015 aquatic life monitoring event may indicate that it was not representative of normal conditions and further monitoring during moderate flows may be warranted to confirm any findings regarding designated aquatic life uses.

The next downstream station in AU 1806_07 is 12618 located on the Guadalupe River at Nimitz Lake Dam (formerly called UGRA Lake Dam). Data from May 2003 – August 2015 was evaluated and average stream flow during this time was 90 cfs with a decreasing trend over time. This station has the lowest E. coli geometric mean of any location in the Guadalupe River above Flat Rock Lake with a concentration of only 6 cfu/100 mL. Due to the long term excellent water quality at this location (Table 2) with little variability, UGRA discontinued Clean Rivers Program monitoring this station in FY16. The station is still included in a UGRA funded weekly summer E. coli sampling program.

Assessment Unit 1806_06 represents a reach in the City of Kerrville from the confluence of Town Creek to 1 mile downstream and includes 3 routinely monitored stations in Louise Hays Park. The 2014 Texas Integrated Report indicates no impairments or concerns for this AU. The most upstream station is 16244 at the Louise Hays Park Footbridge (Table 3), approximately 270 yards downstream is station 12617 at the SH 16 Bridge (Table 4), and approximately 175 yards further downstream is station 16243 at the Louise Hays Park Dam (Table 5). Analysis of the data from May 2003 to December 2016 show E. coli geometric mean concentrations below the contact recreation standard of 126 cfu/100 mL.

GUADALUPE RIVER ABOVE FLAT ROCK DAM

As mentioned previously, this AU was the focus of a multi-year Implementation Plan to address bacteria concentrations that did not meet standards. The 2014 Texas Integrated Report results showed the first time in over 10 years that this AU met bacteria standards. Challenges remain for this AU to continue to meet bacteria goals because it is adjacent to the most urbanized section of the City of Kerrville and receives stormwater runoff from the urban watershed. Additionally, non-native Egyptian geese populations continue to increase in Louise Hays Park. UGRA along with the City of Kerrville promote the message of “Don’t feed the ducks and geese” through signs, public service announcements, and educational programs, but coordinated removal efforts may be necessary to control the waterfowl populations.

Assessment Unit 1806_05 represents a 2 mile reach from Louise Hays Park downstream to the confluence with Camp Meeting Creek and includes 1 routinely monitored station at G Street (12616). The 2014 Texas Integrated Report indicates no impairments or concerns for this AU and it is situated between the two AUs previously impaired for E. coli bacteria. A regression analysis of the data from May of 2003 to December of 2016 revealed several related water quality trends at this station. The average stream flow during this time at station 12616 was 85 cfs with a decreasing trend over time. This station has experienced decrease over time of Total Suspended Solids (Figure 4), Volatile Suspended Solids, and Turbidity. The range in values of these parameters is quite small, but the observed decrease could be due to the reduction in stormwater runoff generating rain events during the period of this report. This station has a low E. coli geometric mean concentration of 45 cfu/100 mL. Overall, we continue to see excellent water quality at this location (Table 6).

Assessment Unit 1806_04 represents a 1 mile reach from the confluence with Camp Meeting Creek downstream into Flat Rock Lake and includes 1 routinely monitored station adjacent to Kerrville-Schreiner Park (12615). The 2014 Texas Integrated Report lists no impairments or concerns for this AU. Analysis of the data from February 2003 to December 2016 show E. coli geometric mean concentration of 83 cfu/100 mL and overall excellent water quality at this location (Table 7). Along with 1806_06, this AU was the focus of a multi-year Implementation Plan to address high bacteria concentrations. The 2012 Texas Integrated Report results showed for the first time in 10 years that this AU met bacteria standards and the standards attainment was confirmed in the 2014 Texas Integrated Report as well. Challenges similar to those previously described for 1806_06 also exist for 1806_04 and local stakeholders are working together to mitigate sources that could potentially lead to future increases in bacteria concentrations. Along with AU 1806_06, this section of the Guadalupe River supports a great deal of summertime contact recreation and tourism focused on the river.

Assessment Unit 1806_03 represents a 1 mile reach covering the portion of the Guadalupe River immediately upstream from Flat Rock Dam and there are no sites currently being monitored in this assessment unit.

TRIBUTARIES TO SEGMENT 1806

Segment 1806A, Camp Meeting Creek is an unclassified water body ranging from the confluence near Flat Rock Lake in Kerrville to the upstream perennial portion of the stream and is approximately 6 miles long. The stream contains two assessment units, but only one station (12546) in the lower AU (1806A_01) has been routinely monitored by UGRA. The 2014 Texas Integrated Report lists no impairments for this segment, but a concern for depressed dissolved oxygen was identified for 1806A_01. Station 12546 is located at the SH 173 crossing of Camp Meeting Creek. A regression analysis of the data from February 2003 to December 2016 revealed several water quality trends at this station. The average stream flow during this time at station 12546 was 1.3 cfs. The station experienced an increase in Sulfate (Figure 5) and on several occasions, the individual values exceeded the 50 mg/L screening criteria for Sulfate (Table 8). Many of the highest Sulfate values observed were associated with extremely low flows and no elevated Sulfate levels were observed at the closest station (12615) on the Guadalupe River directly downstream from the confluence with Camp Meeting Creek. A decrease in dissolved oxygen was also observed over time (Figure 6) and this could be linked to a decrease in flow during the period evaluated. A site specific criteria for dissolved oxygen is approved for Camp Meeting Creek and applies from July 1st to September 30th (minimum dissolved oxygen criterion of 2.0 mg/L and a 24-hour average of 4.0 mg/L). Average and maximum Total Dissolved Solids (calculated from specific conductance measurement) values exceeded the screening criteria of 400 mg/L. The high concentrations of Total Dissolved Solids are most likely due to reduced flows as a result of drought conditions. The E. coli geometric mean from 2003-2016 was 130 cfu/100 mL which exceeds the contact recreation standard of 126 cfu/100 mL. An increasing trend in E. coli bacteria concentration was also observed during this time (Figure 7). The 2014 Texas Integrated Report showed a geometric mean value of 103 cfu/100 mL for this AU during that report’s period, however. Currently, the site is not listed as impaired for elevated bacteria levels, however the geometric mean of the assessed data is expected to exceed the contact recreation standard during future iterations of the report. Camp Meeting Creek shares many of the same challenges as Town Creek and Quinlan Creek that will be discussed

CONTINUED ON PAGE 20

in a subsequent section. All three watersheds are densely populated, and the streams have intermittent and overall very low flow. The watershed immediately upstream of sampling station 12546 on Camp Meeting Creek is a subdivision with a golf course that is home to an increasing number of Egyptian geese. The nuisance waterfowl and stormwater runoff concerns previously discussed in 1806_06 are factors that influence water quality in Camp Meeting Creek as well.

Segment 1806D, Quinlan Creek is an unclassified waterbody in the City of Kerrville with very intermittent flow and is approximately 8 miles long. The stream consists of one assessment unit (1806D_01) and one station that is routinely monitored by UGRA (12541). Many of the bacteria samples considered in the 2014 Texas Integrated Report were collected during times of extreme low flow from a stagnant pool. The 2014 Texas Integrated Report lists this segment as impaired for the bacteria geometric mean value exceeding the state standard for contact recreation. A concern for depressed dissolved oxygen was also identified. Station 12541 is located on Quinlan Creek near the old Travis Street Bridge adjacent to Schreiner University in Kerrville. Data from February 2005 to December 2016 was examined to identify water quality trends at this station (Table 9). The average stream flow during this time at station 12541 was 0.8 cfs. This station has experienced an increase in Specific Conductance (TDS is calculated from this measurement) with several of the most recent values exceeding the screening criteria (Figure 8). The E. coli geometric mean from 2003-2016 was 300 cfu/100 mL which exceeds the contact recreation standard of 126 cfu/100 mL. The 2010 Texas Integrated Report first listed this AU as impaired for elevated bacteria levels that do not meet the contact recreation standard and each subsequent Integrated Report has confirmed that impairment. Additionally, a concern for depressed dissolved oxygen was also identified in the 2014 Integrated Report.

Segment 1806E, Town Creek is an unclassified waterbody in the City of Kerrville with very intermittent flow and is approximately 9 miles long. The stream consists of one assessment unit (1806E_01) and one station that is routinely monitored by UGRA (12549). Many of the bacteria samples considered in the 2014 Texas Integrated Report were collected during time of extreme low flow. The 2014 Texas Integrated Report lists this segment as impaired for the bacteria geometric mean value exceeding the state standard for contact recreation. Station 12549 is located on Town Creek near the intersection of Lowry Street and Hamilton Street in Kerrville. A concern for depressed dissolved oxygen was also identified. Data from February 2005 to December 2016 was examined to identify water quality trends at this station (Table 10). The average stream flow during this time at station 12549 was 2.1 cfs. This station has experienced an increase in Specific Conductance (TDS is calculated from this measurement) with several of the most recent values exceeding the screening criteria (Figure 9). The E. coli geometric mean from 2003-2016 was 267 cfu/100 mL which exceeds the contact recreation standard of 126 cfu/100 mL. The 2010 Texas Integrated Report first listed this AU as impaired for elevated bacteria levels that do not meet the contact recreation standard and each subsequent Integrated Report has confirmed that impairment. Additionally, a concern for depressed dissolved oxygen was also first identified in the 2010 Integrated Report.

Many of the implementation measures put in place to address the bacteria impairment in 1806_06 and 1806_04 addressed pollution sources for the Quinlan and Town Creek watersheds. When both creeks were identified as impaired for bacteria through the Texas Integrated Report assessment process, development of their individual pollution loads was required. Therefore, a Technical Support Document for Total Maximum Daily Loads for Indicator Bacteria in Quinlan Creek and Town Creek was developed in 2017 and was included in the January 2018 update to the Texas Water Quality Management Plan. The Implementation Plan revision process currently underway by UGRA will reference this new report and continue to work to develop strategies to address high E. coli bacteria levels in Quinlan Creek and Town Creek.

Segment 1816, Johnson Creek extends from the confluence with the Guadalupe River in Ingram to SH 41 in western Kerr County and is approximately 21 miles long. The segment consists of one assessment unit (1816_01) and one monitoring station that is routinely monitored by UGRA (12678). There is one USGS gage located in this AU, approximately 3.5 miles upstream from site 12678. The 2014 Texas Integrated Report has no impairments or concerns listed for Segment 1816. Station 12678 is located immediately upstream of the SH 39 Crossing in Ingram. A regression analysis of the data from February 2003 to December 2016 revealed several water quality trends at this station. The average stream flow during this time at station 12678 was 41 cfs and had a decreasing trend over time (Figure 10). The station experienced an increase in E. coli (Figure 11), Turbidity, Total Suspended Solids, and Chlorides over time. A decrease in Nitrate was also observed (Figure 12). With the exception of E. coli, all of the observed changes in water quality parameters showed significant correlations with stream flow and were most likely a result of drought conditions. This station has a low E. coli geometric mean concentration of 56 cfu/100 mL. Overall, this station has excellent water quality (Table 11) including low nutrient levels and little variation exhibited over time. The land use in the Johnson Creek watershed is rural with very low density residential development and some camps upstream of Ingram. The scenery and recreational opportunities attract many people to segment 1816. In fact, site 12678 is a very popular swimming hole for local residents.

Segment 1817, North Fork Guadalupe River extends from the confluence with the Guadalupe River in Hunt to a point past Boneyard Draw in western Kerr County and is approximately 29 miles long. The segment consists of one assessment unit (1817_01) and one monitoring station that is routinely monitored by UGRA (12682). There is one USGS gage located in the AU, approximately 0.5 miles downstream from site 12682. The 2014 Texas Integrated Report has no impairments or concerns listed for Segment 1817. Station 12682 is located at the Waldemar Crossing on FM 1340 in Hunt approximately 6 miles upstream from the confluence with the South Fork. A regression analysis of the data from February 2003 to December 2016 revealed several water quality trends at this station. The average stream flow during this time at the associated USGS gage was 22 cfs and had a decreasing trend over time. The station experienced a decrease in Volatile Suspended Solids, Specific Conductance, and Nitrate (Figure 13) over time. An increase in Chloride and pH (Figure 14) was also observed. Significant correlations with stream flow were found for all these parameters, and the observed changes over time were most likely the result of drought conditions. This station has a low E. coli geometric mean concentration of 32 cfu/100 mL. Overall, this station has excellent water quality with little nutrient loading (Table 12) and the segment maintains an exceptional aquatic life use designation. The North Fork Guadalupe River watershed is rural with very low density residential development. Many Hill Country summer camps are located in segment 1817 due to the beautiful scenery and numerous recreational opportunities.

Segment 1818, South Fork Guadalupe River extends from the confluence with the Guadalupe River in Hunt to a point upstream of FM 187 in western Kerr County and is approximately 27 miles long. The segment consists of five assessment units (1818_01 – 1818_05), but only the most downstream AU (1818_01) contains a station (12684) that is routinely monitored by UGRA. There are no USGS gages located in the segment. The 2014 Texas Integrated Report identified a concern for depressed dissolved oxygen for this segment. However, more recent data suggests that this concern will not persist into the next assessment period, as stream flows return to normal following several years of drought conditions. Station 12684 is located at the SH 39 crossing in Hunt just upstream from the confluence with the North Fork Guadalupe River adjacent to Hunt Lion’s Park. A regression analysis of the data from February 2003 to December 2016 revealed several water quality trends at this station. The average stream flow during this time at the associated USGS gage was 22 cfs and had a decreasing trend over time. The station experienced an increase in Turbidity, Total Suspended Solids, and pH over time. This station has a low E. coli geometric mean concentration of 16 cfu/100 mL. Overall, this station has excellent water quality (Table 13) including low nutrient levels and little variation exhibited over time. The land use in the South Fork Guadalupe River watershed is rural with very low density residential development. Much like the North Fork Guadalupe River, segment 1818 is home to numerous Hill Country summer camps promoting various recreational activities.

GUADALUPE RIVER ABOVE FLAT ROCK DAM

Table 1

Station 15111 – Guadalupe River at Riverview Rd 02/2003 - 12/2016					
AU 1806_07 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	20.7	29.6	9.1	59	30.00
pH	8.0	8.6	7.6	59	6.5 – 9.0
Chloride (mg/L)	16.8	22.2	10.0	55	50.00
Sulfate (mg/L)	10.6	16.3	6.6	55	50.00
Total Dissolved Solids (mg/L)	290	339	257	58	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.07	<0.04	55	0.69
Chlorophyll-a (μg/L)	1.2	2.1	<1	54	14.1
Nitrate Nitrogen (mg/L)	0.3	1.04	<0.04	48	1.95
TKN (mg/L)	0.27	0.46	<0.20	21	N/A
AU 1806_07 Recreational Use					
E. coli (MPN/100 mL)	31 Geomean	200	3	54	126 Geomean
AU 1806_07 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.4	12.0	5.5	59	≥4.0 Minimum & ≥ 6.0 Average

Table 2

Station 12618 – Guadalupe River at Nimitz Lake Dam 05/2003 - 8/2015					
AU 1806_07 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	22.5	32.0	7.3	137	30.00
pH	8.2	9.0	7.8	135	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	278	390	228	137	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	N/A	N/A	N/A	N/A	0.69
Chlorophyll-a (μg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	N/A	N/A	N/A	N/A	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1806_07 Recreational Use					
E. coli (MPN/100 mL)	6 Geomean	210	<1	193	126 Geomean
AU 1806_07 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.6	11.7	3.7	137	≥4.0 Minimum & ≥ 6.0 Average

Table 3

Station 16244 – Guadalupe River at Louise Hays Park Footbridge 05/2003 - 12/2016					
AU 1806_06 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	21.7	31.5	5.3	135	30.00
pH	8.2	8.5	7.9	134	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	278	346	229	135	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	N/A	N/A	N/A	N/A	0.69
Chlorophyll-a (μg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	N/A	N/A	N/A	N/A	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1806_06 Recreational Use					
E. coli (MPN/100 mL)	97 Geomean	>2400	3	207	126 Geomean
AU 1806_06 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.4	14.0	3.9	135	≥4.0 Minimum & ≥ 6.0 Average

Table 4

Station 12617 – Guadalupe River at SH16 05/2003 - 12/2016					
AU 1806_06 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	22.0	30.5	6.0	153	30.00
pH	8.2	9.7	7.8	152	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	281	370	177	153	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	N/A	N/A	N/A	N/A	0.69
Chlorophyll-a (μg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	N/A	N/A	N/A	N/A	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1806_06 Recreational Use					
E. coli (MPN/100 mL)	124 Geomean	2419	5	216	126 Geomean
AU 1806_06 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.9	13.0	4.5	153	≥4.0 Minimum & ≥ 6.0 Average

GUADALUPE RIVER ABOVE FLAT ROCK DAM

Table 5

Station 16243 – Guadalupe River at Louise Hays Park Dam 05/2003 - 12/2016					
AU 1806_06 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	21.7	30.4	6.7	135	30.00
pH	8.2	8.6	7.8	134	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	283	355	235	135	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	N/A	N/A	N/A	N/A	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	N/A	N/A	N/A	N/A	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1806_06 Recreational Use					
E. coli (MPN/100 mL)	82 Geomean	2000	3	207	126 Geomean
AU 1806_06 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.0	12.6	4.5	135	≥4.0 Minimum & ≥ 6.0 Average

Table 6

Station 12616 – Guadalupe River at G Street 05/2003 - 12/2016					
AU 1806_05 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	21.9	31.8	6.8	162	30.00
pH	8.3	8.6	7.7	161	6.5 – 9.0
Chloride (mg/L)	18.9	37.6	12.3	54	50.00
Sulfate (mg/L)	12.9	32.7	7.4	54	50.00
Total Dissolved Solids (mg/L)	283	347	235	162	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.11	<0.04	54	0.69
Chlorophyll-a (µg/L)	1.5	9.0	<1	53	14.1
Nitrate Nitrogen (mg/L)	0.3	1.0	<0.05	48	1.95
TKN (mg/L)	0.34	0.55	<0.2	22	N/A
AU 1806_05 Recreational Use					
E. coli (MPN/100 mL)	45 Geomean	>2400	4	161	126 Geomean
AU 1806_05 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.6	13.1	6.4	162	≥4.0 Minimum & ≥ 6.0 Average

Table 7

Station 12615 – Guadalupe River at Kerrville-Schreiner Park 02/2003 - 12/2016					
AU 1806_04 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	22.2	31.1	6.5	191	30.00
pH	8.2	7.5	8.7	190	6.5 – 9.0
Chloride (mg/L)	20.7	34.9	14.1	55	50.00
Sulfate (mg/L)	14.3	25.4	9.4	55	50.00
Total Dissolved Solids (mg/L)	292	390	230	191	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.24	<0.04	55	0.69
Chlorophyll-a (µg/L)	1.8	8.0	<1	54	14.1
Nitrate Nitrogen (mg/L)	0.35	1.04	<0.05	48	1.95
TKN (mg/L)	0.38	1.22	<0.2	21	N/A
AU 1806_04 Recreational Use					
E. coli (MPN/100 mL)	83 Geomean	4800	3	243	126 Geomean
AU 1806_04 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.8	14.2	5.7	191	≥4.0 Minimum & ≥ 6.0 Average

Table 8

Station 12546 – Camp Meeting Creek at SH 173 02/2003 - 12/2016					
AU 1806A_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	20.4	32	4.7	191	30.00
pH	7.5	8.2	6.8	187	6.5 – 9.0
Chloride (mg/L)	40.1	61.1	14.4	64	50.00
Sulfate (mg/L)	39.7	72.3	12.5	65	50.00
Total Dissolved Solids (mg/L)	467	1,106	150	190	400.00
NH3-N (mg/L)	<1	<1	<0.03	9	0.33
Total Phosphorus (mg/L)	0.05	0.71	<0.04	65	0.69
Chlorophyll-a (µg/L)	1.5	9.6	<1	64	14.1
Nitrate Nitrogen (mg/L)	0.65	2.5	<0.05	49	1.95
TKN (mg/L)	0.41	1.0	<0.05	29	N/A
AU 1806A Recreational Use					
E. coli (MPN/100 mL)	130 Geomean	>2400	3	166	126 Geomean
AU 1806A Aquatic Life Use					
Dissolved Oxygen (mg/L)	6.7	13.0	1.8	189	≥4.0 Minimum (≥2.0 Minimum Jul-Sep) ≥ 6.0 Average

GUADALUPE RIVER ABOVE FLAT ROCK DAM

Table 9

Station 12541 – Quinlan Creek at Travis St. 02/2005 - 12/2016					
AU 1806A General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	21.8	34.0	5.0	120	30.00
pH	8.0	9.0	6.8	119	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	387	657	91	120	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	N/A	N/A	N/A	N/A	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	N/A	N/A	N/A	N/A	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1806A Recreational Use					
E. coli (MPN/100 mL)	300 Geomean	>4800	10	102	126 Geomean
AU 1806A Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.0	18.8	0.5	120	≥4.0 Minimum & ≥ 6.0 Average

Table 11

Station 12678 – Johnson Creek at SH39 02/2003 - 12/2016					
AU 1816 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	20.9	31.0	7.9	73	30.00
pH	8.1	9.4	7.6	72	6.5 – 9.0
Chloride (mg/L)	24.9	32.7	13.0	55	50.00
Sulfate (mg/L)	13.0	27.0	9.0	55	50.00
Total Dissolved Solids (mg/L)	304	390	234	73	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.12	<0.04	55	0.69
Chlorophyll-a (µg/L)	1.4	10.5	<1.0	54	14.1
Nitrate Nitrogen (mg/L)	0.48	1.18	<0.05	48	1.95
TKN (mg/L)	0.27	0.48	<0.20	21	N/A
AU 1806A Recreational Use					
E. coli (MPN/100 mL)	56 Geomean	345	4	125	126 Geomean
AU 1806A Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.2	11.7	5.8	73	≥4.0 Minimum & ≥ 6.0 Average

Table 13

Station 12684 – South Fork Guadalupe River Adjacent to Hunt Lion's Park 02/2003 - 12/2016					
AU 1818_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	19.6	29.1	7.8	55	30.00
pH	7.9	8.1	7.4	55	6.5 – 9.0
Chloride (mg/L)	10.8	36.2	7.1	55	50.00
Sulfate (mg/L)	8.5	15.3	4.6	55	50.00
Total Dissolved Solids (mg/L)	276	330	239	55	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.06	<0.04	55	0.69
Chlorophyll-a (µg/L)	1.2	5.6	<1.0	54	14.1
Nitrate Nitrogen (mg/L)	0.20	0.74	<0.04	48	1.95
TKN (mg/L)	0.29	0.54	<0.2	21	N/A
AU 1818_04 Recreational Use					
E. coli (MPN/100 mL)	16 Geomean	310	<1	54	126 Geomean
AU 1818_04 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.9	10.9	4.8	55	≥4.0 Minimum & ≥ 6.0 Average

Table 12

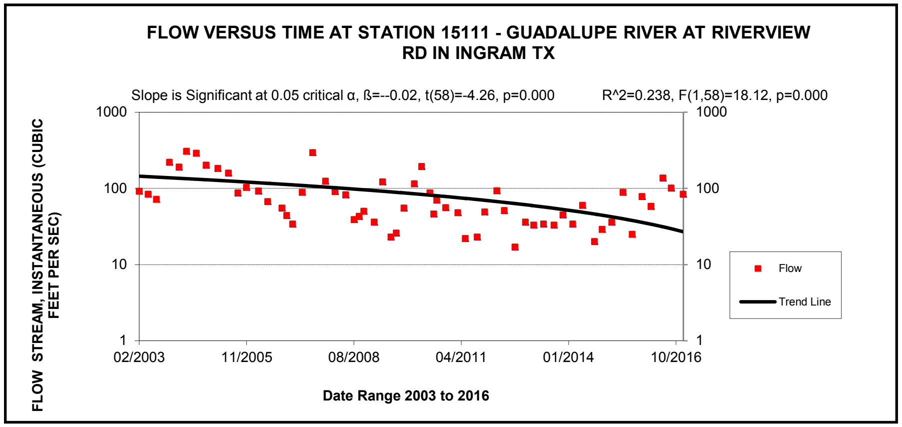
Station 12682 – North Fork Guadalupe River at Waldemar 02/2003 - 12/2016					
AU 1817 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (° C)	19.9	28.2	8.4	55	30.00
pH	7.8	8.1	6.6	55	6.5 – 9.0
Chloride (mg/L)	9.9	12.0	6.1	55	50.00
Sulfate (mg/L)	6.5	13.0	4.4	55	50.00
Total Dissolved Solids (mg/L)	255	341	216	55	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.20	<0.04	55	0.69
Chlorophyll-a (µg/L)	1.6	23.6	<1.0	54	14.1
Nitrate Nitrogen (mg/L)	0.31	0.80	<0.05	48	1.95
TKN (mg/L)	0.33	0.68	<0.20	21	N/A
AU 1806A Recreational Use					
E. coli (MPN/100 mL)	32 Geomean	>2400	2	125	126 Geomean
AU 1806A Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.8	11.2	5.0	55	≥4.0 Minimum & ≥ 6.0 Average

GUADALUPE RIVER ABOVE FLAT ROCK DAM

Table 13

Station 12684 – South Fork Guadalupe River Adjacent to Hunt Lion's Park 02/2003 - 12/2016					
AU 1818_01 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (° C)	19.6	29.1	7.8	55	30.00
pH	7.9	8.1	7.4	55	6.5 – 9.0
Chloride (mg/L)	10.8	36.2	7.1	55	50.00
Sulfate (mg/L)	8.5	15.3	4.6	55	50.00
Total Dissolved Solids (mg/L)	276	330	239	55	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.06	<0.04	55	0.69
Chlorophyll-a (µg/L)	1.2	5.6	<1.0	54	14.1
Nitrate Nitrogen (mg/L)	0.20	0.74	<0.04	48	1.95
TKN (mg/L)	0.29	0.54	<0.2	21	N/A
AU 1818_04 Recreational Use					
E. coli (MPN/100 mL)	16 Geomean	310	<1	54	126 Geomean
AU 1818_04 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.9	10.9	4.8	55	≥4.0 Minimum & ≥ 6.0 Average

Figure 1



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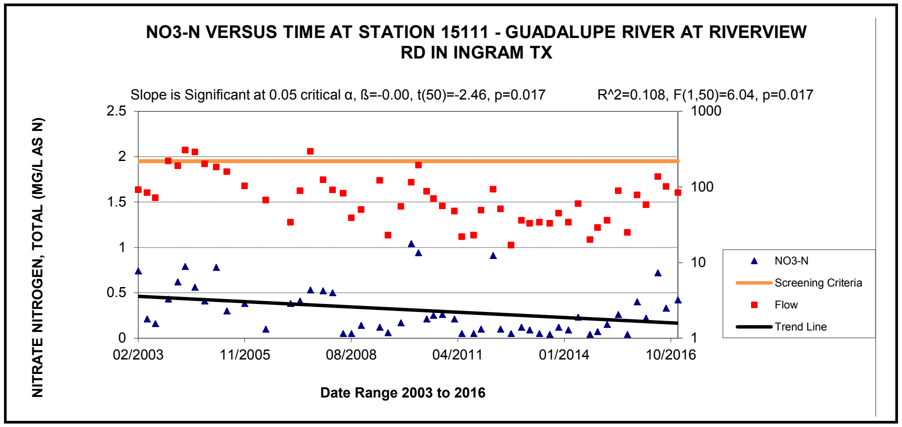

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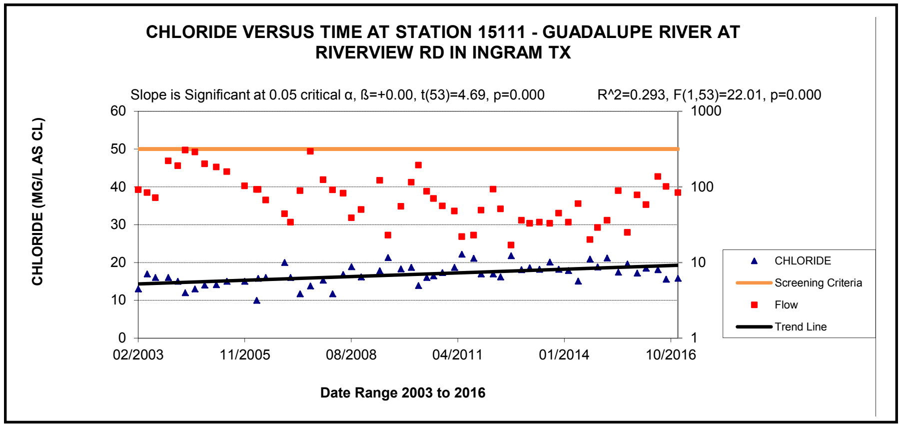


GUADALUPE RIVER ABOVE FLAT ROCK DAM

Figure 4

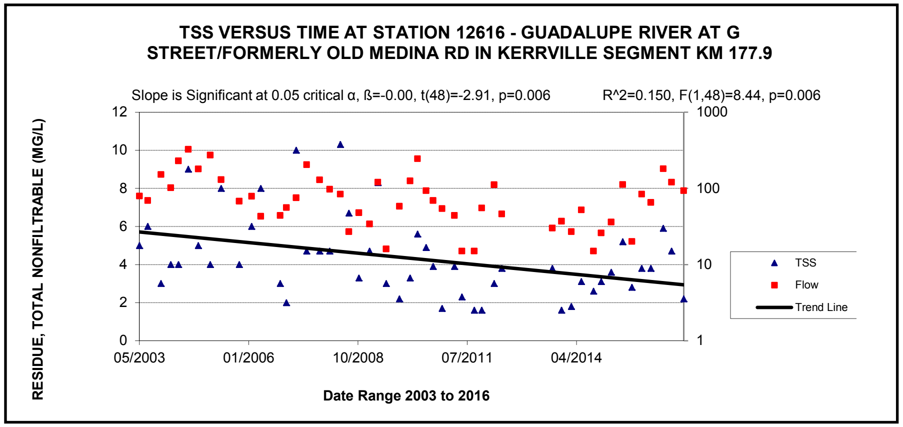


Figure 5

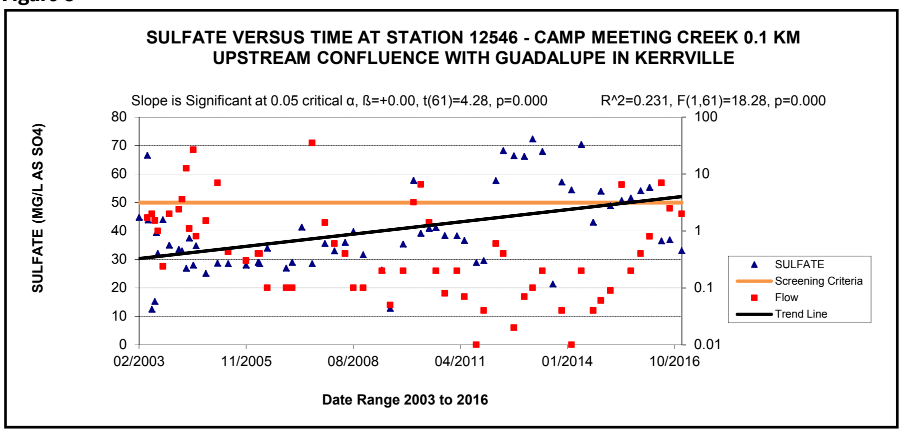


Figure 6

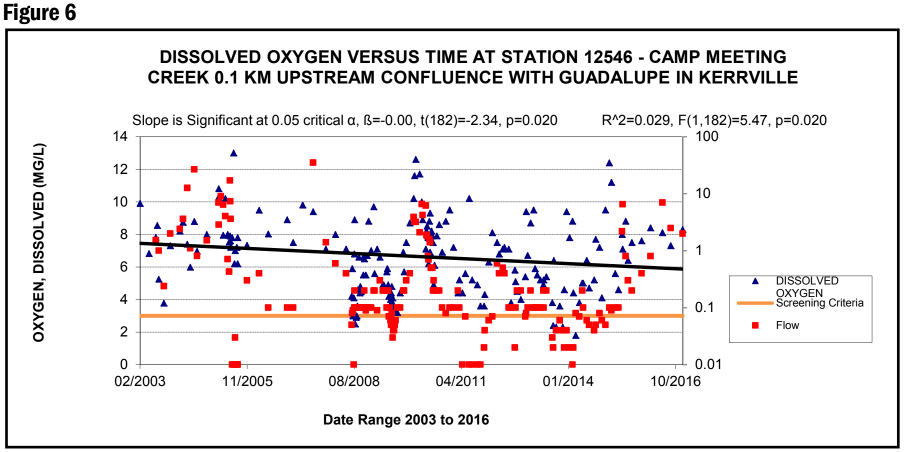
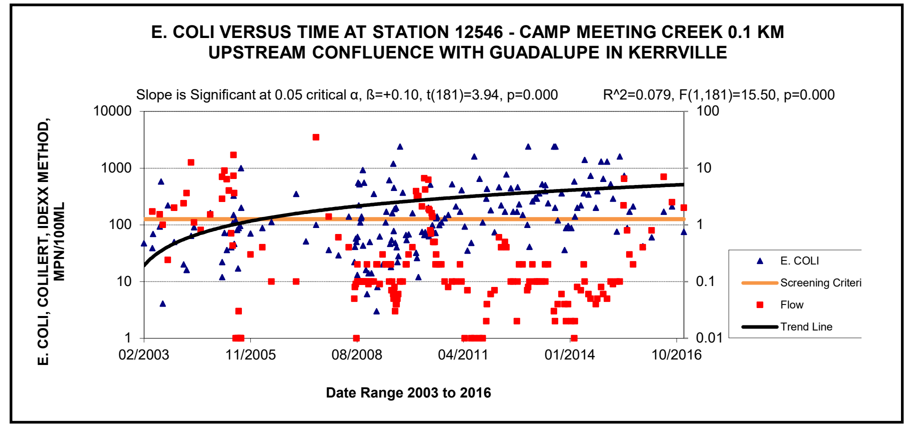


Figure 7



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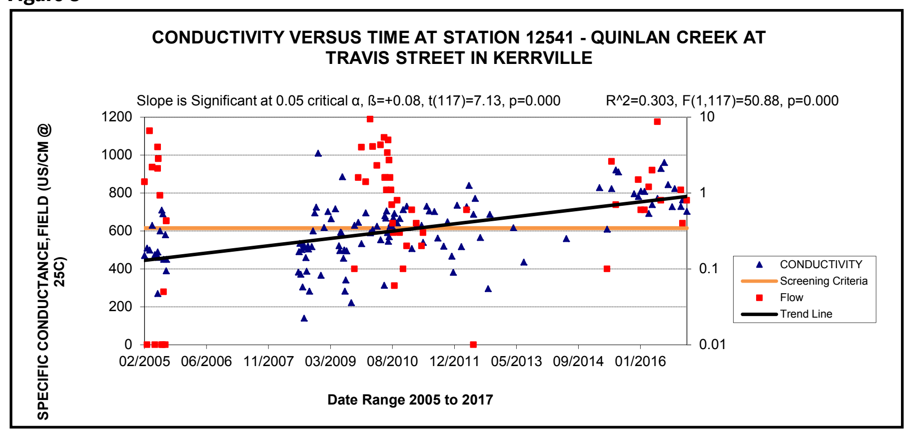
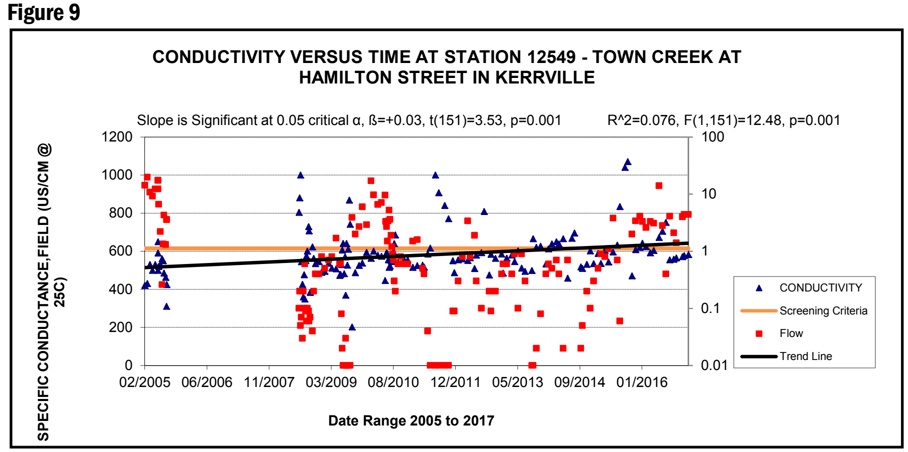
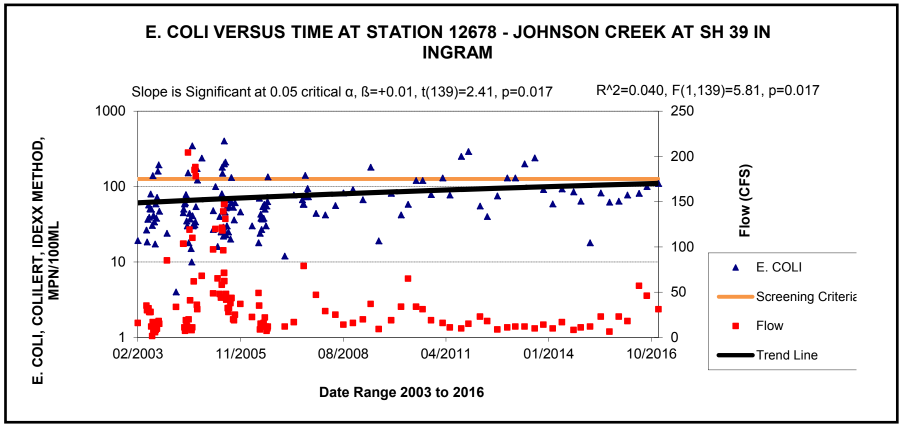


Figure 9



GUADALUPE RIVER ABOVE FLAT ROCK DAM

Figure 10



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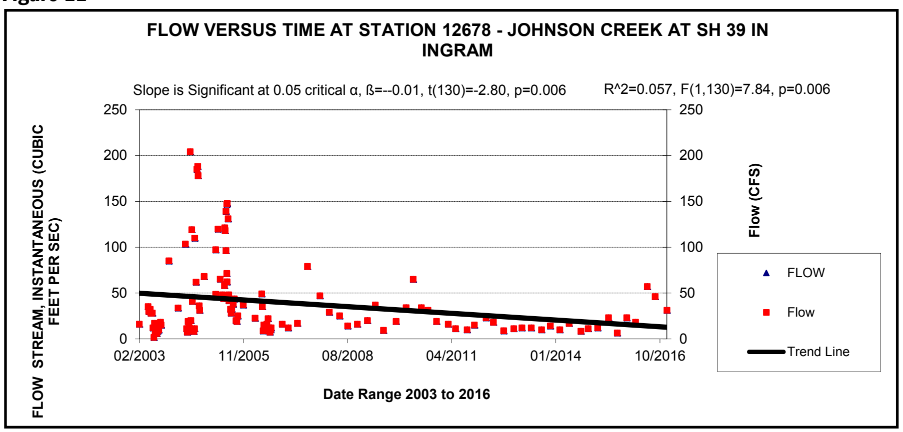

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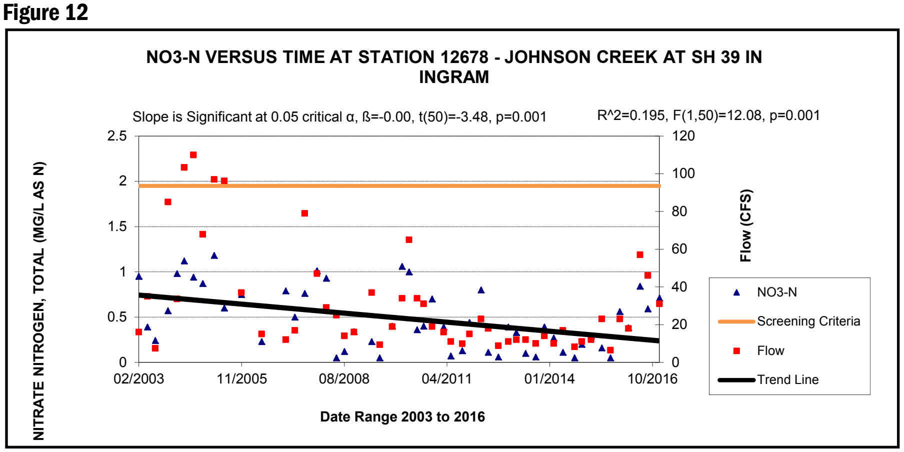


Figure 13

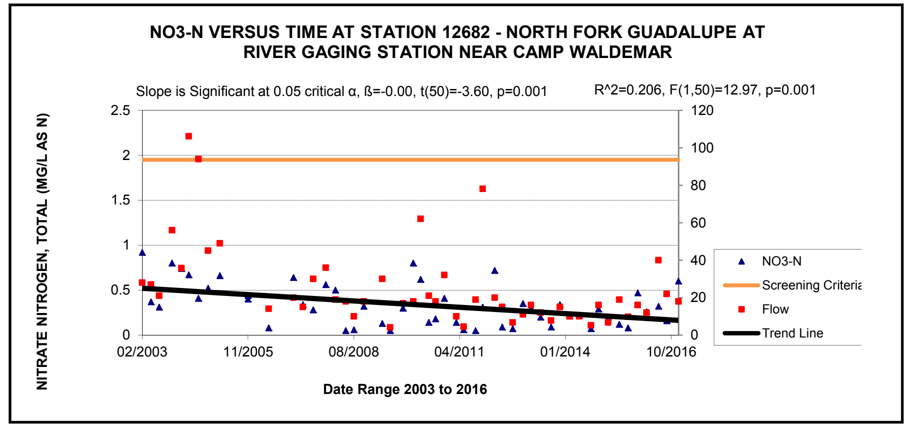
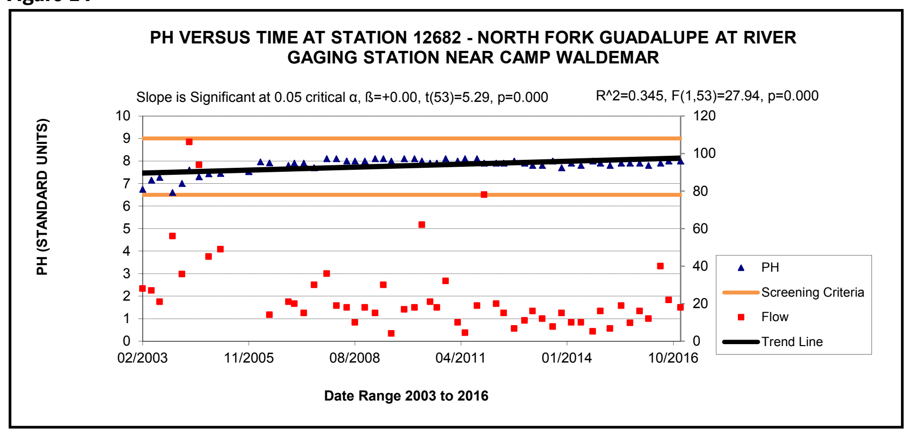
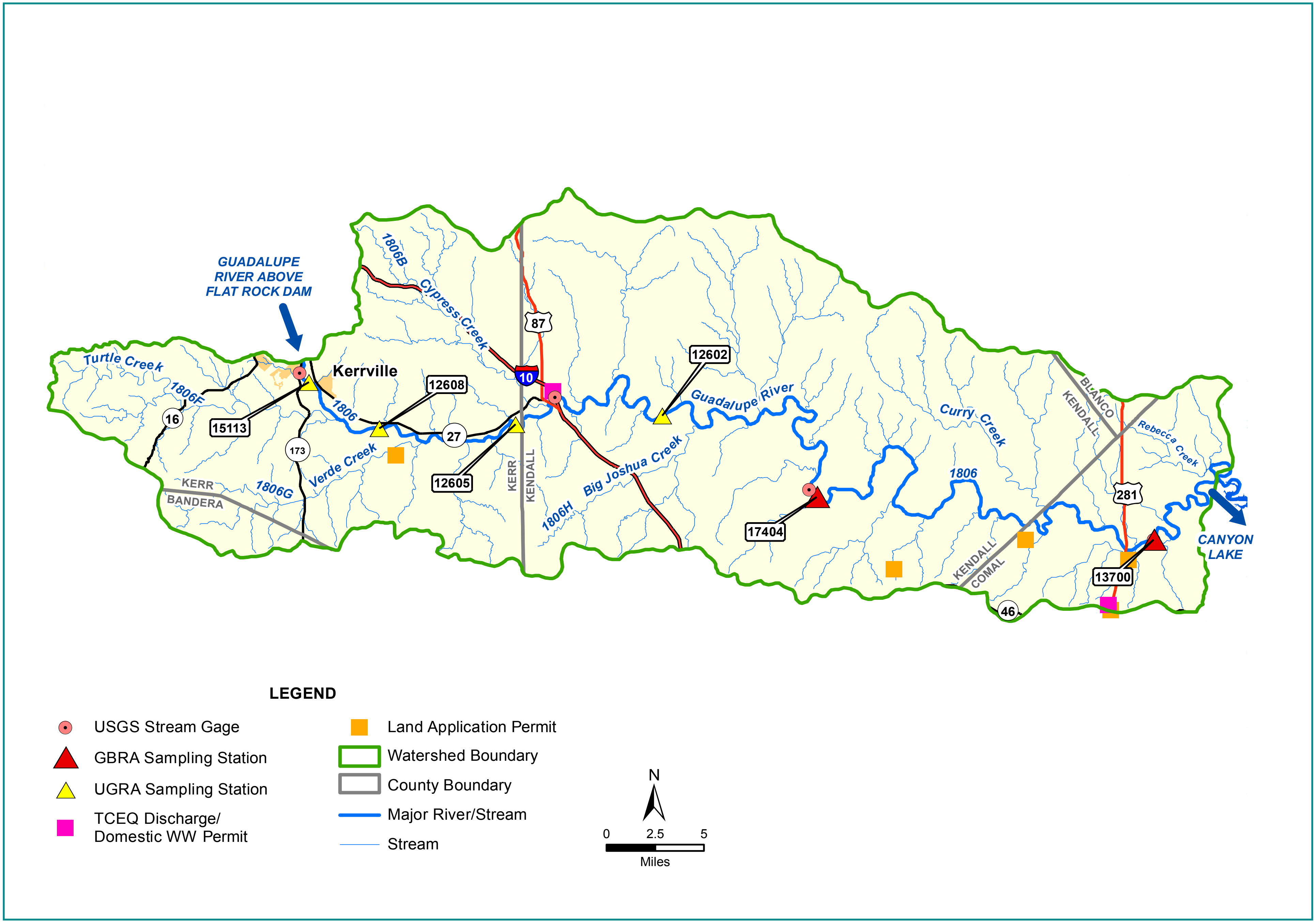


Figure 14



GUADALUPE RIVER BELOW FLAT ROCK DAM



GUADALUPE RIVER BELOW FLAT ROCK DAM

Segment 1806 comprises the 103 mile portion of the Guadalupe River that flows from the confluence between the North Fork and South Forks in Kerr County to Canyon Reservoir in Comal County. This summary report will discuss this segment as two sub-watersheds in order to better describe the effects of a Total Maximum Daily Load (TMDL) implementation plan that has been put into place upstream of Flat Rock Dam in the City of Kerrville. The TCEQ has divided this segment into eight assessment units (AUs). The three AUs that describe the lower sub-watershed below Flat Rock Dam are 1806_02 from the confluence with Big Joshua Creek to Flat Rock dam in Kerrville, 1806_08 from the confluence with Honey Creek upstream to the confluence with Big Joshua Creek and 1806_01 which covers the lower 25 miles of segment from 1.7 miles downstream of Rebecca Creek Road up to the confluence with Honey Creek. These three AUs represent over 93% of the total river reach for this segment. For information regarding the remaining five AUs in this segment please refer to the section of this report covering the Guadalupe River above Flat Rock Dam.

In 2002, segment 1806 was listed on the Texas 303(d) list of impaired waterbodies, as required by Clean Water Act Sections 303(d) and 305(b). The TCEQ found that two assessment units 1806_06 and 1806_04 in the City of Kerrville had bacteria levels that exceeded the primary contact recreation standard geometric mean of 126 colony forming units of E. coli per 100 mL (CFUs/100mL) of water. Please see the section of this summary report regarding the upper sub-watershed above Flat Rock Dam for a more in depth discussion of the resulting TMDL study that was accepted by the EPA in 2007 and implementation plan that was put into place in 2011. In 2008, AU 1806_08 in the lower sub-watershed was also found to be in non-support of the primary contact recreation standard. An assessed E. coli geometric mean of 140 most probable number per 100 mL (MPN/100 mL) of water was identified downstream of Big Joshua Creek in Kendall County. This new impairment was included into impairment category 4a at this time, because the TMDL reach covered the entire segment.

In the most recently approved 2014 Texas Integrated Report of Surface Water Quality, Segment 1806 of the Guadalupe River is no longer listed as impaired for contact recreation. The data from that report revealed that the geometric means of E. coli data from all eight AUs of this segment are now fully supporting primary contact recreation standards.

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Guadalupe River below Flat Rock Dam
Drainage Area: 827 square miles
Streams and Rivers from Flat Rock Dam to Canyon Lake: Silver Creek, Turtle Creek, Steel Creek, Verde Creek (1806G), Bluff Creek, Cherry Creek, Bruins Creek, Wilson Creek, Cypress Creek (1806B), Holliday Creek, Flat Rock Creek, Block Creek, Joshua Creek (1806H), Violet Creek, Sister Creek, Jacobs Creek, Wasp Creek, Bear Creek, Sabinas Creek, Goss Creek, Spring Creek, Swede Creek, Panther Creek, Walter Creek, Honey Creek, Curry Creek, Spring Branch, Swine Creek, Elm Creek, Cypress Creek, Miller Creek
Aquifer: Trinity, Edwards Plateau
River Segments: 1806
Cities: Center Point, Comfort, Kendalia, Bergheim, Bulverde, Spring Branch
Counties: Kerr, Comal, Kendall, Blanco
EcoRegion: Edwards Plateau
Climate: Average annual rainfall 31.68 inches, Average annual temperature January 38°, July 95°
Vegetation Cover: Evergreen Forest 30.7%; Deciduous Forest 7.0%; Shrubland 48.8%; Grassland: 9.6%; Cultivate Crops 0.4%; Pasture Hay 0.4%
Land Uses: urban, unincorporated suburban sprawl, cattle, goat and sheep production, light and heavy industry, and recreational
Development: Low Intensity 0.5%; Medium Intensity 0.2%; High Intensity 0.1%; Open Space 2.3%
Water Body Uses: aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: Land Application 6, Domestic 1

GUADALUPE RIVER BELOW FLAT ROCK DAM

In the 2014 Integrated Report, the AU 1806_08 geometric means dropped to a concentration of 109 MPN/100 L and were removed from the 303(d) list. The TMDL process and associated watershed protection and stewardship activities were focused on the AUs upstream of Flat Rock Dam, near the City of Kerrville. The TMDL may have contributed to the recovery of this stream segment, none of the TMDL activities were directly targeted at the impairment on AU1806_08. The majority of the BMPs that were implemented in this segment were focused on the urban areas immediately surrounding the city of Kerrville and therefore unlikely to directly affect this rural AU. The diminished E. coli concentrations in this AU may have been more profoundly affected by the extended drought that began in 2008. The reduced non-point source runoff associated with these drought years corresponded with several years of lower E. coli concentrations, which proved to be beneficial to the assessment of this segment. Unfortunately, as rainfalls and stream flow have begun to rise out of drought levels, the bacteria geometric mean in this AU has also begun to increase.

Assessment Unit 1806_02 represents a ~32 mile reach between Big Joshua Creek in Kendall County upstream to the Flat Rock Dam in Kerr County. This AU falls in the transition area between the portion of the watershed that is managed by the UGRA and the watershed downstream of Kerr County, which is managed by the GBRA. There are two USGS gages located in this AU, two miles downstream of Flat Rock Dam and downstream of the City of Comfort. The UGRA performs routine sampling at four stations within the AU. The most upstream monitoring station located on this AU is 15113, which is located off Split Rock Road near SH 27, ~1.5 miles downstream of Flat Rock Dam and Kerrville Lake. A regression analysis of the data from June of 2003 to December of 2016 revealed several water quality trends at this station. This station has experienced an increase in specific conductance (TDS is calculated from this measurement), an increase in pH, and a decrease in Total Suspended Solids (Figures 1 & 2 & 3). Although no significant correlations with stream flow were noted for these parameters, stream flow was significantly decreasing over time and the changes in these parameters were most likely due to prolonged drought conditions. This station also has the lowest E. coli geometric mean in the AU, with a concentration of 22 MPN/100 mL. The excellent water quality (Table 1) at this station, including the diminishing suspended sediments and exceptional bacteria values may be due to the proximity of this station to active best management practices associated with the TMDL implementation plan that have been put into place immediately upstream. The only concern in this segment is for biological habitat. Two aquatic life monitoring events were performed in 2012 and 2014, which scored the biological habitat below the "excellent" designation for this water body. These scores were partially depressed due to low flow conditions during aquatic life monitoring, likely as a result of several years of drought. The next downstream station in this AU is 12608, which is located at Center Point Lake, ~5.1 miles downstream of Split Rock Road. The only statistically significant observation that could be made at this station was that stream flow was diminishing over time, just as in the other stations in this AU (Figure 4). The 62 MPN/100 mL geometric mean of E. coli at this station was slightly higher than any other station in this AU. This value was most likely slightly elevated due to depositions from water fowl on Center Point Lake. The next downstream

GUADALUPE RIVER BELOW FLAT ROCK DAM

monitoring location is station 12605, which is located just upstream of the Kerr County line at the Hermann Sons Road crossing of the Guadalupe River. This station is located ~8.4 miles downstream of Center Point Lake. An analysis of the data from this station over the same time period as the other stations in this AU has revealed several trends. A significant reduction in flow over time (Figure 5) and an increase in sulfate over time (Figure 6) have been documented at this station. The sulfate trend at this station was not statistically correlated with changes in stream flow, but the similar chloride anion did inversely correlate with stream flow. The geometric mean concentration of 44 MPN/100mL of E.coli at this station was even lower than in the Center point station upstream. The average annual streamflow recorded at USGS gage near this this monitoring station for the period of data examined was 194 cfs. The next station is the only routine monitoring station in this AU located outside of Kerr County. This station 12602 is located near the FM 1621 bridge in the town of Waring ~16.4 miles downstream of the Kerr County line. This monitoring station in downstream of the only permitted wastewater discharge in this AU. The Kendall County Water Control and Improvement district is permitted to discharge up to 0.35 million gallons per day of treated wastewater into the Guadalupe River below the city of Comfort. This wastewater is treated to a high level with permit limits of 5 mg/L of Biochemical Oxygen Demand (BOD), 5 mg/L of TSS, 2 mg/L of Ammonia Nitrogen and 1 mg/L of Total Phosphorus. Much of this wastewater is reused for irrigation of a local golf course, since a Texas Administrative Code Title 30 Chapter 210 authorization for beneficial use was granted by the TCEQ in 2002. A regression analysis revealed one trend over time. The chloride anion concentration was found to be significantly increasing over time (Figure 7). A significant correlation with flow was not observed for chloride. Water quality parameters at this station were within normal assessment criteria and met all designated uses (Table 4). Although this station is positioned immediately upstream of a previously assessed E.coli impairment on AU 1806_08, the geometric mean for E. coli always remained well below the primary contact recreation standard. The E. coli geometric mean at the Waring monitoring station is currently 49 MPN/100 mL for all data available.

Assessment Unit 1806_08 is located immediately upstream of the confluence with Honey Creek in Comal County and comprises a reach of approximately 39 miles upstream to the confluence with Big Joshua Creek in Kendall County. This AU flows northeast of the City of Boerne and is frequently used for contact recreation and fishing activities. The only monitoring station in this AU is station 17404, which is located on the Guadalupe River upstream of the FM 474 Bridge in Kendall County. Station 17404 has been monitored quarterly by the GBRA since 2001. The E. coli data

collected from this station was used to assess the 140 MPN/100 mL geometric mean and resulting 303(d) listing for non-support of the 126 MPN/100 mL primary contact recreation standards in 2008. This AU was included into category 4a with the other impaired AUs on this stream segment, due to the existence of the TMDL that was approved in 2007. The land use for this AU differed significantly from the other impaired AUs included in the segment 1806 TMDL and no BMPs were specifically targeted at this area as a part of the TMDL implementation plan. This AU is much more rural and has a greater potential to be influenced by agricultural runoff than the urbanized AUs upstream in the city of Kerrville. Only one permitted discharge occurs in this AU, but it is located on a small tributary, whose confluence is ~13 miles downstream of the monitoring station at FM 474. The effects of this discharge would be measured at station 13700 in the downstream AU. The data for station 17404 was reviewed from January of

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GUADALUPE RIVER BELOW FLAT ROCK DAM

2003 to December of 2016 to look for trends in water quality. Water quality trending was noted for several parameters at this station. The chloride and sulfate anions both appeared to be significantly increasing with time (Figures 8 & 9). Total Hardness appears to be significantly decreasing with time (Figure 10). All three of these trends are significantly correlated with stream flow. The chloride and sulfate levels both decrease as stream flow increases (Figures 11 & 12). Total Hardness increases as stream flow increases (Figure 13). These correlations seem to make sense as the anions are diluted by additional water in the system and more calcium carbonate is flushed out of the limestone of the surrounding Edwards Plateau during higher flow events. Although a significant correlation between stream flow and time was not noted for the data collected at this station, the effects of the multi-year drought, beginning in 2008, on stream flow have been identified at several other monitoring locations within segment 1806. At several stations outside of this AU, significant decreases in stream flow over time have been noted (See Figures 4 & 5). The quarterly monitoring frequency for this particular monitoring station may have made identification of long term flow patterns more difficult due to the lower resolution of data collected, but flows at this station most likely followed similar patterns to other stations in the segment. The mean chloride level for this assessment unit was 23.3 mg/L with a maximum value of 38.4 mg/L. The mean sulfate level was 24.8 mg/L with a maximum value of 36.9 mg/L. At no point did the concentrations of either chloride or sulfate anions exceed the 50 mg/L general use screening criteria (Table 5). Although this station was removed from the 303(d) list for primary contact recreation in the 2014 Texas Water Quality Inventory, an analysis of all of the E. coli data collected to date reveals a long term geometric mean of 140 MPN/100 mL. By reducing the data to the 7 year periods that bracket each 2 year assessment several predications can be made. The 2016 assessment will cover a seven year period beginning in December of 2007 and ending in November of 2014. No significant trending pattern was found for E. coli at this station (Figure 14). An analysis of this data during the 2016 assessment period of record revealed that this AU will have a slightly higher geometric mean of 117 MPN/100 mL. If the 2018 assessment advances the data forward two more years then several years of low concentration data will be removed from the assessment. A preliminary analysis of the E. coli data from this period of record indicates a geometric mean of 146 MPN/100 mL which is greater than the contact recreation standard of 126 MPN/100 mL for this AU. . This is primarily due to an abundance of higher E. coli concentrations in the years 2014 through 2016. These concentrations were most likely higher due to a greater amount of non-point source runoff resulting from higher rainfall totals following the extended drought period.

The most downstream AU 1806_01 covers a 25 mile reach in Comal County from a point 1.7 miles downstream of Rebecca Creek Road upstream to the confluence of Honey Creek near the Kendall County line. This AU is represented by a single monitoring station 13700. Station 13700 is located on the Guadalupe River upstream of the FM 311 Bridge near the USGS gaging station in Spring Branch and has been monitored monthly by the GBRA since 1996. This segment of the Guadalupe River immediately upstream of Canyon Lake is a part of the Guadalupe River Paddling Trail and is known for clear water with abundant contact recreation. There are no known permitted discharges into this assessment unit. The 2014 Texas Integrated Report of Water Quality indicates full support of all designated uses and the geometric mean of E. coli was well below the primary contact reaction standard of 126 MPN/100 mL with a concentration of 62 MPN/100 mL. A review of the data from December of 2002 to November of 2016 was conducted at this station. The average stream flow at the nearby USGS gage during this time period was 362 cfs. Several important data trends were identified at this station. Much like the other stations upstream, stream flow at this station appears to be significantly declining (Figure 15). This trend is most likely due to several years of drought, beginning in 2008, including an extended period during from August till October of 2011, when the stream flow at this station was measured at 0.00 cfs and the river was reduced to unconnected pools of water. A significant increase in chlorides and sulfates over time was also identified at this station (Figure 16 & 17). These rising chloride and sulfate levels can be at least partially explained by the overall reduction in streamflow, because chlorides are significantly increasing as stream flow decreases (Figure 18). Although the concentrations of these anions appear to increasing, at no point did any value exceed the stream general use screening criteria of 50 mg/L. All of the available data shows that this station appears to support the AU's designated uses (Table 6). The geometric mean of E. coli at this station remains at 64 MPN/100 mL with a maximum recorded value of 2400 MPN/100 mL. The average concentrations measured for all water quality parameters fall within the designated use criteria for this segment.

Table 1

Station 15113 – Guadalupe at Split Rock Road 02/2003 - 12/2016					
AU 1806_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (‘C)	21.8	30.0	9.8	65	32.20
pH (S.U.)	8.1	8.5	7.6	64	6.5 – 9.0
Chloride	26.4	45.1	17.6	55	50.00
Sulfate	17.1	23.8	10.8	55	50.00
Total Dissolved Solids (mg/L)	316	378	268	64	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.08	<0.04	55	0.69
Chlorophyll-a (µg/L)	<1.0	13.3	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.63	1.4	<0.04	52	1.95
TKN (mg/L)	0.41	0.71	<0.2	21	N/A
AU 1806_02 Recreational Use					
E c.oli (MPN/100 mL)	23 Geomean	120	<1	54	126 Geomean
AU 1806_02 Aquatic Life Use					
Dissolved Oxygen	9.5	14.2	5.5	64	≥4.0 Minimum & ≥6.0 Average

Table 2

Station 12615 – Guadalupe at Center Point 02/2003 - 12/2016					
AU 1806_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (‘C)	21.7	31.5	9.1	73	32.20
pH (S.U.)	8.0	8.4	6.6	73	6.5 – 9.0
Chloride	26.2	45.6	16.0	55	50.00
Sulfate	22.5	32.0	14.9	55	50.00
Total Dissolved Solids (mg/L)	322	385	267	73	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.15	<0.04	55	0.69
Chlorophyll-a (µg/L)	<1.0	6.6	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.57	1.48	<0.05	52	1.95
TKN (mg/L)	0.35	0.59	<0.2	20	N/A
AU 1806_02 Recreational Use					
E c.oli (MPN/100 mL)	62 Geomean	3500	5	144	126 Geomean
AU 1806_02 Aquatic Life Use					
Dissolved Oxygen	8.5	8.4	6.6	73	≥4.0 Minimum & ≥6.0 Average

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Table 3

Station 12605 – Guadalupe at Hermann Sons Road 02/2003 - 12/2016					
AU 1806_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature ('C)	20.9	29.4	9.4	56	32.20
pH (S.U.)	8.0	8.4	7.4	56	6.5 – 9.0
Chloride	25.0	52.4	13.0	56	50.00
Sulfate	24.8	37.6	9.2	56	50.00
Total Dissolved Solids (mg/L)	330	379	275	56	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.07	<0.04	56	0.69
Chlorophyll-a (µg/L)	<1.0	6.6	<1.0	55	14.10
Nitrate Nitrogen (mg/L)	0.59	1.49	<0.05	53	1.95
TKN (mg/L)	0.31	0.59	<0.2	22	N/A
AU 1806_02 Recreational Use					
E c.oli (MPN/100 mL)	44 Geomean	520	5	55	126 Geomean
AU 1806_02 Aquatic Life Use					
Dissolved Oxygen	8.8	13.9	6.0	56	≥4.0 Minimum & ≥6.0 Average

Table 4

Station 12602 – Guadalupe at FM 1621 in Waring Data from 06/2003 - 12/2016					
AU 1806_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature ('C)	21.0	31.3	9.0	58	32.20
pH (S.U.)	8.1	8.6	6.7	58	6.5 – 9.0
Chloride	25.4	40.4	13.0	57	50.00
Sulfate	26.5	37.0	14.0	58	50.00
Total Dissolved Solids (mg/L)	344	401	242	58	400.00
NH3-N (mg/L)	<0.10	<0.10	<0.10	41	0.33
Total Phosphorus (mg/L)	<0.02	0.09	<0.02	56	0.69
Chlorophyll-a (µg/L)	<1.0	3.37	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.61	1.61	<0.04	53	1.95
TKN (mg/L)	0.23	0.8	<0.2	54	N/A
AU 1806_02 Recreational Use					
E c.oli (MPN/100 mL)	49 Geomean	2000	<2	57	126 Geomean
AU 1806_02 Aquatic Life Use					
Dissolved Oxygen	9.3	12.6	6.7	58	≥4.0 Minimum & ≥6.0 Average

Table 5

Station 17404 – Guadalupe at FM 474 NE of Boerne Data from 12/2002 - 11/2016					
AU 1806_08 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature ('C)	19.6	29.0	8.4	56	32.20
pH (S.U.)	7.9	8.2	7.4	56	6.5 – 9.0
Chloride	23.2	38.4	7.5	55	50.00
Sulfate	24.9	36.9	10.8	55	50.00
Total Dissolved Solids (mg/L)	348	408	180	56	400.00
NH3-N (mg/L)	<0.10	0.35	<0.10	55	0.33
Total Phosphorus (mg/L)	<0.02	0.21	<0.02	55	0.69
Chlorophyll-a (µg/L)	<1.0	2.52	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.36	1.21	<0.02	55	1.95
TKN (mg/L)	<0.2	0.52	<0.2	35	N/A
AU 1806_08 Recreational Use					
E c.oli (MPN/100 mL)	140 Geomean	>4800	16	55	126 Geomean
AU 1806_08 Aquatic Life Use					
Dissolved Oxygen	9.1	14.8	5.7	56	≥4.0 Minimum & ≥6.0 Average

Table 6

Station 13700 – Guadalupe at FM 311 in Spring Branch Data from 12/2002 - 11/2016					
AU 1806_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature ('C)	20.8	33.0	5.3	161	32.20
pH (S.U.)	8.0	8.5	7.5	161	6.5 – 9.0
Chloride	21.9	35.6	9.1	161	50.00
Sulfate	24.1	33.9	12.5	161	50.00
Total Dissolved Solids (mg/L)	339	644	275	161	400.00
NH3-N (mg/L)	<0.10	0.95	<0.10	80	0.33
Total Phosphorus (mg/L)	<0.02	0.28	<0.02	161	0.69
Chlorophyll-a (µg/L)	<1.0	6.2	<1.0	159	14.10
Nitrate Nitrogen (mg/L)	0.36	1.78	<0.02	159	1.95
TKN (mg/L)	<0.2	0.95	<0.2	63	N/A
AU 1806_01 Recreational Use					
E c.oli (MPN/100 mL)	64 Geomean	>2400	<2	161	126 Geomean
AU 1806_01 Aquatic Life Use					
Dissolved Oxygen	9.5	14.9	5.2	160	≥4.0 Minimum & ≥6.0 Average

GUADALUPE RIVER BELOW FLAT ROCK DAM

Figure 1

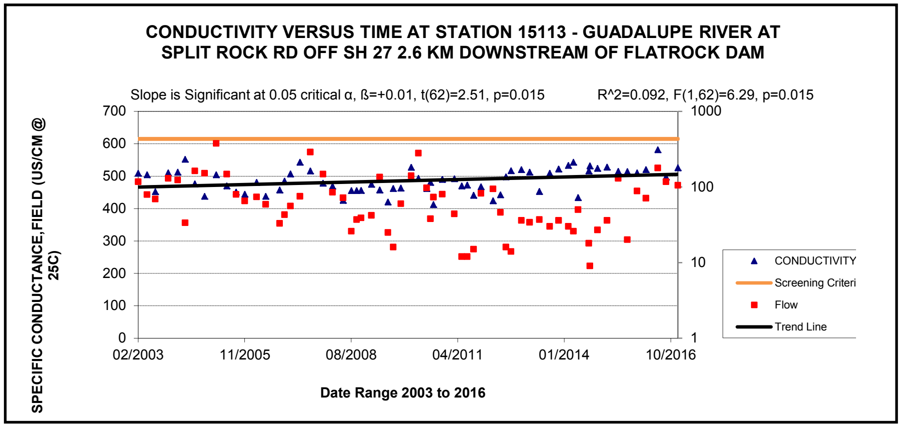


Figure 2

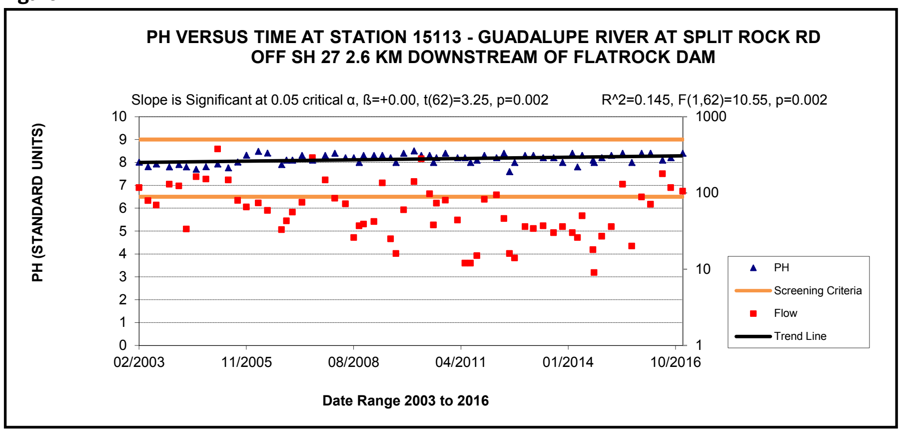
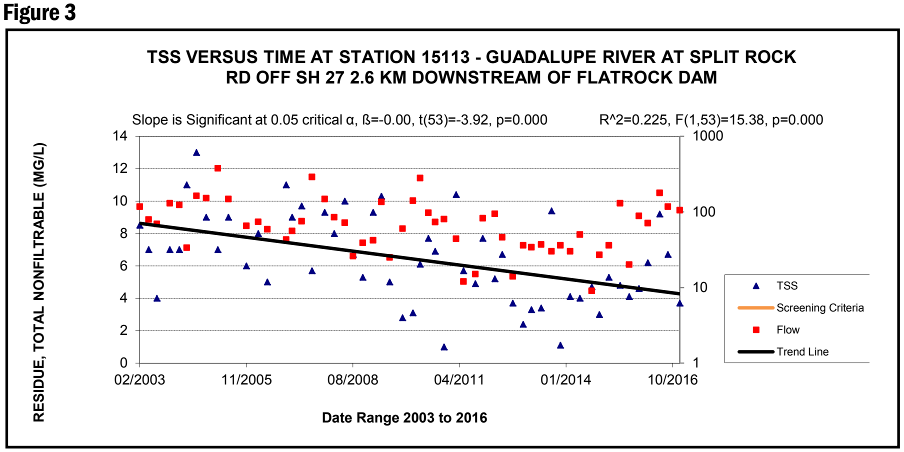


Figure 3



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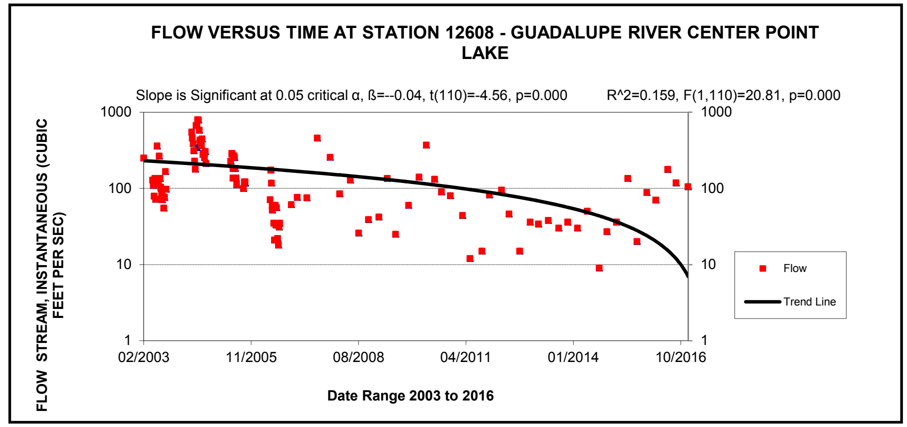

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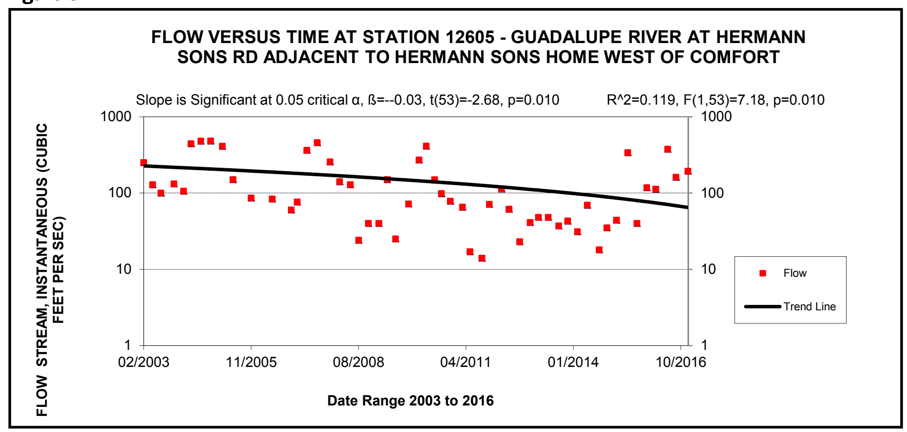

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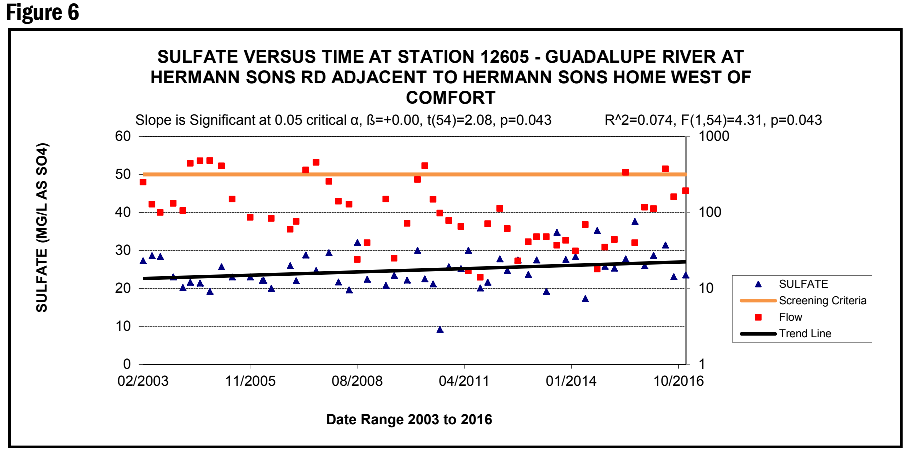
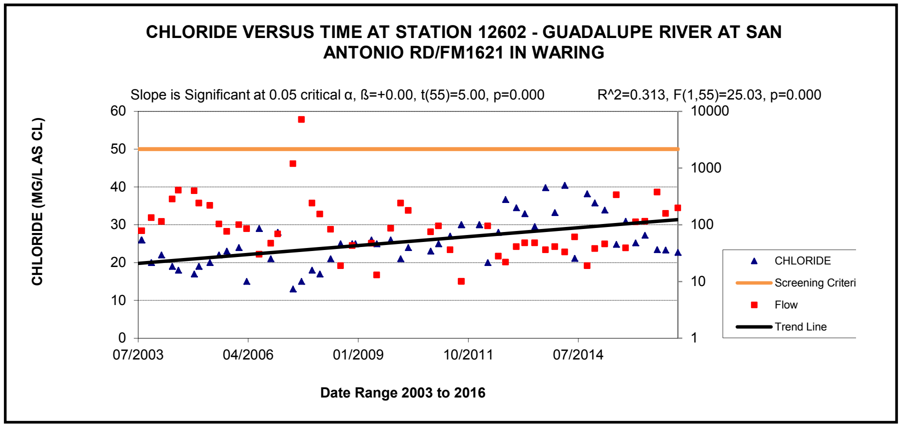


GUADALUPE RIVER BELOW FLAT ROCK DAM

Figure 7



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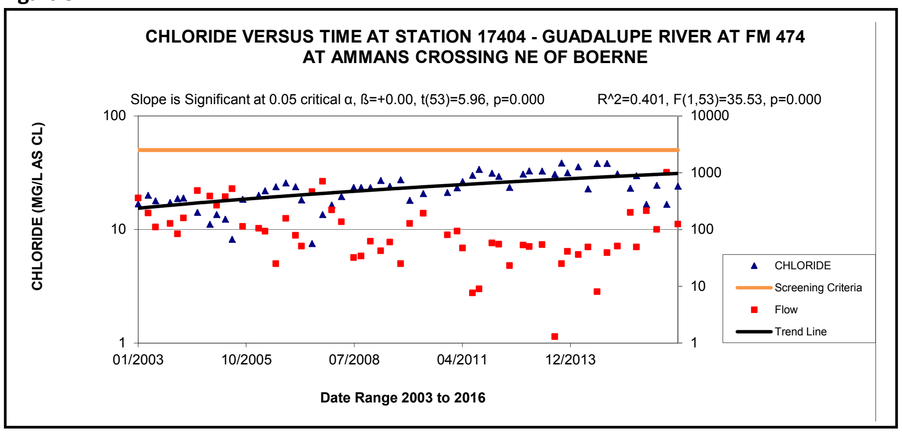

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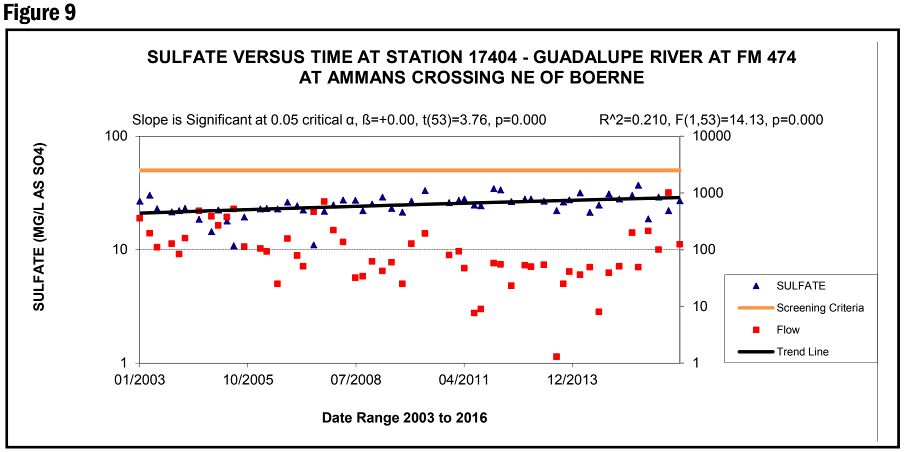

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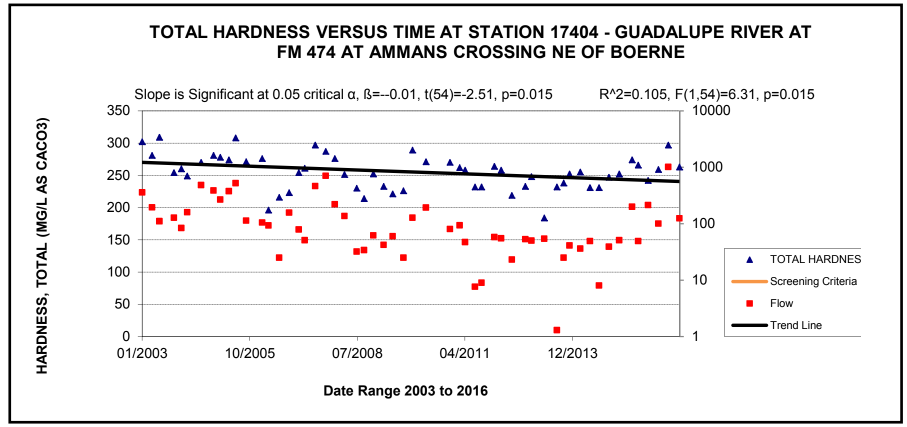

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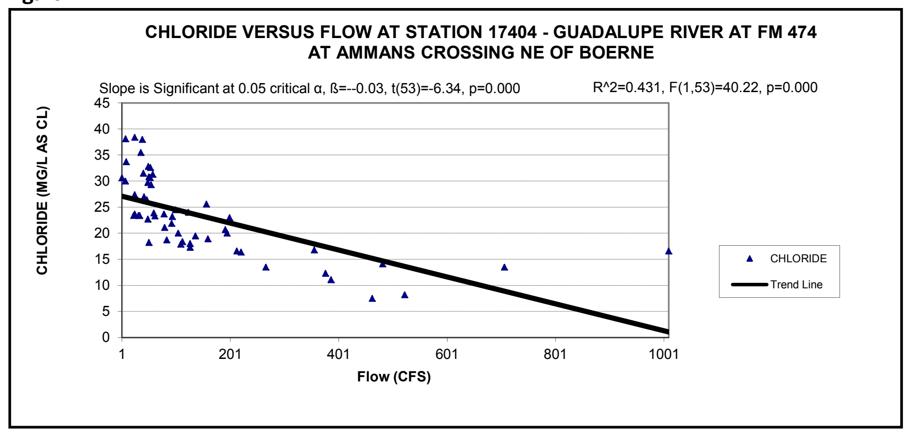
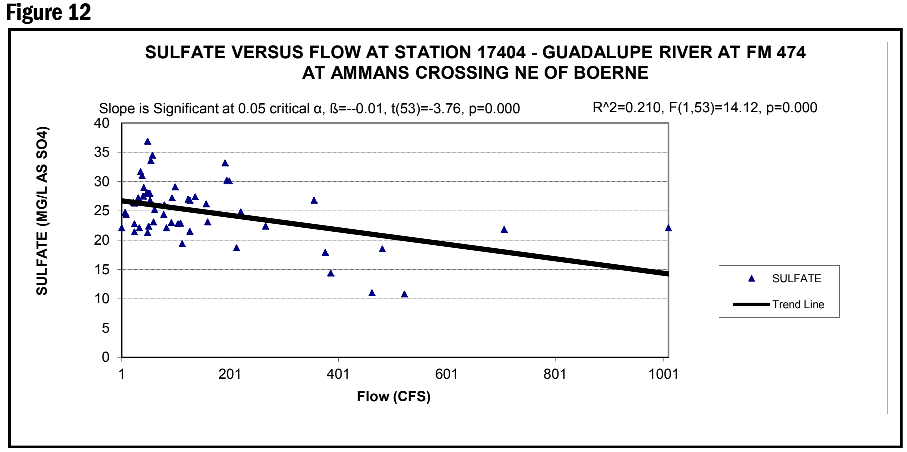


Figure 12



GUADALUPE RIVER BELOW FLAT ROCK DAM

Figure 13

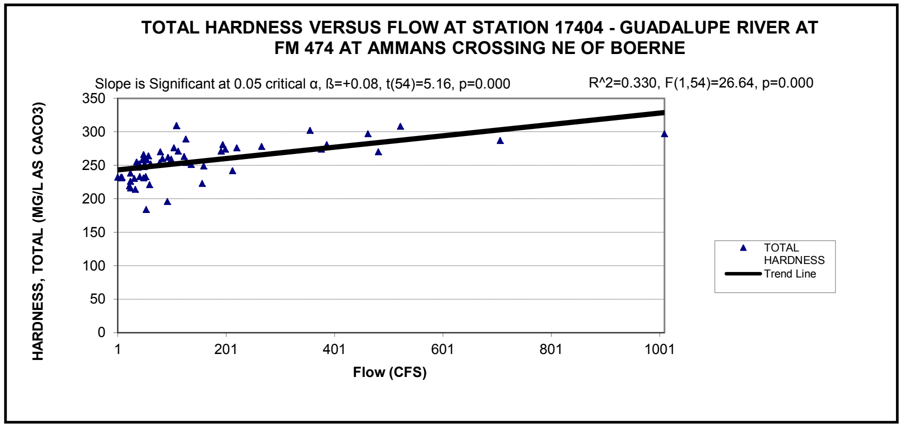
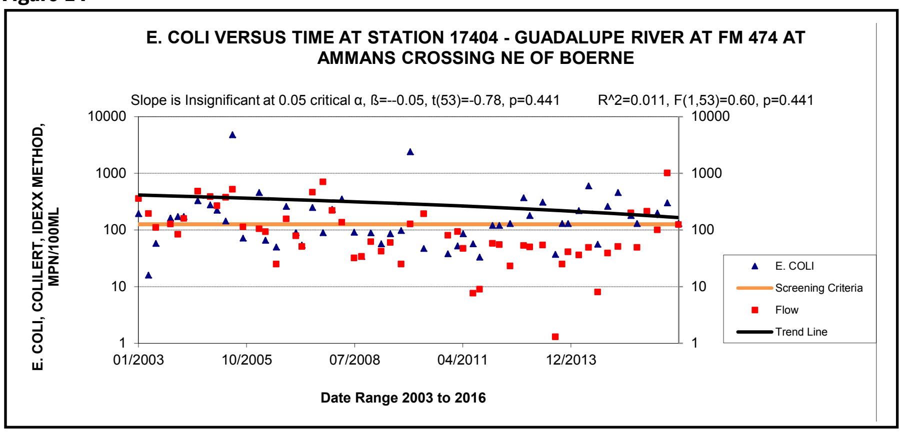


Figure 14



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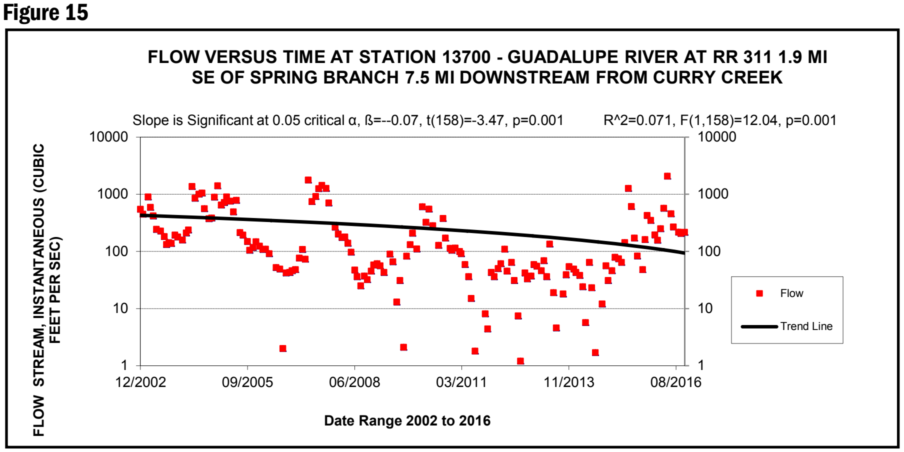


Figure 16

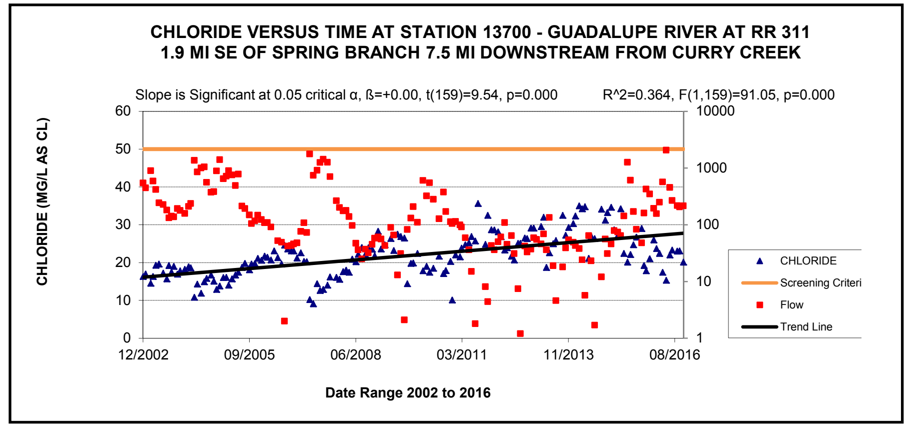


Figure 17

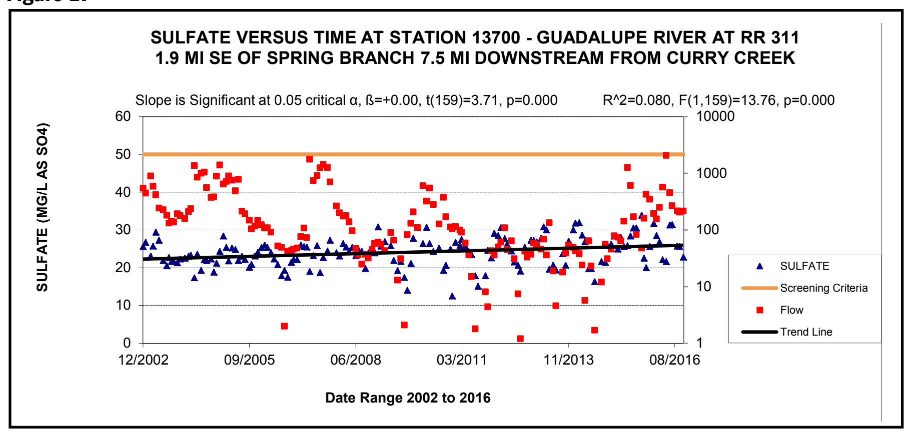
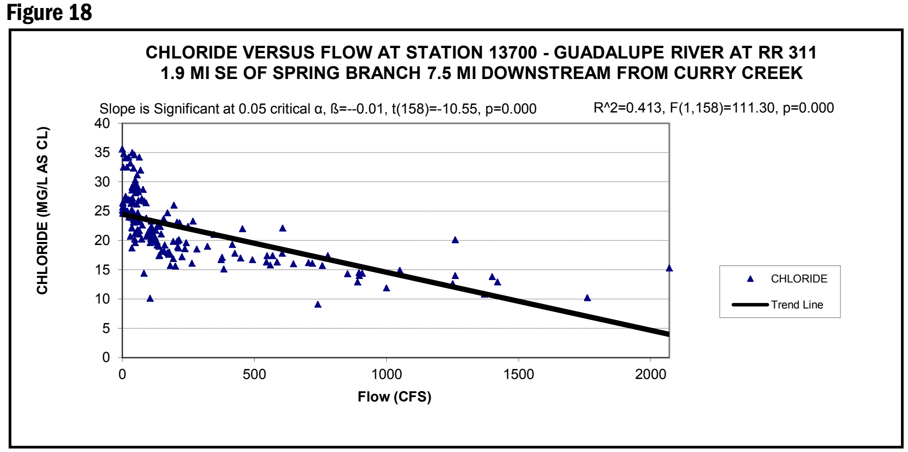
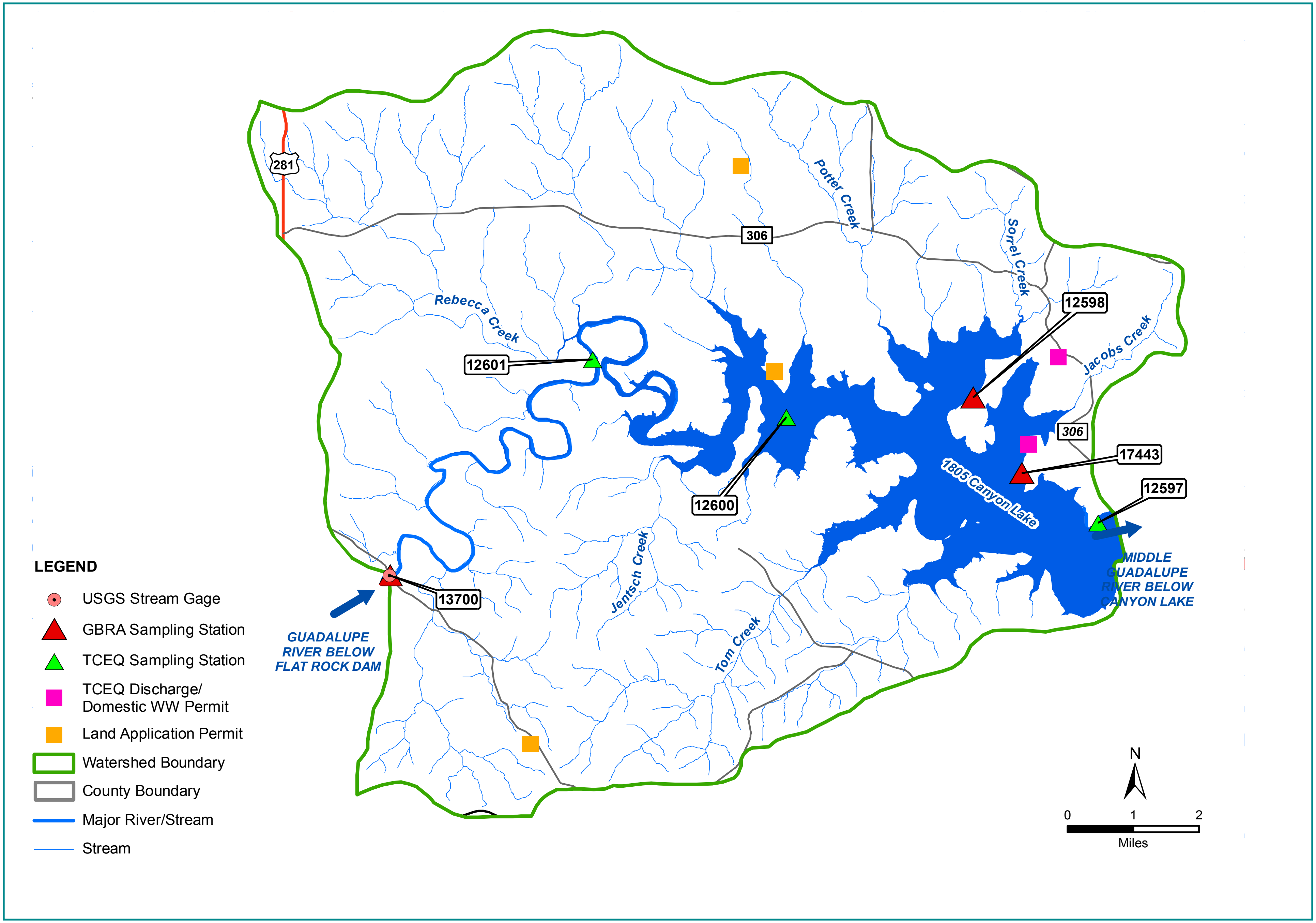


Figure 18



CANYON LAKE



281
306
Potter Creek
Sorrel Creek
Rebecca Creek
12601
12598
Jacobs Creek
306
12600
17443
1805 Canyon Lake
12597
Jentsch Creek
MIDDLE GUADALUPE RIVER BELOW CANYON LAKE
13700
GUADALUPE RIVER BELOW FLAT ROCK DAM
Tom Creek
LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Sampling Station
TCEQ Discharge/ Domestic WW Permit
Land Application Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream
N
0
1
2
Miles

CANYON LAKE

Segment 1805 represents the portion of the Guadalupe impounded in Canyon Lake. This stream segment encompasses the area upstream of Canyon Dam to a point 1.7 miles downstream of Rebecca Creek Road in Comal County. A total of 1432 square miles drain into Canyon Lake. The lake is used for conservation of water, flood control, and recreation. Construction of the dam began in 1958 and ended in 1964, when the first water impoundment began. The normal maximum operating level of the reservoir is 909 feet above mean sea level (msl) with a conservation storage capacity of 382,000 acre-feet, a shoreline of 80 miles and a surface area of 8,240 acres. The stream segment has been divided by the TCEQ into four assessment units: 1805_01 is in the cove around Jacob's Creek Park, 1805_02 is near the center of the lake from the north end of Crane's Mill Park peninsula to the south of Canyon Park, 1805_03 is the upstream portion of the segment, and 1805_04 is between Canyon Dam and Canyon Park.

The total reservoir storage of Canyon Lake is divided into three sections. The dead pool is the portion of water in the reservoir below 775 msl that cannot be drained through the dam by gravity (71 acre-ft). The conservation pool is the dead pool capacity subtracted from the design conservation capacity of the lake (378,781 acre-ft), between 775 msl and 909 msl. The flood pool is the storage capacity at the point when the spillway is crested at 943 msl, to the top of the conservation pool at 909 msl (373,738 acre-ft). Canyon Lake is operated by two governmental entities. The United States Army Corp of Engineers (USACE) owns the 6,830 foot long earthen dam, and controls the release of water in the flood pool above 909 msl. The Guadalupe-Blanco River Authority (GBRA) has the rights to the use and release of water in the conservation pool, when the lake level is between 775 msl to 909 msl. The water in the conservation pool is used for water supply to municipalities, industries, agricultural irrigation, and hydroelectric power generation.

Canyon is a holomytic lake, which means that it experiences uniform water temperatures throughout the entire depth of the lake during the winter months. The lake is also monomictic, which means that it usually only experiences a single thermal stratification event during the early summer. The epilimion water layer is the uppermost layer of a thermally stratified lake near the surface, which becomes significantly warmer and less dense than the hypolimnion water layer at the bottom due to solar radiation. This causes the lake to separate around a transitional thermocline water layer, where the temperature rapidly decreases below the surface layer. Precipitation and freshwater discharges into the lake are particularly influential on the amount of mixing that occurs in the lake. Thermal stratification of the lake is usually less pronounced during periods of high rainfall because the influx of water and subsequent releases from the bottom of the dam cause mixing of the eplimnion and the hypolimion. The hypolimion layer at the bottom of the lake also tends to

CONTINUED ON PAGE 40

Canyon Lake
Drainage Area: 1432 square miles
Reservoir Surface Area: 8,308 acres
Reservoir Conservation Capacity: 378,781 acre-ft
Tributaries of Canyon Lake: Rebecca Creek, Shultz Creek, Jentsch Creek, Tom Creek, Potter Creek, Sorrel Creek, Jacobs Creek
Aquifer: Trinity, Edwards Plateau
River Segments: 1805
Cities and Communities: Sattler, Startzville, Cranes Mill, Hancock
Counties: Comal
EcoRegion: Edwards Plateau
Climate: Average annual rainfall 37.43 inches, Average annual temperature 19.36°C

Vegetation Cover: Evergreen Forest 64.19%, Deciduous Forest 8.49%, Shrubland 10.98%, Grassland 8.35%, Woody Wetlands .08%, Cultivated Crops 0.08% , Pasture Hay 0.75%
Land Uses: unincorporated suburban sprawl, cattle, goat and sheep production, light industry, and recreational.
Development: Low Intensity 1.3% ; Medium Intensity 0.2%; High Intensity 0.06%; Open Space 3.94%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: Land Application 1, Domestic 2

experience seasonal anoxic conditions as inflows of organic matter are deposited near the dam and broken down by bacteria. Biological organisms deplete the dissolved oxygen from the bottom layer of the lake and then use the oxygen from any available nitrate or sulfate molecules in the water. This process can sometimes cause a "rotton egg" smell to occur in the discharges downstream of the dam as the sulfate molecules are reduced and hydrogen sulfide molecules are formed.

Two permitted wastewater discharges occur in Canyon Lake. Both wastewater treatment facilities (WWTFs) discharge directly into a cove on the north side of the lake around Jacob's Creek Park, in assessment unit 1805_01. The GBRA operates the Canyon Park Estates Wastewater Treatment Facility (CPE WWTF), which is permitted to discharge up to 0.26 million gallons per day (MGD). The CPE WWTF discharges a very high quality effluent, with an average daily biochemical oxygen demand (BOD) of 5 milligrams per liter (mg/L), total suspended solids (TSS) of 5 mg/L, ammonia nitrogen (NH3-N) of 2 mg/L and total phosphorus (TP) of 1 mg/L and 126 MPN/100 mL of E. coli. The second WWTF on the lake is owned and operated by the U.S. Department of the Air Force and is permitted to discharge 0.0125 MGD of treated wastewater. The effluent for this WWTF has an average daily BOD of 10 mg/L, a TSS of 15 mg/L and an E. coli concentration of 126 MPN/100 mL. The remaining developments around the lake are served by septic tanks permitted by Comal County. The USACOE has an ordinance that prohibits placement of septic systems, plumbing and electricity below 948 msl and requires Corp approval of other construction around the lake.

In 2005, the Texas Parks and Wildlife Department collected and analyzed a composite sample from 3 largemouth bass for mercury. The initial results from this sample indicated that the 0.7 milligrams per kilogram (mg/kg) concentration of mercury in this sample exceeded the human health screening criteria of 0.525 mg/kg. This finding prompted the Department of State Health Services (DSHS) to perform additional fish tissue monitoring for mercury. In November of 2005, the DSHS collected 30 fish samples from Canyon Lake spread across three different locations near the dam (AU 1805_04), in the middle portion of the lake (AU 1805_02) and in the upper portion of the lake (AU 1805_03).

CANYON LAKE

Largemouth bass, striped bass, blue catfish, flathead catfish, longnose gar and white bass were collected during the study. All fish samples collected during the study contained detectable levels of total mercury. The mean concentrations for longnose gar (0.772 mg/kg) and striped bass (1.149 mg/kg) were determined to exceed the chronic ingestion minimal risk level if more than two 8 ounce portions of these fish were consumed per month by adults or two 4 ounce portions were consumed by children under the age of 12. As a result of this study, all four assessment units of Canyon Lake were recognized as impaired for fish consumption due to mercury in edible fish tissue. Fish can absorb methylmercury from water or feeding more quickly than it passes through their bodies. This process can lead to bioaccumulation of toxic methylmercury in the tissues of the fish and often occurs more frequently in larger predatory fish. To date, no direct sources of mercury into Canyon Lake have been discovered. Atmospheric deposition from airborne emissions produced by coal power plants and industrial uses remains the most likely source.

The Texas Parks and Wildlife Department has been monitoring for invasive Zebra Mussels (Dreissena Polymorpha) since they were first discovered in Texas in April 2009. Zebra Mussels were accidently introduced into the U.S. Great Lakes from the Balkans in 1986. The high proclivity and unique ability of this species to hitch rides on recreational watercraft have allowed them to quickly make their way down the Mississippi River drainage to the waterways of the southern U.S. Adult mussels are less than 1.5 inches long and have a long smooth shell with a zebra striped pattern on the surface. These mussels form large clusters which can cause significant economic and environmental damage by attaching to all sorts of natural and artificial surfaces such as submerged pipes, recreational boats, and even the shells of native freshwater mussels. On June 8th of 2017, employees of the Crane's Mill Marina discovered a boat parked in a slip with Zebra Mussels attached to the hull. A TPWD fisheries biologist and Game Warden investigated the boat and verified the presence of Zebra Mussels. The TPWD conducted additional plankton monitoring at multiple sites throughout the lake and found microscopic zebra mussel larvae at multiple stations. The identification of both adults and larval mussels confirmed that Canyon Lake has an established reproducing population. The TPWD has designated Canyon Lake as fully infested, along with 12 other lakes in Texas. Canyon is the southernmost lake in the United States with a breeding population of Zebra Mussels, but many other water bodies in the area are now in significant danger of infestation because the microscopic larvae and adults can be easily transported on boats and trailers without being seen. Proper decontamination protocols for boats and trailers that are transported between freshwater reservoirs are being strictly enforced in order to prevent the spread of these organisms. The TPWD requires all boats and onboard receptacles to be completely drained of water and dried before entering or leaving a body of freshwater. The TPWD and the GBRA have partnered to actively monitor the reservoirs downstream of Canyon Lake with deployed recruitment traps, as well as microscopic and DNA analysis of plankton samples collected in the spring and fall of each year, in order to document any further spread of these organisms.

The TCEQ has divided Canyon Lake into four assessment units. All four assessment units have at least one monitoring station where data is collected at a routine frequency by either the TCEQ or the GBRA. The main body of the lake is divided into three assessment units that are all monitored for conventional and bacteria parameters at the surface and for field measurements such as temperature, pH, dissolved oxygen and specific conductance throughout the water column. A fourth assessment unit is monitored at the surface of the coves on the north sides of the lake. All five active monitoring stations were analyzed for trends in water quality and compared against TCEQ water quality screening criteria. The EPA has mandated that states incorporate numerical nutrient criteria into their water quality standards in order to evaluate nutrient impacts from discharge permits. The TCEQ had previously developed preliminary numerical screening levels for total phosphorus, nitrate nitrogen, and chlorophyll a concentrations. In 2010, the TCEQ developed numerical nutrient indicator criteria for many of the reservoirs in Texas. The numerical criterion that the TCEQ has developed for evaluation of Canyon Lake is a chlorophyll-a concentration of 27.60 µg/L.

The body of Canyon Lake between the dam and Canyon Park peninsula is defined by assessment unit 1805_04. This AU is represented by a single monitoring station 12597, which is monitored by the TCEQ on a quarterly basis. This station is located by the dam close to the north side of the lake. The deepest monitoring depth recorded at this station was 42.6

CONTINUED ON PAGE 42

meters, but the historical average depth is 29.3 meters. All conventional and bacteria parameters are collected at a surface depth of 0.3 meters, but depth profiles for temperature, dissolved oxygen, pH and specific conductance are regularly performed by the TCEQ at this station. A depth profile at this station consists of a measurement at 0.3 meters from the surface, another measurement at 1.0 meters from the surface, additional measurements at 3.0 meters increments, and a final measurement at 0.3 meters above the bottom. The average temperature at the bottom of the lake is 15.3°C, compared to 19.1°C at the surface. The average dissolved oxygen readings ranged from 8.7 mg/L at the surface to 4.4 mg/L at the bottom. Dissolved oxygen values of 0 mg/L have been recorded near the bottom of the lake during periods of thermal stratification. Mean total dissolved solid (TDS) concentrations ranged from 255 mg/L at the surface to 272 mg/L at the bottom. The average pH ranged from 8.2 standard units at the surface 7.7 at the bottom of the lake. The average concentrations of all water quality parameters collected at 0.3 meters from the surface were within the TCEQ screening criteria. The only water quality parameter that showed

a significant change over time at this station was chloride, which is significantly increasing (Figure 1). The increasing level of chlorides is mostly likely due to the influence of several years of drought that began 2008. During this time period, fresh water inflows were reduced and salts became more concentrated in the water column. The average chloride concentration of 16.8 mg/L remains well below the state screening criteria of 50.0 mg/L.

The middle of the lake is defined by assessment unit 1805_02. This AU stretches through the middle of the lake body from the south end of the Canyon Park peninsula to the north end of the Crane's Mill Park peninsula. This AU is represented by monitoring station 12600, which is located in the middle of the lake south of Potter's Creek Park. This maximum depth recorded at this station was 70.0 meters with an average sampling depth of 19.2 meters. The average temperature at this station ranged from 22.6°C at the surface to 18.2°C at the bottom. The average total dissolved solids ranged from 259 mg/L at the surface to 270 mg/L at the bottom. The average dissolved oxygen ranged from 8.6 mg/L at the surface to 5.1 mg/L at the bottom. Dissolved oxygen concentrations of 0 mg/L were measured at the bottom of the lake. The average pH ranged from 8.2 at the surface to 7.8 at the bottom. The only significant trend in this portion of the lake was an increase in chloride concentrations over time (Figure 2). Water quality conditions at this station were very similar to station 12597 near the dam.

The most upstream portion of the lake body is defined by assessment unit 1805_03. This portion of the lake shares many similar properties to the more riverine portions of the Guadalupe River, including shallower depths, narrower banks, and a more sinuous flow path. The only monitoring station in this AU is station 12601, which is located near the headwaters of Canyon Lake upstream of Crane's Mill Park. This station is monitored quarterly by the TCEQ. The maximum depth recorded at this station was 13.8 meters with an average depth at the sampling point of 7.5 meters. Depth profiles for this station were collected in one meter increments in order to better identify thermal differentials. The average temperature at this station ranged from 22.8°C at the surface to 21.4°C at the bottom. The average total dissolved solids ranged from 269 mg/L at the surface to 282 mg/L at the bottom. The average dissolved oxygen ranged from 8.4 mg/L at the surface to 6.5 mg/L at the bottom. Dissolved oxygen concentrations of 0.2 mg/L were measured at the bottom of the lake. The average pH ranged from 8.2 at the surface to 8.0 at the bottom. Much like the rest of Canyon Lake, the only significant water quality trend that could be identified at this station was an increase in chloride levels over time (Figure 3).

The final assessment unit of Canyon Lake is 1805_01, which covers the two coves on the north side of the lake between Jacob's Creek park peninsula and Canyon Park peninsula and between Canyon Park peninsula and the southeast end of Potter's Creek peninsula. This AU is uniquely representative of recreational use because it is the location of a major public boat launch for the north side of the lake near Farm to Market Road 306. This cove also contains at least three major private boat launches in Canyon Park, Jacob's Creek Park and Joint Base San Antonio. Monitoring for this AU is conducted by the GBRA at two shoreline stations located near recreational boat launches. Both of these stations are usually less than 1.5 meters deep and measurements are collected at 0.3 meters from the surface. Station 12598 is located at the private boat launch for Canyon Park Marina on the west side of the Canyon Park peninsula. This station is monitored monthly and has a mean temperature of 22.7°C, TDS of 259 mg/L, dissolved oxygen concentration of 9.3 mg/L and a pH of 8.2. Canyon Park Marina is one of the locations being monitored for Zebra Mussels and in November of 2017 adult mussels colonized a recruitment sampler that had previously been deployed by the GBRA. The other station on this AU is 17443 located at the Jacob's Creek Park private boat ramp on the west side of the Jacob's Creek peninsula. This location is also located in the same cove as the only two permitted wastewater discharges to the lake. This station is monitored on a quarterly basis by the GBRA and mean field measurements at this station are very similar to station 12598 with an average temperature of 22.1 °C, TDS of 259 mg/L, dissolved oxygen of 9.5 mg/L and a pH of 8.2. Although this AU is listed as impaired in the 2014 TCEQ Texas Integrated Report for mercury in edible fish tissue, none of the fish samples that led to this listing were collected in either of the coves that comprise this AU. The AU does have a concern for ammonia nitrogen because 28 of the 66 data points that were assessed in the 2014 integrated report exceeded the TCEQ nutrient screening criteria of 0.11 mg/L (Figure 4). This nutrient screening criteria has been set marginally higher than the current laboratory method reporting limit of 0.10 mg/L. None of the ammonia data collected at either of the monitoring stations in this AU during the years of 2016 or 2017 exceeded the method reporting limit. The previously measured exceedances of the screening criteria occurred during periods of excessive drought, which may have led to concentration of nutrients as lake levels declined. The only water quality trend that was identified at either of the monitoring stations in AU 1805_01 was an increase in salt anion concentrations. Both chloride and sulfate were found to be increasing over time at station 12598 (Figures 5 & 6), while only chloride was found to be increasing over time at station 17443 (Figure 7). The increasing concentrations of these parameters are also likely due to the effects from several years of prolonged drought.

CANYON LAKE

Table 1

Station 12597 – Canyon Lake at Canyon Dam 03/2003 - 08/2017					
AU 1805_04 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.0	30.0	10.5	52	32.20
Temperature (°C) at All Depths	19.1	30.0	10.0	789	32.20
pH (S.U.) at 0.3 meters	8.2	9.0	7.2	51	6.5 – 9.0
pH (S.U.) at All Depths	8.0	9.0	7.0	788	6.5 – 9.0
Chloride	16.8	22.0	11.0	54	50.00
Sulfate	21.7	27.0	16.0	54	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	255	309	225	52	400.00
Total Dissolved Solids (mg/L) at All Depths	262	346	225	788	400.00
NH3-N (mg/L)	<0.05	0.18	<0.02	52	0.11
Total Phosphorus (mg/L)	<0.04	<0.06	<0.02	52	0.20
Chlorophyll-a (µg/L)	<10.0	<10.0	<3.0	33	26.70
Nitrate Nitrogen (mg/L)	0.09	0.4	<0.02	52	0.37
TKN (mg/L)	0.26	0.37	<0.2	52	N/A
AU 1805_04 Recreational Use					
E c.oli (MPN/100 mL)	2 Geomean	10	<1	51	126 Geomean
AU 1805_04 Aquatic Life Use					

Table 2

Station 12600 – Canyon Lake Mid Lake South of Potters Creek Park 03/2003 - 08/2017					
AU 1805_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.6	31.2	10.0	53	32.20
Temperature (°C) at All Depths	20.6	31.2	9.0	559	32.20
pH (S.U.) at 0.3 meters	8.2	8.6	7.1	53	6.5 – 9.0
pH (S.U.) at All Depths	8.1	8.6	6.8	559	6.5 – 9.0
Chloride	16.8	22.0	11.0	53	50.00
Sulfate	22.0	28.3	16.0	53	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	259	332	220	52	400.00
Total Dissolved Solids (mg/L) at All Depths	268	404	220	535	400.00
NH3-N (mg/L)	<0.05	0.24	<0.02	51	0.11
Total Phosphorus (mg/L)	<0.06	0.84	<0.02	52	0.20
Chlorophyll-a (µg/L)	<10.0	13.6	<3.0	32	26.70
Nitrate Nitrogen (mg/L)	0.12	0.63	<0.02	51	0.37
TKN (mg/L)	0.26	0.46	<0.1	49	N/A
AU 1805_02 Recreational Use					
E c.oli (MPN/100 mL)	2 Geomean	77	<1	46	126 Geomean
AU 1805_02 Aquatic Life Use					

Table 3

Station 12601 – Canyon Lake Headwaters Upstream of Cranes Mill Park 03/2003 - 08/2017					
AU 1805_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.8	31.9	9.2	50	32.20
Temperature (°C) at All Depths	22.5	31.9	9.0	386	32.20
pH (S.U.) at 0.3 meters	8.2	9.0	7.6	50	6.5 – 9.0
pH (S.U.) at All Depths	8.1	9.0	7.0	386	6.5 – 9.0
Chloride	17.1	22.0	11.0	53	50.00
Sulfate	22.0	27.0	14.0	53	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	269	348	177	50	400.00
Total Dissolved Solids (mg/L) at All Depths	274	376	177	386	400.00
NH3-N (mg/L)	<0.05	0.18	<0.02	52	0.11
Total Phosphorus (mg/L)	<0.06	0.70	<0.02	49	0.20
Chlorophyll-a (µg/L)	<10.0	<10.0	<3.0	32	26.70
Nitrate Nitrogen (mg/L)	0.16	1.01	<0.02	52	0.37
TKN (mg/L)	0.29	0.74	<0.1	51	N/A
AU 1805_03 Recreational Use					
E c.oli (MPN/100 mL)	3 Geomean	54	<1	48	126 Geomean
AU 1805_03 Aquatic Life Use					

Table 4

Station 12598 – Canyon Lake at Canyon Park Marina Boat Ramp 12/2002 - 11/2016					
AU 1805_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.7	36.3	10.9	177	32.20
Temperature (°C) at All Depths	23.0	36.3	10.9	195	32.20
pH (S.U.) at 0.3 meters	8.2	8.5	7.5	177	6.5 – 9.0
pH (S.U.) at All Depths	8.2	8.5	7.5	195	6.5 – 9.0
Chloride	16.8	24.6	6.6	162	50.00
Sulfate	22.0	29.5	13.8	162	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	259	342	149	177	400.00
Total Dissolved Solids (mg/L) at All Depths	260	342	149	195	400.00
NH3-N (mg/L)	<0.10	0.33	<0.02	81	0.11
Total Phosphorus (mg/L)	<0.05	0.16	<0.02	177	0.20
Chlorophyll-a (µg/L)	1.8	7.5	<1.0	177	26.70
Nitrate Nitrogen (mg/L)	0.12	1.22	<0.02	177	0.37
TKN (mg/L)	0.39	2.7	<0.2	81	N/A
AU 1805_01 Recreational Use					
E c.oli (MPN/100 mL)	5 Geomean	2000	<1	159	126 Geomean
AU 1805_01 Aquatic Life Use					

CANYON LAKE

Table 5

Station 17443 – Canyon Lake at Jacob's Creek Park Boat Ramp 01/2003 - 11/2016					
AU 1805_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.1	31.5	11.4	54	32.20
pH (S.U.) at 0.3 meters	8.2	8.6	7.8	54	6.5 – 9.0
Chloride	16.8	32.0	7.2	54	50.00
Sulfate	22.7	78.3	11.4	54	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	260	300	213	54	400.00
NH3-N (mg/L)	<0.10	0.38	<0.02	54	0.11
Total Phosphorus (mg/L)	<0.05	0.08	<0.02	54	0.20
Chlorophyll-a (µg/L)	1.6	10.8	<1.0	54	26.70
Nitrate Nitrogen (mg/L)	0.12	0.39	<0.02	53	0.37
TKN (mg/L)	0.26	0.63	<0.2	36	N/A
AU 1805_01 Recreational Use					
E.coli (MPN/100 mL)	3 Geomean	61	<1	54	126 Geomean
AU 1805_01 Aquatic Life Use					
Dissolved Oxygen at 0.3 meters	9.5	12.5	6.8	54	≥4.0 Minimum & ≥6.0 Average

Figure 1

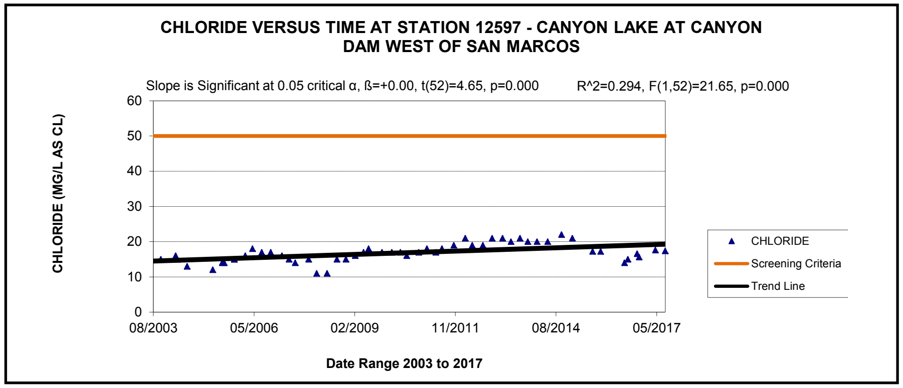


Figure 2

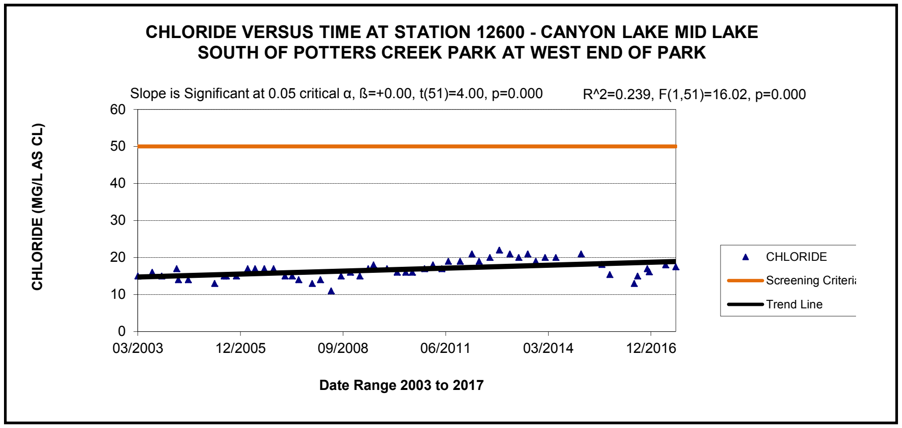


Figure 3

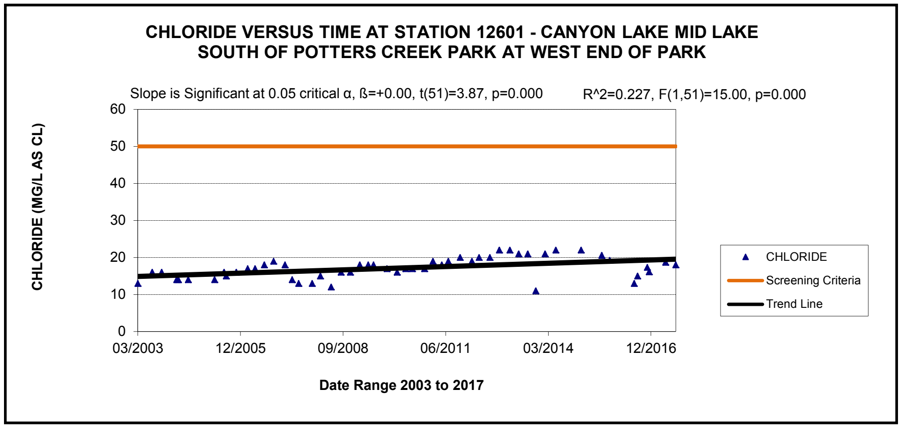
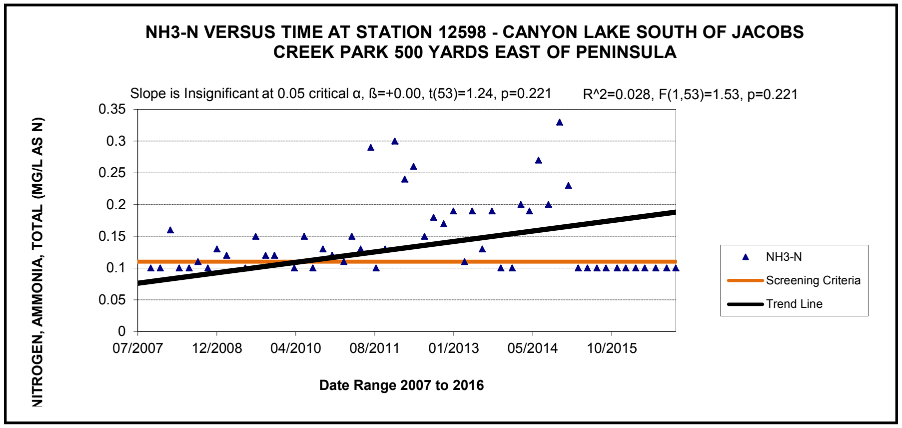
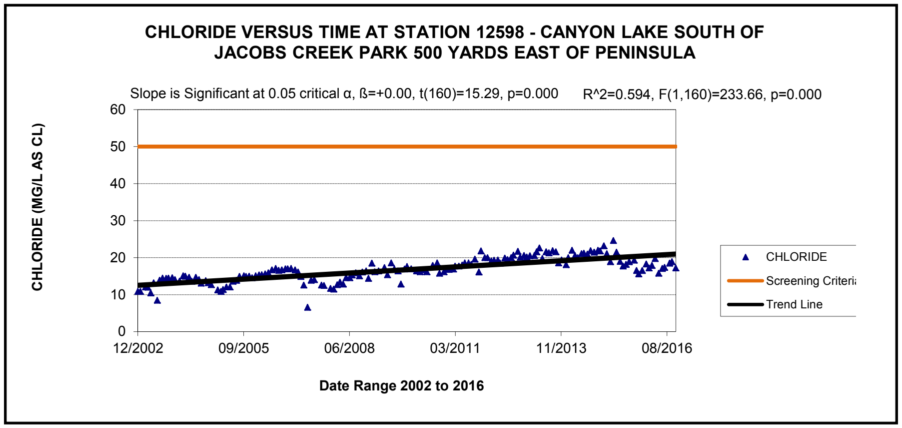


Figure 4



CANYON LAKE

Figure 5



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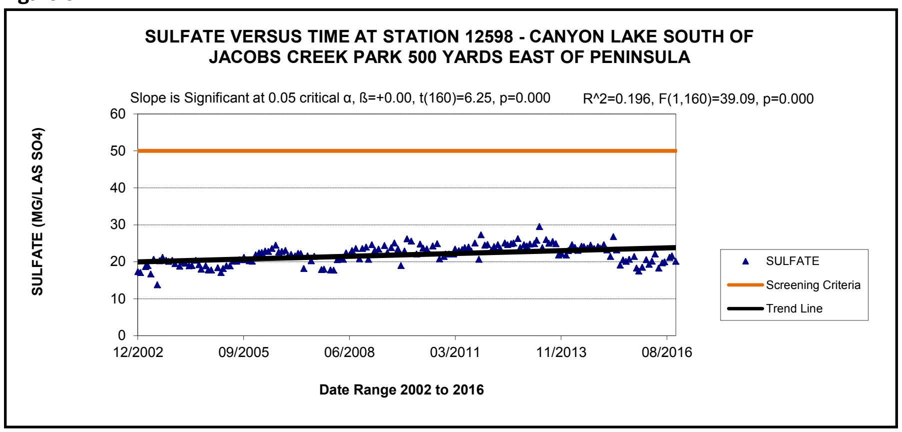
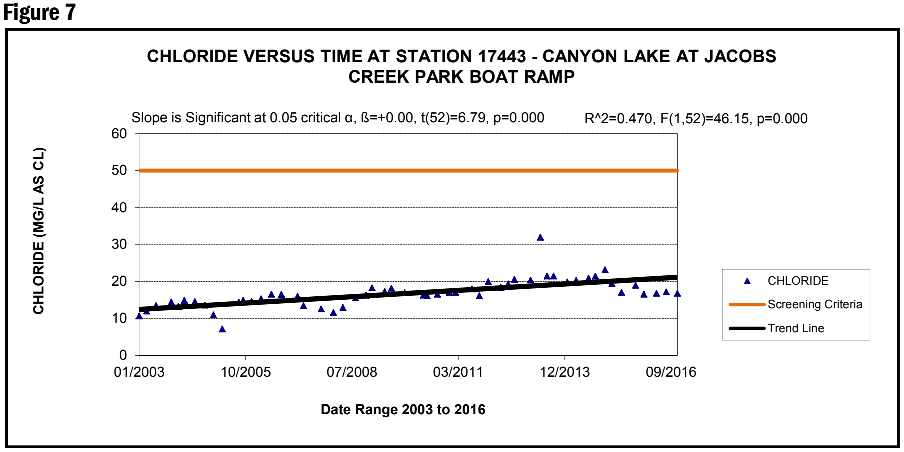
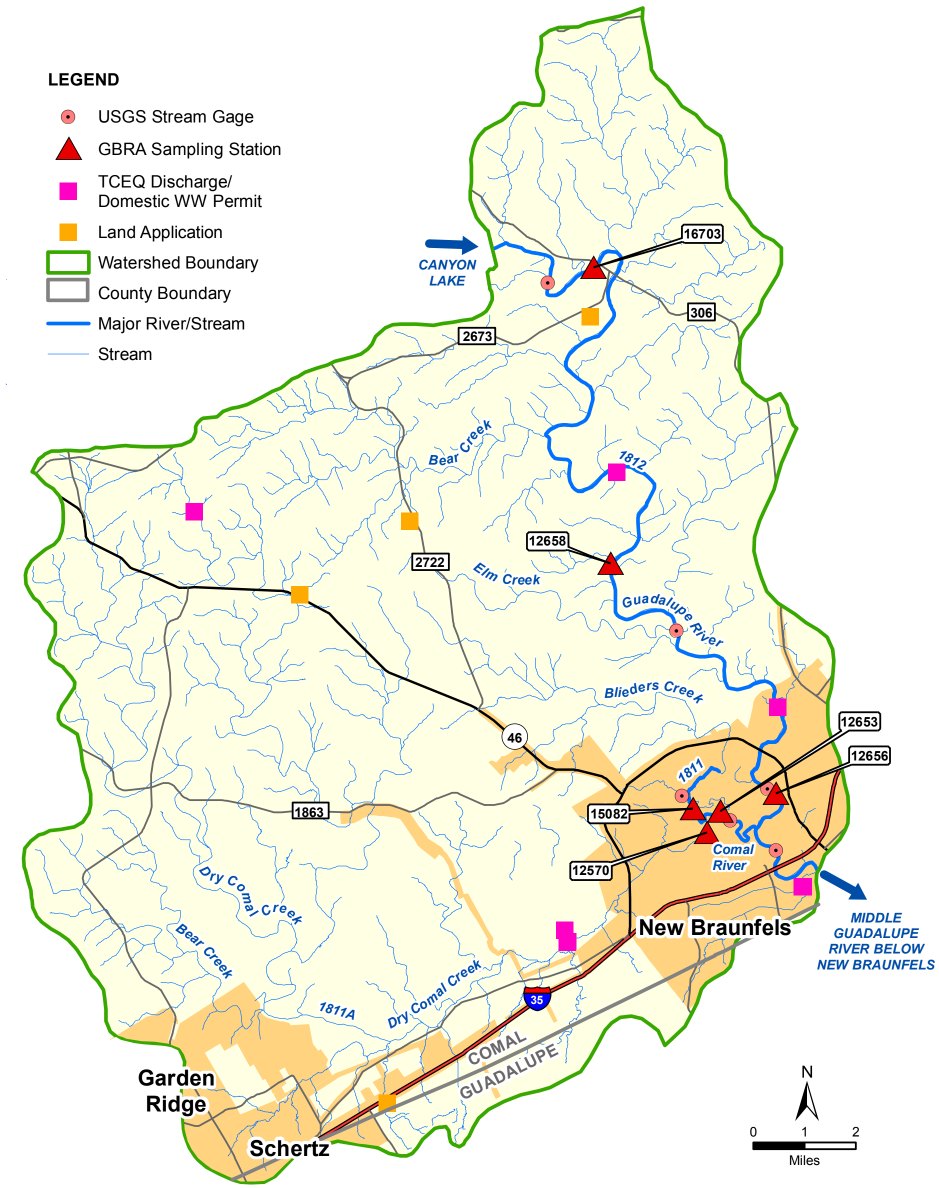


Figure 7



GUADALUPE RIVER BELOW CANYON DAM



GUADALUPE RIVER BELOW CANYON DAM

Segment 1812 represents the Guadalupe River below Canyon Lake to the Comal River confluence. This heavily recreated stream segment receives the majority of its stream flow from regulated discharges from the bottom Canyon Dam. Several underground springs from the Edwards Aquifer contribute to the river as it travels 23 miles down the limestone substrates of the Edwards Plateau to the confluence with the Comal River.

Segment 1812 represents the Guadalupe River below Canyon Lake to the Comal River confluence. This heavily recreated stream segment receives the majority of its stream flow from regulated discharges at the bottom Canyon Dam. Several underground springs from the Edwards Aquifer contribute to the river as it travels 23 miles down the limestone substrates of the Edwards Plateau to the confluence with the Comal River.

The segment of the Guadalupe River below Canyon Dam is extensively used for seasonal contact recreation. The cold water that is released from the bottom of the dam and the limestone substrate create clear, slow river runs and contrasting whitewater rapids. The area is a popular destination for tubers, rafters, kayakers and swimmers. The cold and clear water also create a unique environment for sport fishing. The Texas Parks and Wildlife Department (TPWD) and Trout Unlimited release rainbow trout and brown trout below Canyon Dam at multiple dates throughout the winter. The land use in this area of the Guadalupe River is mostly limited to recreational businesses, campgrounds and private homes. There is very little agricultural land use due to the rocky soils and limestone hills associated with this portion of the Edwards plateau.

The only wastewater treatment facility (WWTF) in this segment is operated by the New Braunfels Utilities (NBU). This plant was designed to release up to 1.1 million gallons per day (MGD) of treated wastewater at a discharge point downstream of Gruene Road. This facility treats the wastewater to ensure that the Carbonaceous Biochemical Oxygen Demand (CBOD), which controls for oxygen depletion from nitrogenous bacteria, does not exceed 5 mg/L, the Total Suspended Solids (TSS) does not exceed 10 mg/L, the Ammonia Nitrogen (NH3-N) does not exceed 3 mg/L and the E. coli does not exceed 126 MPN/100 mL. This current WWTF is located within the 100 year flood plain and experienced damage from flooding in 2010. NBU is working with the TCEQ in order to relocate the facility outside of the floodplain in a new location near Loop 337. The proposed new facility will have expanded treatment capacity up to 4.9 MGD. The permitted effluent after completion of the expansion will include a new CBOD limit of 10 mg/L, a new TSS limit of 15 mg/L and will now include a tertiary treatment of total phosphorus to concentrations below 0.5 mg/L. This proposed expansion should help to serve the proposed 5,000 home Veramendi development that will be located along 1.7 miles of river frontage in this segment, immediately upstream of the plant.

The water releases from Canyon Lake are dictated by contractual agreements between the United States Army Corp of Engineers (USACE), the GBRA, the Federal Regulatory Energy Commission and Trout Unlimited. If the water level

CONTINUED ON PAGE 50

Guadalupe River below Canyon Lake
Drainage Area: 87.79 square miles
Length: 23.1 miles
Tributaries: Mountain Creek, Jacob's Creek, Bear Creek, Turkey Creek, Isaac Creek, Deep Creek, Elm Creek,
Aquifer: Trinity, Edwards Trinity
River Segments: 1812
Cities: New Braunfels, Gruene, Canyon City
Counties: Comal
EcoRegion: Edwards Plateau
Climate: Average annual rainfall 34.98 inches, Average annual temperature 19.58°C

Vegetation Cover: Evergreen Forest 60.92%, Deciduous Forest 8.70%, Shrubland 11.61%; Grassland 9.44%; Woody Wetlands: 1.19% Cultivated Crops 0.29% ; Pasture Hay 0.68%
Land Uses: urban, suburban sprawl, light industry, and recreational.
Development: Low Intensity 0.1.58% ; Medium Intensity 0.38%; High Intensity 0.15%; Open Space 4.25%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: 1 Domestic

of Canyon Lake rises to above 909 msl, the USACE controls releases of water from the flood pool of the reservoir. The rates of release are a function of the head pressure from the elevation of the reservoir and these typically range from 5,000-5,600 cfs at levels greater than 911 mls. The Corp of Engineers release water at rates up to 1,500 cfs when the reservoir level is between between 909 msl and 911 msl. When the water level of Canyon Lake falls below the level 909 msl, GBRA takes control of the releases from the dam. The Federal Regulatory Energy Commission licensing agreement ensures that releases from the GBRA are at least 100 cfs, unless drought conditions cause the amount of inflow into the lake is less than that threshold. If the minimum amount of water entering the lake upstream is less than 100 cfs then the GBRA will release water from the dam at a rate greater than or equal to the inflow. A secondary agreement between the GBRA and Trout Unlimited ensures that at least 150 cfs is released from the dam from May 16th to September 30th, so long as the water level of Canyon Lake is at least 909 msl on May 16th. The Trout Unlimited agreement is designed to ensure that the river maintains thermal tolerance ranges suitable for the Rainbow Trout that are seasonally stocked in the Guadalupe River by the TPWD.

WATER QUALITY

The latest approved 2014 Texas Integrated Report of Surface Water Quality does not identify any water quality impairments or concerns in this segment. The stream segment has been divided by the TCEQ into three assessment units (AUs). The GBRA routinely samples one surface water quality monitoring station in each TCEQ assessment unit.The historical data from all three active TCEQ monitoring stations were reviewed for statistical trends, comparing each monitoring parameter against time and stream flow for the period between December of 2002 and November of 2016. The stream flows for segment 1812 did not show any statistical trends over time at any of the stations analyzed. The geometric mean of E. coli in all three assessment units of this segment was well below the contact recreation standard of 126 MPN/100 mL, but no statistical trends were observed. The observed E. coli geometric means of 62 MPN/100 mL at station 16703 (AU 1812_03), 63 MPN/100 mL at station 12658 (AU1812_02) and and 71 MPN/100 mL at station 12656 (AU1812_01), all preliminarily appear to support a designated contact recreational use.

AU 1812_03 is the 9 mile portion of the segment from the confluence with Bear Creek up to the discharge from Canyon Dam station 16703 is located on the uppermost assessment unit 1812_03, off Farm to Market Road 306 immediately below Canyon Dam. This station has been monitored on a quarterly basis since it was initiated by the TCEQ in 1999. Monitoring duties for this station were transferred to the GBRA in 2012. This AU has a significantly lower average temperature of 16.4°C than the downstream AUs (19.5°C & 19.7°C) because of its proximity to the releases of Canyon Dam. chloride and sulfate levels were both significantly increasing over time at station 16703 (Figures 1 &

2). The increased concentrations in salt anions may be due to diminished stream flow as a result of years of drought, but no statistically significant correlation was found between these parameters and stream flow.

AU 1812_02 is the middle portion of the segment from the confluence with Elm Creek upstream to the confluence of the Bear Creek tributary. This AU is in the middle of stream segment and has been monitored by the GBRA at station 12658 on a monthly basis since 1990. This station is located on the second road crossing of River Road upstream from the City of New Braunfels. Station 12658 is representative of one of the most heavily recreated portions of the segment. This station showed statistically significant increases in chloride and sulfate concentrations similar to the upstream AU1812_03 (Figures 3 & 4) and a statistically significant inverse correlation with stream flow was observed for both parameters (Figures 5 & 6). The dissolved oxygen at station 12658 also showed a statistically significant decline over time (Figure 7), but the average concentration of 10.0 mg/L is well above the aquatic life standard average of 6.0 mg/L and the lowest value ever recorded at this station was 6.3 mg/L.

AU 1812_01 is the lower 4 mile long portion of the river from the confluence with the Comal River (Segment 1811) to just upstream of the confluence with the Elm Creek. This AU is also heavily recreated and receives the discharge from the only domestic wastewater facility in the segment. AU 1812_01 has been historically monitored at two stations. Station 13511 was established in 1999 and monitored quarterly at the Gruene Road crossing of the river by the TCEQ. This station was discontinued in 2012 because the location was in the mixing zone of a wastewater treatment outfall operated by New Braunfels Utilities (NBU). A second monitoring station, 12656 at Cypress Bend Park in New Braunfels, was monitored quarterly by the TCEQ from 1983 until 2012 when monitoring was transferred to GBRA. The most downstream station in the segment, station 12656, is located in a public park in the City of New Braunfels. A significant decline in dissolved oxygen over time was observed at this station (Figure 8), but average dissolved oxygen concentrations at this station were a very high 10.1 mg/L with a minimum recorded value of 7.4 mg/L, which are values indicative of strong support for aquatic life uses.

Table 1

Station 16703 – Guadalupe River at FM 306 12/2002 - 11/2016					
AU 1812_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	16.4	24.7	9.2	55	32.2
pH (S.U.)	8.0	9.4	6.9	54	6.5 – 9.0
Chloride (mg/L)	16.3	24.8	11.0	55	50.00
Sulfate (mg/L)	23.4	50.1	14.0	55	50.00
Total Dissolved Solids (mg/L)	280	440	233	54	400.00
NH3-N (mg/L)	<0.10	0.31	<0.05	54	0.33
Total Phosphorus (mg/L)	<0.06	0.07	<0.02	53	0.69
Chlorophyll-a (µg/L)	4.2	<10.0	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.21	0.59	<0.05	55	1.95
TKN (mg/L)	0.29	0.52	<0.2	52	N/A
AU 1812_03 Recreational Use					
E. coli (MPN/100 mL)	62 Geomean	440	7.3	48	126 Geomean
AU 1812_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	10.1	12.9	5.7	48	≥4.0 Minimum & ≥6.0 Average

Table 2

Station 12658 – Guadalupe River at Second Crossing 12/2002 – 11/2016					
AU 1812_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	19.5	30.4	8.3	162	32.2
pH (S.U.)	8.1	8.5	6.8	162	6.5 – 9.0
Chloride (mg/L)	15.6	23.1	6.2	163	50.00
Sulfate (mg/L)	21.7	30.1	8.7	163	50.00
Total Dissolved Solids (mg/L)	284	343	195	162	400.00
NH3-N (mg/L)	<0.10	0.37	<0.02	83	0.33
Total Phosphorus (mg/L)	<0.04	0.38	<0.02	162	0.69
Chlorophyll-a (µg/L)	<1.0	<5.0	<1.0	161	14.10
Nitrate Nitrogen (mg/L)	0.20	1.78	<0.02	162	1.95
TKN (mg/L)	0.31	1.35	<0.20	66	N/A
AU 1812_02 Recreational Use					
E. coli (MPN/100 mL)	63 Geomean	1100	11	162	126 Geomean
AU 1812_02 Aquatic Life Use					
Dissolved Oxygen (mg/L)	10.0	13.8	6.3	161	≥4.0 Minimum & ≥6.0 Average

GUADALUPE RIVER BELOW CANYON DAM

Table 3

Station 12656 – Guadalupe River at Cypress Bend Park 12/2002 – 11/2016					
AU 1812_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	19.7	30.4	10.2	40	32.2
pH (S.U.)	8.0	8.5	7.0	40	6.5 – 9.0
Chloride (mg/L)	17.9	27.0	10.5	40	50.00
Sulfate (mg/L)	22.9	29.8	12.2	41	50.00
Total Dissolved Solids (mg/L)	306	343	241	40	400.00
NH3-N (mg/L)	<0.10	0.25	<0.02	40	0.33
Total Phosphorus (mg/L)	<0.04	0.07	<0.02	39	0.69
Chlorophyll-a (µg/L)	<3.0	5.2	<1.0	39	14.10
Nitrate Nitrogen (mg/L)	0.58	1.37	0.06	40	1.95
TKN (mg/L)	0.27	0.45	<0.20	38	N/A
AU 1812_01 Recreational Use					
E. coli (MPN/100 mL)	71 Geomean	770	10	38	126 Geomean
AU 1812_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	10.1	14.0	7.4	40	≥4.0 Minimum & ≥6.0 Average

Figure 1

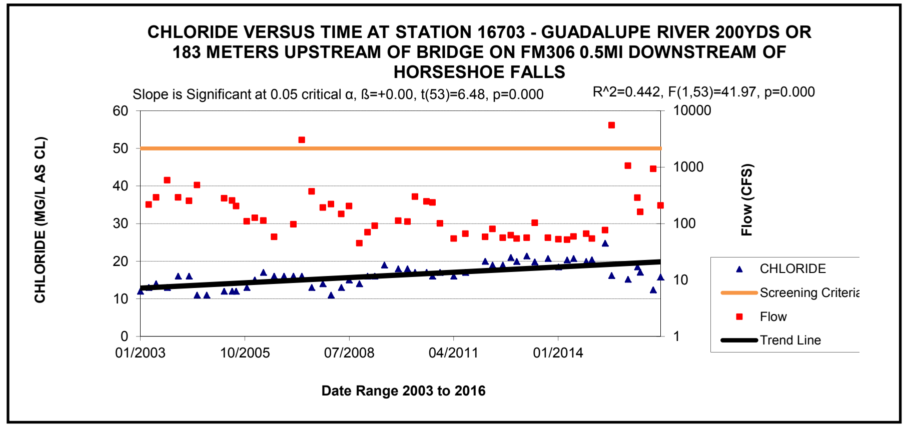


Figure 2

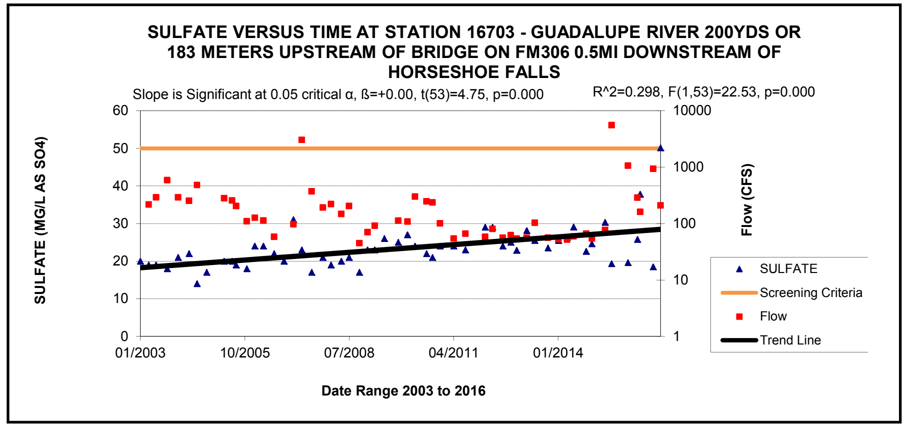
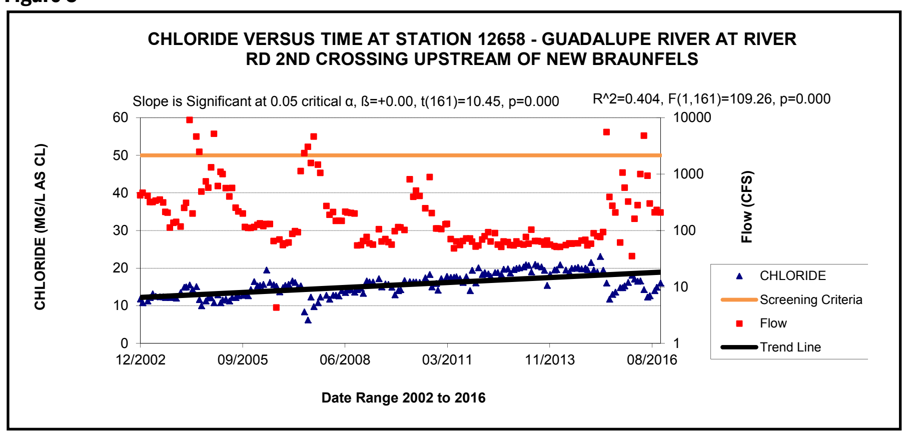


Figure 3



GUADALUPE RIVER BELOW CANYON DAM

Figure 4

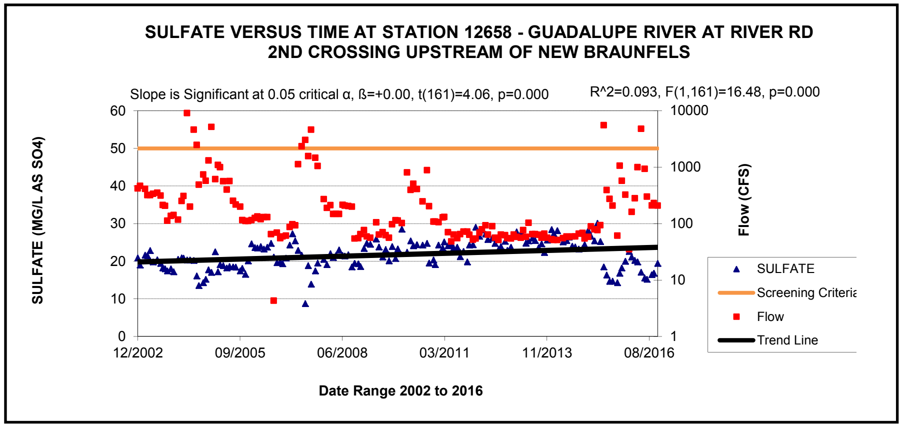


Figure 5

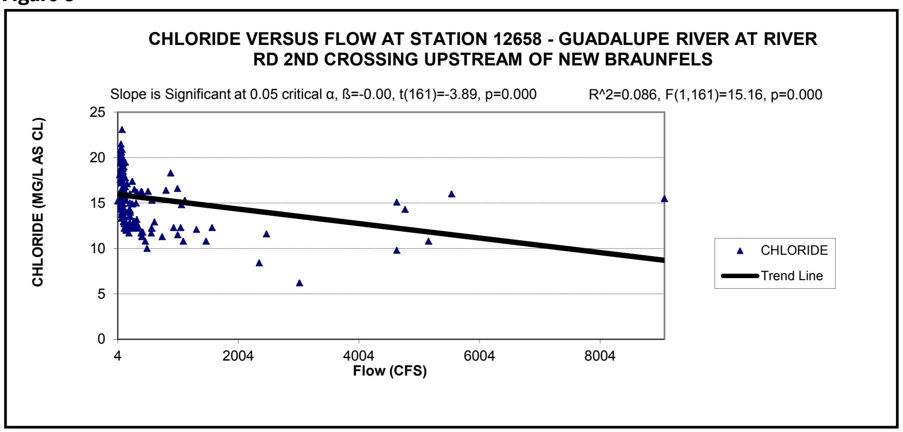


Figure 6

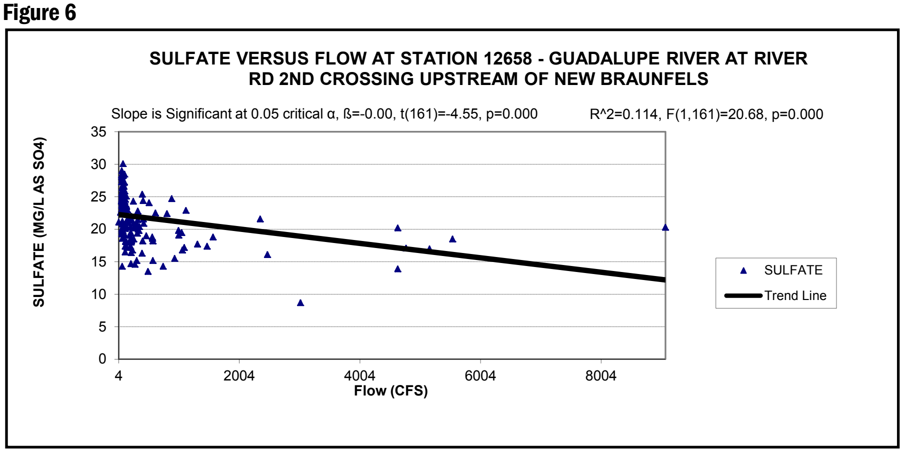


Figure 7

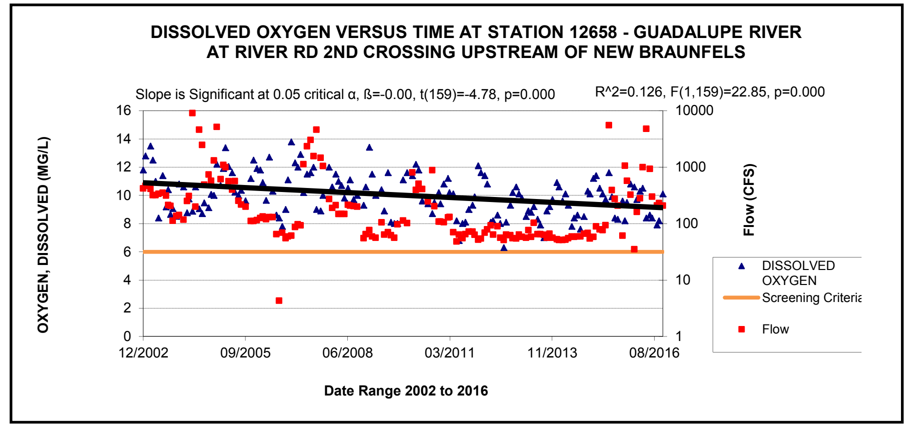
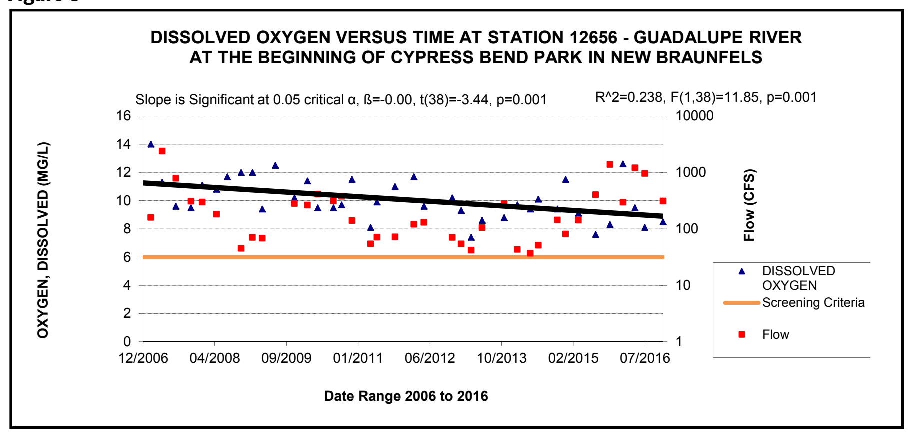
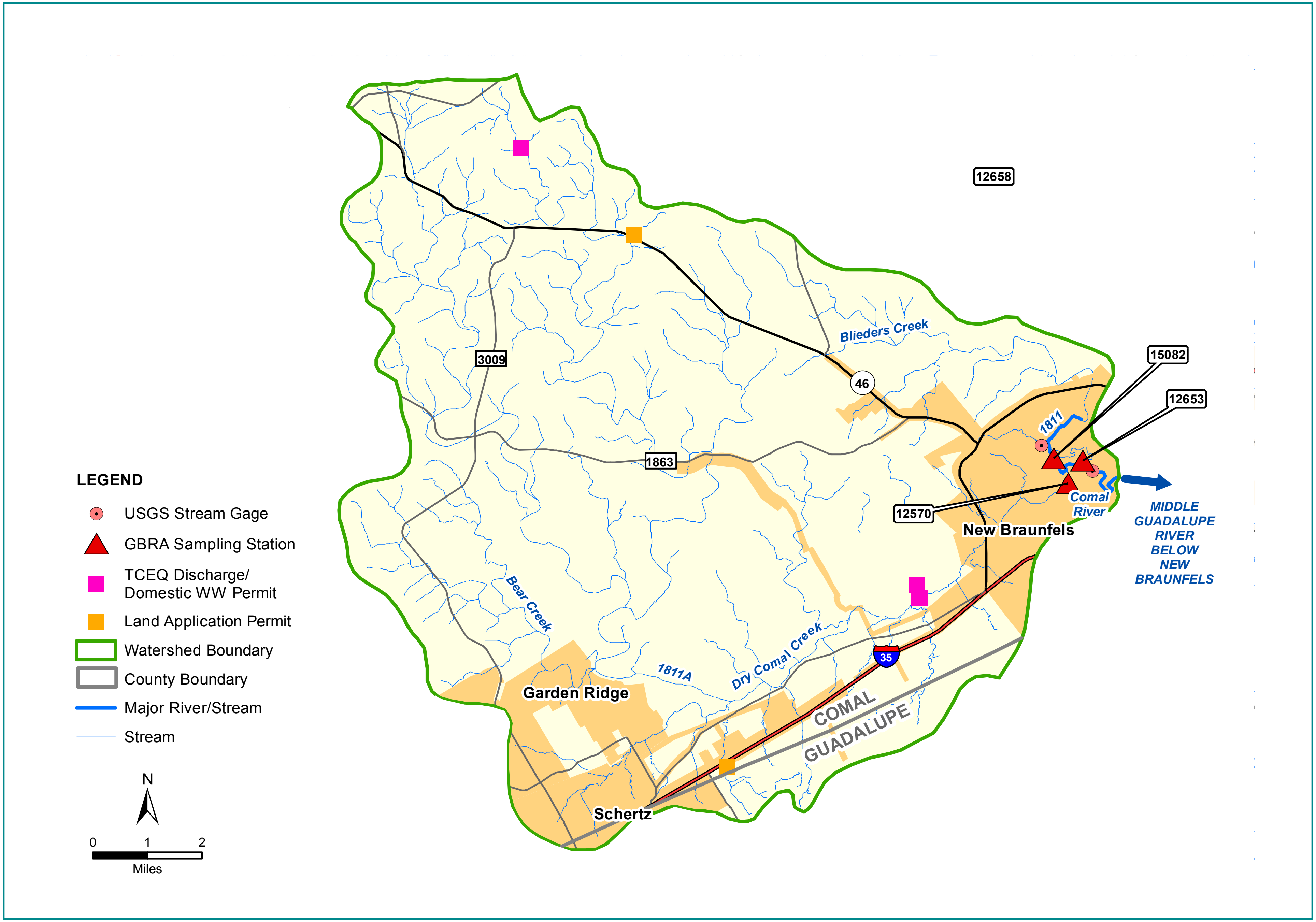


Figure 8




LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Discharge/ Domestic WW Permit
Land Application Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream
N
0 1 2
Miles
12658
3009
Blieders Creek
46
15082
12653
1811
1863
12570
Comal River
New Braunfels
MIDDLE GUADALUPE RIVER BELOW NEW BRAUNFELS
Bear Creek
1811A
Dry Comal Creek
35
Garden Ridge
COMAL
GUADALUPE
Schertz

COMAL RIVER

Segment 1811 represents the Comal River. This stream segment is fed by underground springs from the Edwards Aquifer. The Comal Springs discharge into Landa Lake and travel approximately 2.5 miles to the confluence with the Guadalupe River. Several smaller contributing springs occur in the approximately 1 mile long wetted portion of the segment upstream of Landa Lake. The stream segment has been divided by the TCEQ into two assessment units (AUs). AU 1811_01 is the portion of the river from the confluence with the Guadalupe River (Segment 1804) to just upstream of the confluence with the Dry Comal Creek tributary (Segment 1811A). AU 1811_02 is the portion of the stream upstream of the confluence with the Dry Comal Creek tributary to Klingemann Street in the City of New Braunfels, TX. The Dry Comal Creek has a much larger drainage area that is fed by several seeps in the lower portion of the watershed. The creek remains dry for most of the year in the portions of the watershed upstream of the City of New Braunfels.

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Comal River
Drainage Area: 130 square miles
Length: 2.5 miles
Tributaries of Comal River: Blieders Creek, Dry Comal Creek (1811A),
Aquifer: Edwards Trinity, Edwards Balcones Fault Zone
River Segments: 1811
Cities: New Braunfels
Counties: Comal
EcoRegion: Edwards Plateau, Blackland Prairie
Climate: Average annual rainfall 33.98 inches, Average annual temperature 19.58°C
Vegetation Cover: Evergreen Forest 37.72%, Deciduous Forest 9.25%, Shrubland 22.10%; Grassland 17.35%; Woody Wetlands: 0.86% Cultivated Crops 0.69% ; Pasture Hay 0.69%
Land Uses: urban, light industry, and recreational.
Development: Low Intensity 2.50% ; Medium Intensity 1.32%; High Intensity 0.75%; Open Space 4.90%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: N/A

Dry Comal Creek
Drainage Area: 110.7 square miles
Length: 34.8 miles
Tributaries of the Dry Comal Creek: Bear Creek, West Fork of Dry Comal Creek
Aquifer: Edwards Trinity
River Segments: 1811
Cities and Communities: New Braunfels, Garden Ridge
Counties: Comal
EcoRegion: Edwards Plateau, Blackland Prairie
Climate: Average annual rainfall 33.98 inches, Average annual temperature 19.58°C
Vegetation Cover: Evergreen Forest 37.14%, Deciduous Forest 9.71%, Shrubland 22.73%; Grassland 18.73%; Woody Wetlands: 0.88% Cultivated Crops 0.82% ; Pasture Hay 0.76%
Land Uses: urban, suburban sprawl, cattle, goat and sheep production, light industry, and recreational.
Development: Low Intensity 1.94% ; Medium Intensity 0.77%; High Intensity 0.57%; Open Space 3.64%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: N/A

COMAL RIVER

The Comal River is the shortest river in the state of Texas and is located entirely within the City limits of the City of New Braunfels. The portion of the River above Clemens dam was split into two channels in the late 19th century in order to provide hydraulic energy to historical mills and power plants of the area. The old river channel that currently flows through the Landa Park golf course had a portion of the spring flows diverted into a new river channel that receives the discharge from the Dry Comal Creek. The Dry Comal Creek tributary is largely comprised of agricultural land use, but urban development continues to grow throughout the watershed. The underground springs that feed the Comal River create unique water quality conditions. The river maintains consistent water temperatures and high water clarity throughout the year. These conditions have made the Comal a perennial tourist destination for recreational swimming and tubing, while also providing suitable living conditions for several aquatic endangered species. The Comal River and springs are home to several federally endangered species, including the Fountain Darter (Etheostoma fonticola), Comal Springs Riffle Beetle (Heterelmis comalensis), Comal Springs Dryopid Beetle (Stygoparnus comalensis) and the Peck's Cave Amphipod (Stygobromus pecki). The U.S. Fish and Wildlife Service has (USFWS) identified diminished springflows and pollution of groundwater as the largest potential threats to these species.

In 2013, a large 2,430 acre property with drainage into the Blieders Creek arm of the Comal River was approved for development. The first phase of construction has begun on this Veramendi subdivision, which includes 1200 acres devoted to the construction of a new elementary school, roads and over 5,000 houses. An additional 380 acres of nonresidential hotels, town centers and schools and 480 acres of public parks are also planned for the future. To date, the new elementary school is the only impervious cover that has been developed. The development should significantly change the drainage into the Comal, with planned dam infrastructure in Bleiders Creek designed to reduce up to 1,000 cubic feet per second (cfs) of runoff into the Comal watershed.

The GBRA routinely samples one surface water quality monitoring station in each TCEQ assessment unit on a monthly basis. In 1968, a historical monitoring station 12653 on the Comal River at Hinman Island was established by the Texas Water Quality Board, which was a predecessor agency of the TCEQ in AU 1811_01. The station was monitored by subsequent iterations of the current TCEQ until 1998. The GBRA began sampling at this station in 1994 and has collected routine samples on a monthly basis since 1996, when it joined the Clean Rivers Program. The GBRA has also monitored one routine station 12570 monthly since 1996, on the Dry Comal Creek (Segment 1811A) near the confluence with the Comal River. In order to better measure the impacts of the bacterial impairment from the Dry Comal Creek tributary on the Comal River, the GBRA began monitoring at station 15082 on the new river channel below Landa Lake in 2014. This station was located upstream of any influence from the Dry Comal Creek.

The spring fed source of the river and distinct aquatic habitat have lead the TCEQ to assess the river with a unique temperature criterion of 25.6°C in AU 1811_02 upstream of the Dry Comal Creek. This temperature criterion excludes the Blieders Creek arm of Landa Lake, Spring Island on the Western Channel and Pecan Island on the Eastern Channel. The average temperature of the Comal River at station 12653 below the Dry Comal is 23.3°C for the 163 data points available for analysis between December of 2002 and November of 2016. The average temperature for the Dry Comal Creek at station 12570 averaged 21.5°C during the same time period. The much smaller data set available from station 15082 upstream of the Dry Comal Creek showed an average temperature very similar to the 23.4°C for the 30 data points available from June 2016 to November of 2016.

The water quality data from all active monitoring stations on the Comal River and the Dry Comal Creek were analyzed for trends and several significant changes were noted. Station 12653 is the only active monitoring station in AU 1811_01 below the confluence with the Dry Comal Creek confluence. This station also has the most available historical monitoring data. The monthly streamflow at station 12653 was found to be significantly decreasing over time for the 164 data points evaluated since 2002 (Figure 1). Stream flow is of particular importance in this watershed because of the unique recreational and aquatic life uses. Dissolved Oxygen and Nitrate Nitrogen at this station were both found to be significantly correlated to streamflow. The dissolved oxygen concentrations in this AU were found to be significantly decreasing over time and decreasing with streamflow (Figure 2 & 3). Nitrate nitrogen is the form of nitrogen most readily available for use by aquatic organisms. The nitrate nitrogen at station 12653 is significantly increasing over the 163 data points assessed and inversely correlated with streamflow (Figure 4 & 5). E. coli bacteria analyses are of particular importance in the watershed because it is assessed as an indicator of support for contact recreation standards, which are currently evaluated at a geometric mean of 126 MPN/100 mL. When the data set of 166 points was evaluated between December of 2002 and November of 2016 an E. coli geometric mean concentration of 114 MPN/100 mL was calculated, but no significant change was discovered over time (Figure 6). A closer examination of the data points beginning in August of 2014 showed a significant reduction of E. coli was occurring over time for the 31 data points available during this smaller window of time (Figure 7). These concentrations were most likely reduced as the result of a return to normal stream flow and precipitation conditions, as the area recovered from a historic drought.

The only active monitoring station in AU 1811_02 above the confluence with the Dry Comal Creek is station 15082. This station has a much more limited data set available for analysis, which began in June of 2014 through November of 2016. The streamflow at this station was found to be increasing with time (Figure 8), which was also significantly affecting several other water quality parameters. The chloride and sulfate levels at station 15082 are both decreasing over time (Figures 9 & 10) and are inversely correlated with streamflow (Figures 11 & 12). Chloride and sulfate are salt anions that are common constituents of total dissolved solids in the water column. The nitrate nitrogen at this station is significantly increasing over time (Figure 13) and appears to be following a similar pattern as the long term data set available from station 12653 in the watershed downstream. The E. coli bacteria concentrations at this station were higher than anticipated, with a geometric mean 141 MPN/100 mL, but they are also significantly decreasing over time for the 30 data points available (Figure 14). The E. coli concentrations at this station indicate that there may be a persistent source of bacteria in the Comal River upstream of the Dry Comal Creek and the majority of any influences from recreational activities.

The Dry Comal Creek is a 34.8 mile long tributary of the Comal River with a large 110.7 square mile drainage area that is heavily influenced by agricultural land use. The Dry Comal Creek was listed on the Texas 303(d) list of impaired water bodies, as required by Clean Water Act Sections 303(d) and 305(b) in 2010. The TCEQ found that the assessed geometric mean of 173.90 MPN/100 mL of E. coli bacteria in the lower 25 miles of the segment exceeded the station contact recreation standard of 126 MPN/100 mL. The creek was initially classified in category 5b, which indicated that the water quality standards for this segment were being reviewed to determine applicability. The segment was reclassified into category 5c in 2012 with 291.03 MPN/100 mL, which indicated that more information needed to be collected in order to develop a management strategy to address the impairment. The most recent Texas Integrated Report on Water Quality assessed a geometric mean of 301.89 MPN/100 mL in this segment. A trending analysis was performed on station 12570 on the Dry Comal Creek on AU1811A_01. This station is located near the confluence with the Comal River immediately downstream of the Mill Dam on the new river channel. The flows of the Dry Comal have less spring flow influence and experience greater changes from rainfall runoff than the Comal River due to a much larger drainage area. No significant changes were noted in streamflow over time at this location. The chloride and sulfate concentrations in the Dry Comal Creek are both significantly decreasing over time (Figure 15 & 16). The E. coli bacteria concentration is being closely tracked in this watershed due to the assessed geometric mean in the 2014 Texas Integrated report above the contact recreation standard of 126 MPN/100 mL. The geometric mean for the 169 data points available from December of 2002 to November of 2016 is 257 MPN/100 mL. There was not a significant trend in E. coli concentrations found in the data set for this monitoring station (Figure 17).

The City of New Braunfels secured

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COMAL RIVER

Clean Water Act Section 319 Non-Point Source Grant funding in 2015 to develop a watershed protection plan for the Dry Comal Creek and Comal River in order to address the contact recreation impairment for E. coli bacteria in the watershed. The first phase of the watershed protection plan began in 2015, when the City assembled a group of stakeholders; defined target bacteria load reduction goals, and characterized the watershed. The load duration curves created by the WPP identified a 50% reduction of bacteria was needed on the Comal River and a 34% load reduction was needed on the Dry Comal Creek in order to meet targeted bacterial reductions during normal flow conditions. A second phase of the WPP was implemented in 2016 in order identify best management practices to address bacteria concerns and meet the load reduction goals. In support of the WPP, the City of New Braunfels commissioned additional bacteria sampling by the GBRA at multiple locations throughout the watershed. Bacterial source tracking (BST) samples were also collected by the GBRA and analyzed by the Texas A&M Soil and Microbiology Laboratory (TAMU SAML) in order to assist with identifying the source of the bacteria. The results of the BST analysis indicated that the majority of the bacteria in both the Comal River and Dry Comal Creeks came from wildlife sources with additional contributions from livestock, humans and pets. A draft watershed protection plan was reviewed by stakeholders in June of 2017. The City of New Braunfels is currently addressing TCEQ comments to the WPP draft in preparation for submittal to the United States Environmental Protection Agency (US EPA).

The USFWS officially approved the Edwards Aquifer Habitat Conservation Plan (EAHCP) to provide protection for the endangered species in 2013. The EAHCP was developed through the consensus based Edwards Aquifer Recovery Implementation Program (EARIP), which included a diverse group of stakeholders, including municipalities, industries, agricultural users, river authorities, state agencies and environmental organizations. The EAHCP is designed to sustain spring flows from the Edwards Aquifer by restoring and improving the habitat available to endangered species, while minimizing the impact of development and recreational activities in the watershed. The EAHCP also issues incidental take permits for water withdrawals, recreational activities and other covered actions that may result in unintended mortalities of the endangered species. The flow of the Comal River splits into two parts as it leaves Landa Lake. The majority of the flow moves down a man-made mill race called the new river channel. Many of the EAHCP activities have focused on restoration of the Old River Channel of the Comal through restoration of eroding riparian zones and the removal of excess sediment and non-native plants. In 2014, the City of New Braunfels removed culverts that previously separated Landa Lake from the old river channel. The culverts were restored and flow-control gates installed in order to better control flows into the Old Channel to meet biological objectives, prevent channel and vegetation scouring during high-flow periods and to route more water to the Old Channel during periods of drought.. Many implementation activities have also focused on preserving springflows by reducing water pumped from the Edwards Aquifer. The Voluntary Irrigation Suspension Program Option, (VISPO) has been implemented by the Edwards Aquifer Authority (EAA) to compensate farmers for suspension of groundwater pumping during times of drought. If the J-17 index well on the Edwards Aquifer falls below 635 feet on October 1st of a given year, then participants in the program will suspend their pumping from the aquifer on January 1st of the following year. The goal of this program was to reduce 40,000 acre feet of pumping from the aquifer per year, which was met during the drought year of 2014. The San Antonio Water System (SAWS) has also developed an Aquifer Storage and Recovery program (ASR) to purchase water leases and store the water underground for use during times of drought. If all EAHCP recommended implementation and conservation practices are followed, the Comal springs are projected to remain at flow rates that are capable of sustaining the species of concern during periods of drought.

COMAL RIVER

Table 1

Station 12653 – Comal River at Hinman Island 12/2002 – 11/2016					
AU 1811_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	23.3	27.0	17.0	163	25.6
pH (S.U.)	7.6	8.2	7.0	163	6.5 – 9.0
Chloride (mg/L)	18.2	24.4	12.1	164	50.00
Sulfate (mg/L)	28.1	59.2	19.7	164	50.00
Total Dissolved Solids (mg/L)	378	445	333	163	400.00
NH3-N (mg/L)	<0.10	0.30	<0.02	83	0.33
Total Phosphorus (mg/L)	<0.04	0.17	<0.02	163	0.69
Chlorophyll-a (µg/L)	<1.0	<5.0	<1.0	163	14.10
Nitrate Nitrogen (mg/L)	1.64	2.28	<0.02	163	1.95
TKN (mg/L)	<0.20	1.84	0.11	66	N/A
AU 1811_01 Recreational Use					
E. coli (MPN/100 mL)	114 Geomean	2900	4	166	126 Geomean
AU 1811_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.6	13.2	7.4	162	≥4.0 Minimum & ≥6.0 Average

Table 3

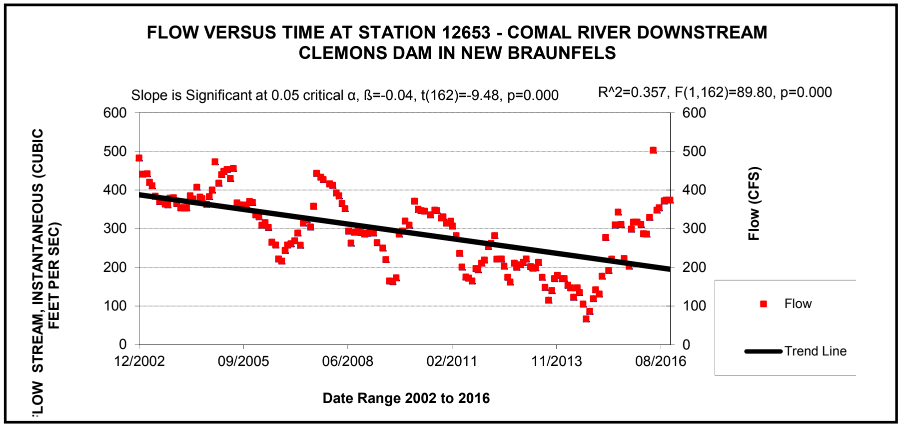
Station 12570 – Dry Comal Creek at Knights of Columbus 12/2002 - 11/2016					
AU 1811A_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.5	31.7	9.0	171	25.6
pH (S.U.)	7.6	8.1	7.1	170	6.5 – 9.0
Chloride (mg/L)	28.3	55.1	3.65	164	50.00
Sulfate (mg/L)	60.7	138	12	164	50.00
Total Dissolved Solids (mg/L)	445	725	149	170	400.00
NH3-N (mg/L)	0.12	0.36	<0.02	84	0.33
Total Phosphorus (mg/L)	<0.06	0.49	<0.02	164	0.69
Chlorophyll-a (µg/L)	5.3	117.0	<1.0	162	14.10
Nitrate Nitrogen (mg/L)	0.83	2.60	0.15	163	1.95
TKN (mg/L)	0.45	1.22	<0.2	67	N/A
AU 1811A_01 Recreational Use					
E. coli (MPN/100 mL)	257 Geomean	9600	29	169	126 Geomean
AU 1811A_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.2	18.2	4.8	169	≥4.0 Minimum & ≥6.0 Average

Table 2

Station 15082 – Comal River at Landa Park Rest Area 16 06/2014 - 11/2017					
AU 1811_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	23.4	25.4	21.5	30	25.6
pH (S.U.)	7.2	7.5	7.0	30	6.5 – 9.0
Chloride (mg/L)	19.7	22.8	18.2	30	50.00
Sulfate (mg/L)	31.7	38.2	28.1	30	50.00
Total Dissolved Solids (mg/L)	384	402	374	30	400.00
NH3-N (mg/L)	<0.10	0.29	<0.02	30	0.33
Total Phosphorus (mg/L)	<0.02	<0.02	<0.02	30	0.69
Chlorophyll-a (µg/L)	<1.0	2.0	<1.0	30	14.10
Nitrate Nitrogen (mg/L)	1.85	2.10	1.57	30	1.95
TKN (mg/L)	<0.20	<0.20	<0.20	30	N/A
AU 1811_02 Recreational Use					
E. coli (MPN/100 mL)	141 Geomean	650	20	30	126 Geomean
AU 1811_02 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.8	10.3	5.2	30	≥4.0 Minimum & ≥6.0 Average

COMAL RIVER

Figure 1



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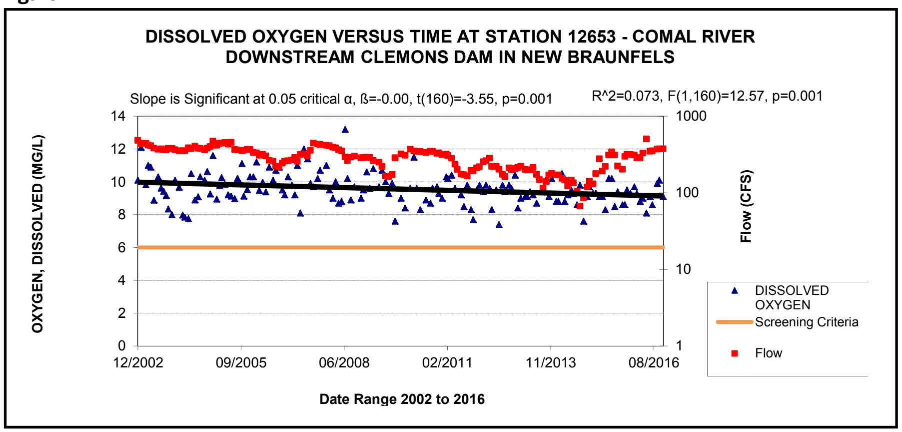

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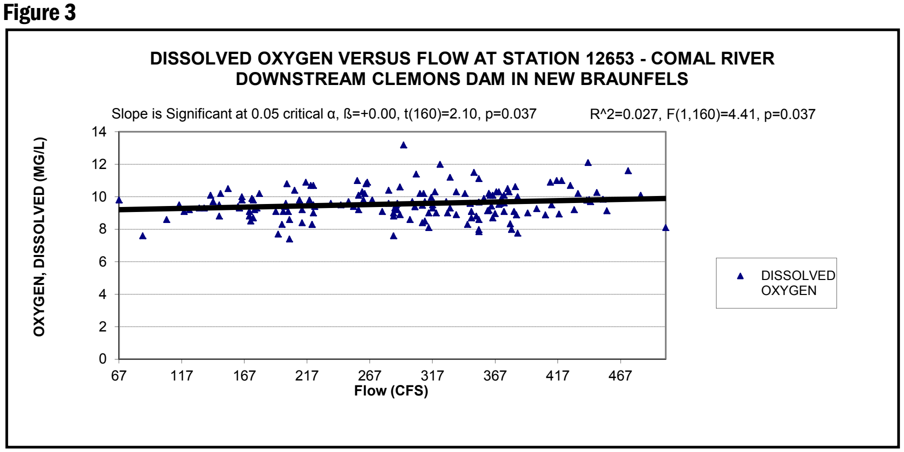

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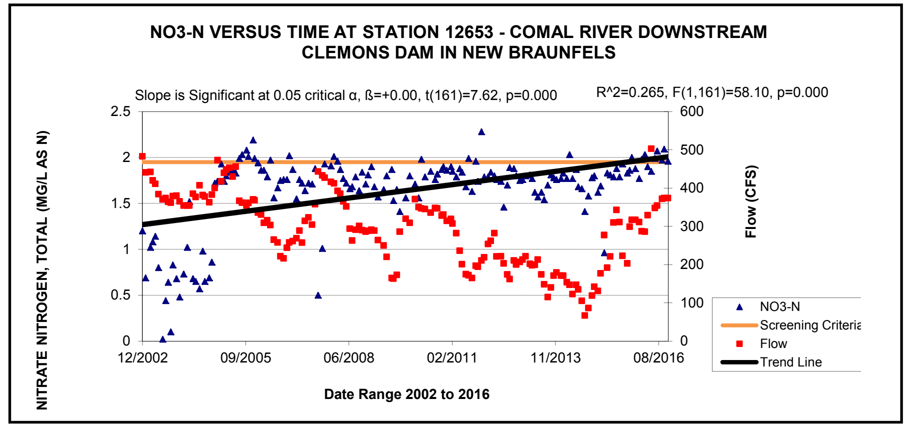

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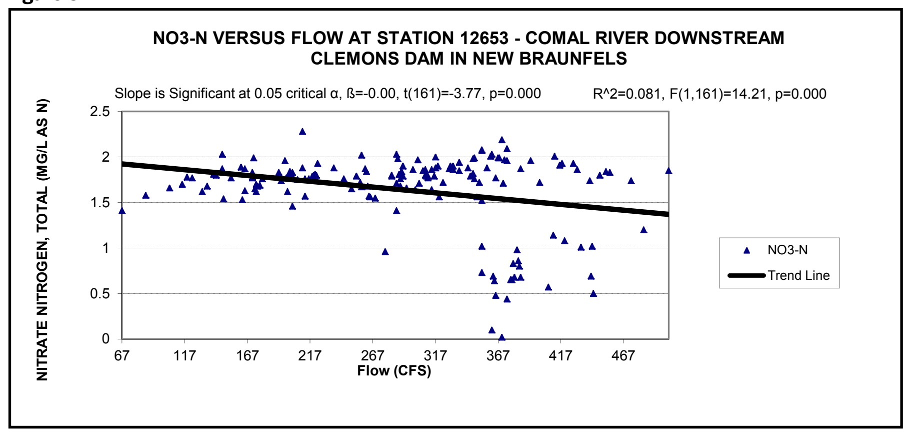

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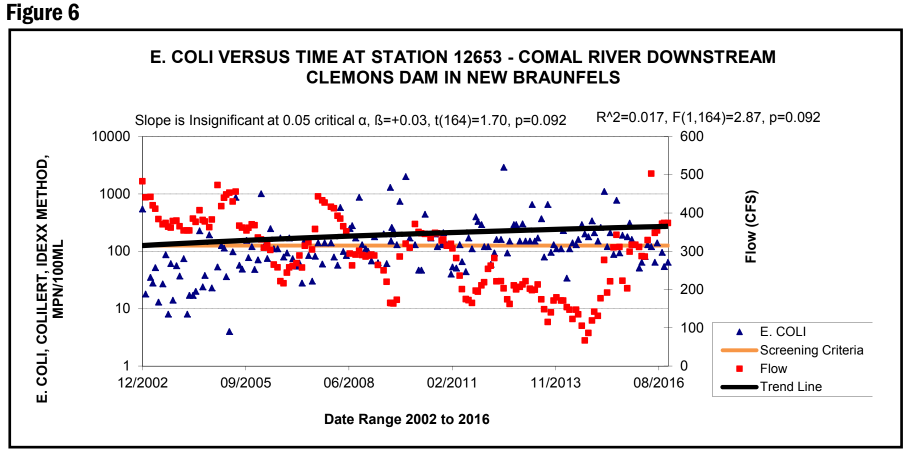
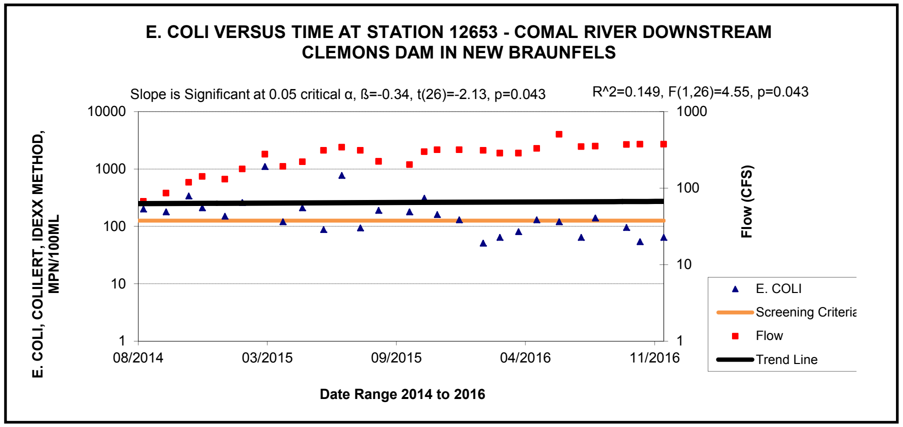


COMAL RIVER

Figure 7



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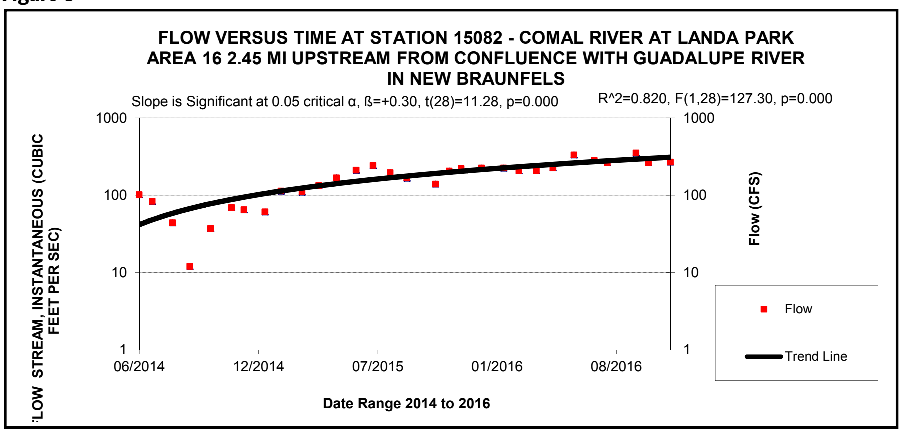

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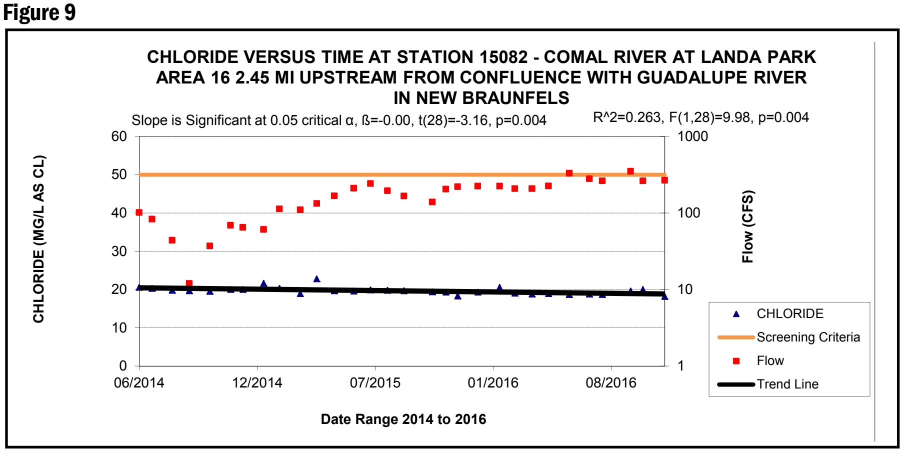

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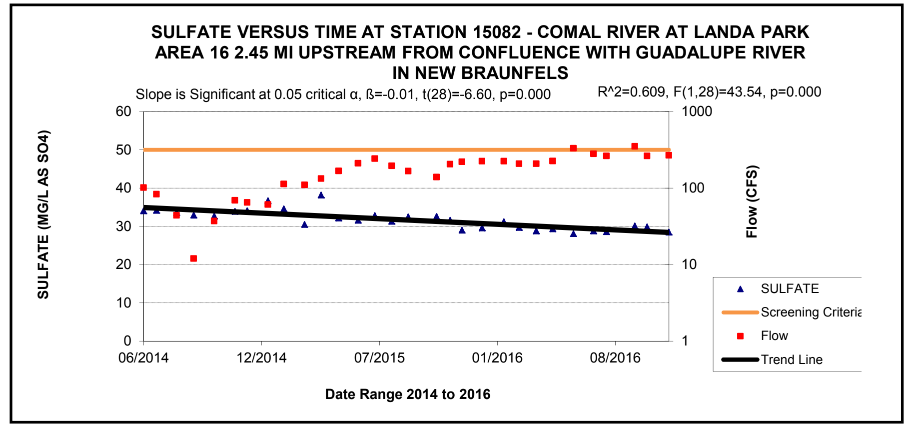

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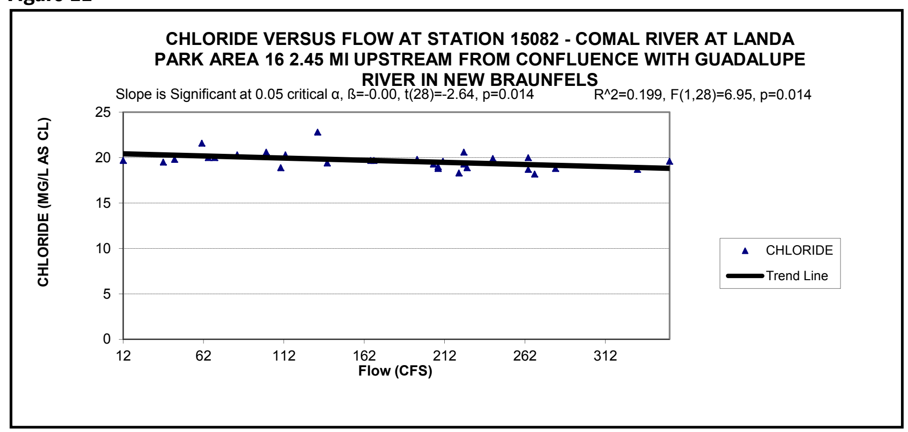

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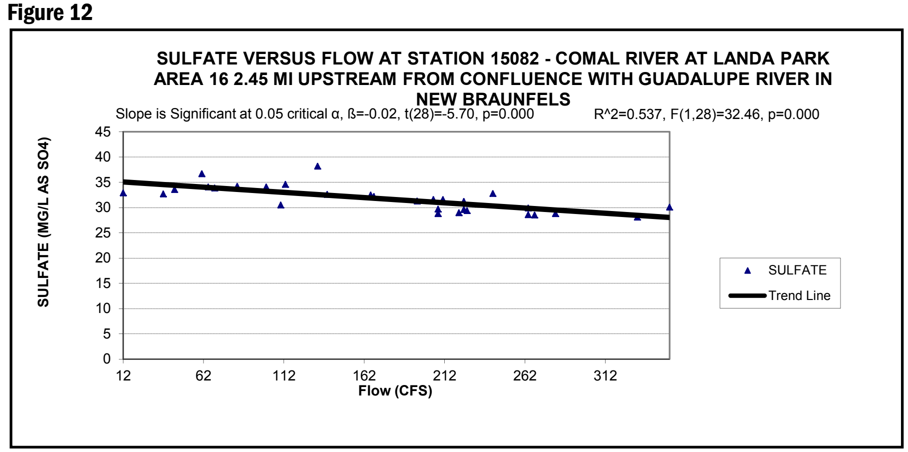
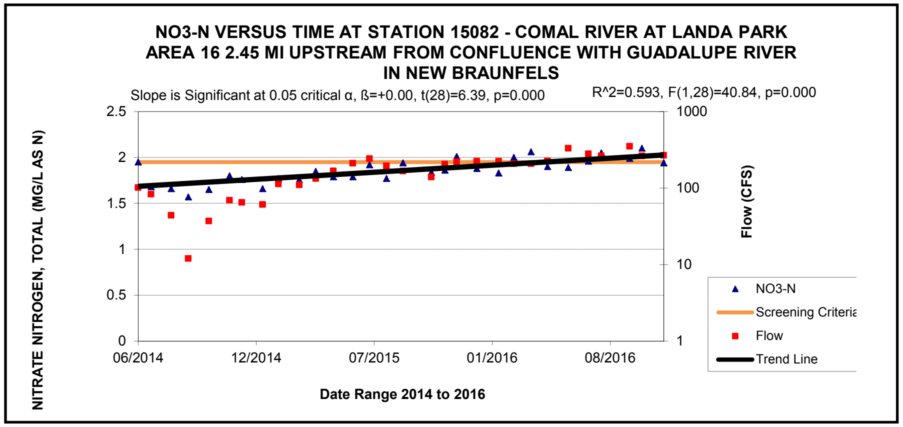


COMAL RIVER

Figure 13



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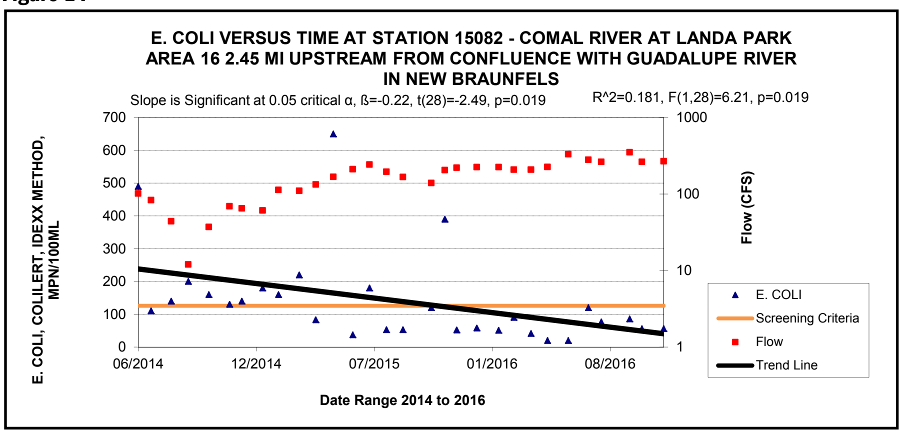

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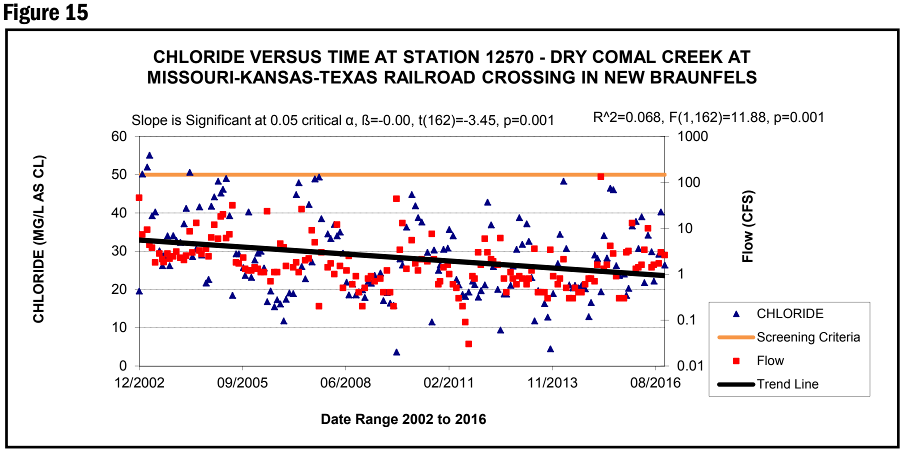

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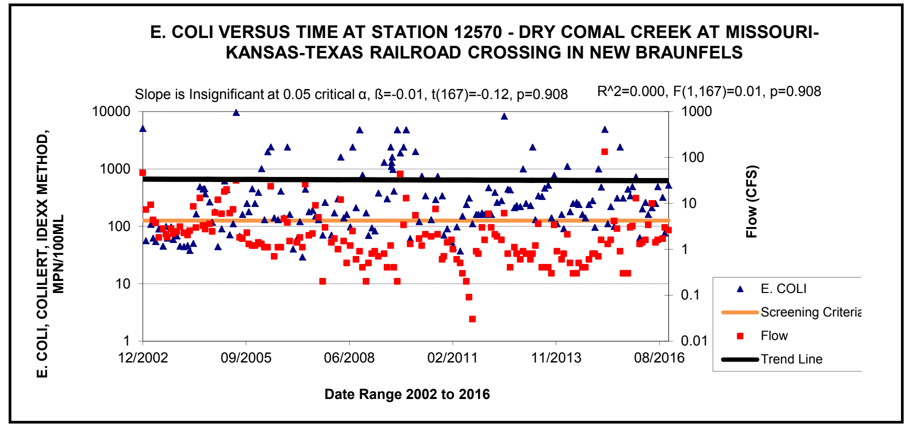

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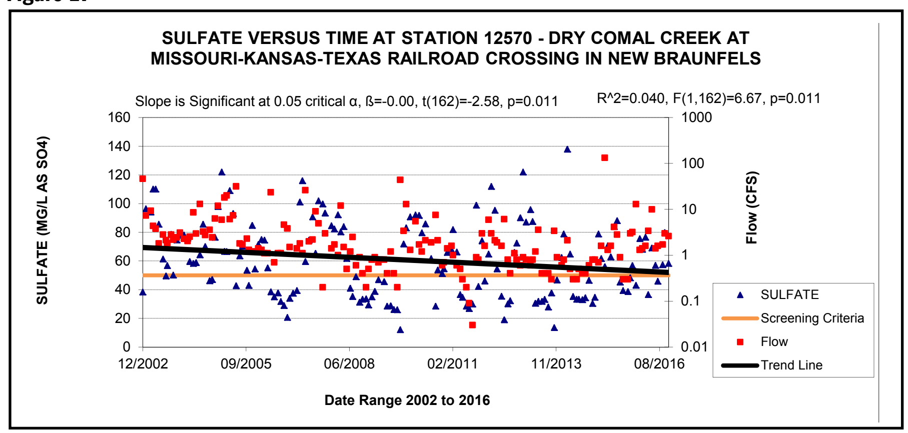
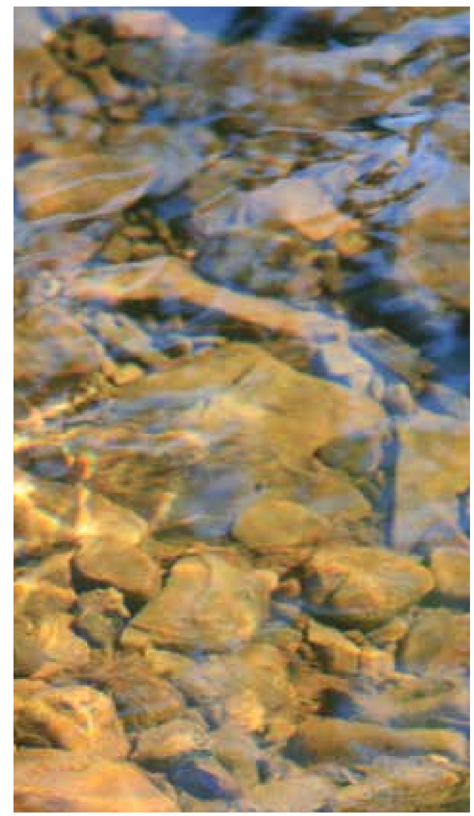
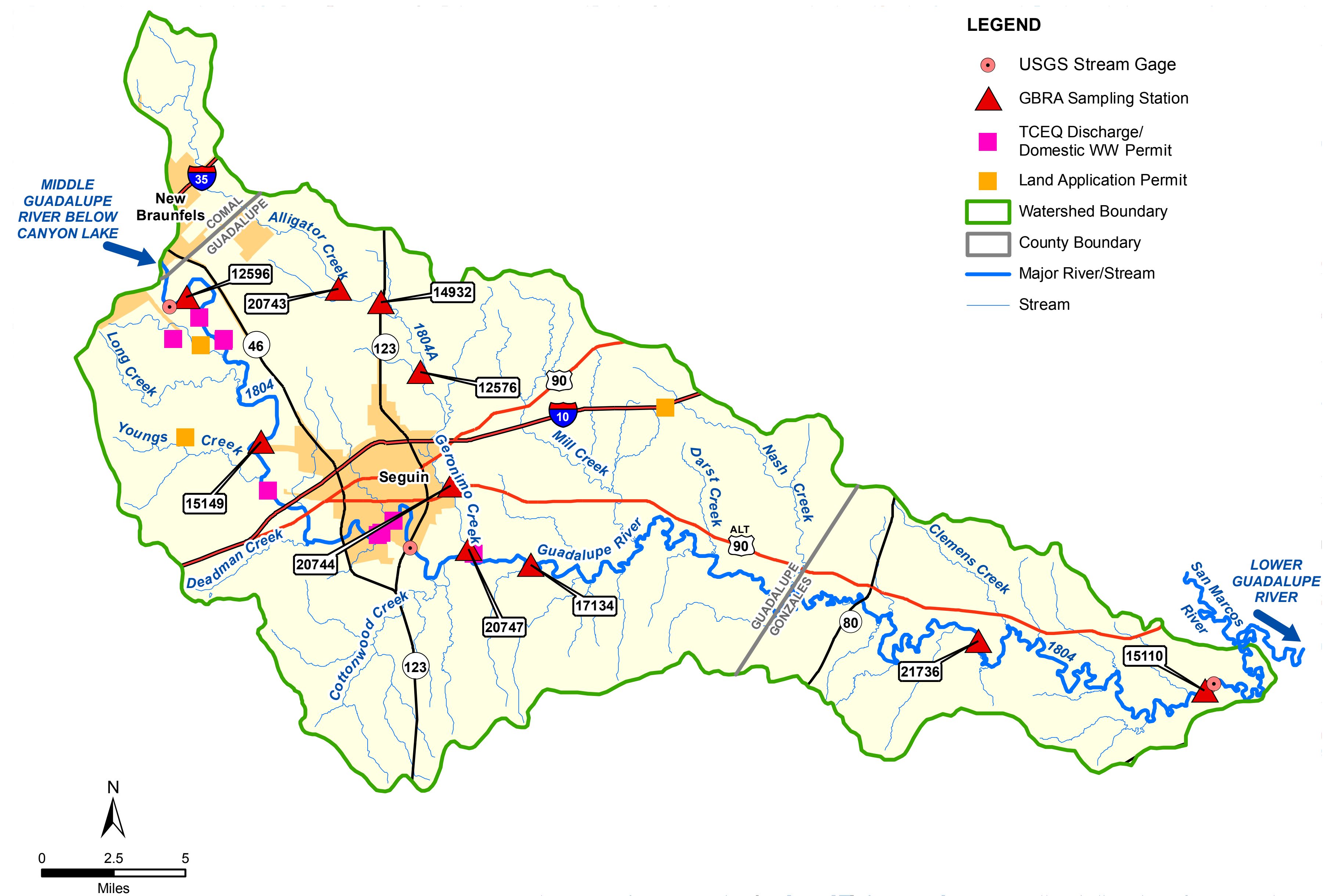


COMAL RIVER



GUADALUPE RIVER BELOW COMAL RIVER



GUADALUPE RIVER BELOW COMAL RIVER

Segment 1804 represents the middle portion of the Guadalupe River that transitions between the rapidly urbanizing Texas Hill Country and the ranchlands of the Blackland Prairie. This portion of the river is used extensively for recreational swimming and boating on the small hydroelectric power generating lakes scattered along its length. The middle portion of the Guadalupe River is one of the most ecologically diverse, due to the significant hydrological and geomorphological changes that occur along its length.

Segment 1804 represents the 101 mile stretch of the Guadalupe River between the confluence of the Comal River in the City of New Braunfels and the confluence with the San Marcos River near the City of Gonzales. The majority of the stream flow in this segment comes from releases of water from Canyon Dam and spring flows from the Comal River. The segment also receives additional stream flow from several wastewater treatment discharges located along its length. The river in this segment experiences a drop in elevation of over 300 feet (585 msl to 266 msl) from the Comal River confluence to the San Marcos River. The significant changes in elevation along this reach have provided ideal locations for the construction of 7 hydroelectric dams. These dams are all operated by GBRA and are much smaller in size than Canyon Dam. The water quality of the river in the impounded portions of the segment is significantly different than in larger reservoirs. The relatively high velocities in these impoundments keep the lakes from stratifying on a regular basis as is seen in Canyon Lake. These hydroelectric plants operate by diverting water into canals that run parallel to the river in order to turn hydroelectric turbines to generate power. Hydroelectricity is only generated in times when stream flow at the Dunlap power plant is at least 528 cubic feet per second (cfs). The largest canal in the segment is located above the Lake Dunlap hydroelectric power plant, where the City of San Marcos pulls water to supply a surface water treatment plant. The San Marcos plant also supplies water to the cities of Kyle and Buda. Many other water purveyors draw on water from this segment as well: Canyon Regional Water Authority, Springs Hills Water Supply Corporation and Gonzales County Water Supply. The upper portions of the segment are primarily dominated by Lake Dunlap (TP-1 Dam), Lake McQueeney (McQueeney Dam), Lake Placid (TP-4 Dam), and Meadow Lake (Nolte Dam). These impoundments located in the upper portions of the segment are extensively used for recreational boating, swimming, public water supply and fishing. The land use in these areas is primarily urban with houses built along most

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Guadalupe River below Comal River
Drainage Area: 939 square miles
Length: 101 miles
Tributaries: Comal River (1811), Long Creek, Youngs Creek, Deadman Creek, Walnut Branch, Cottonwood Creek, Krams Creek, Geronimo Creek (1804A), Cantau Creek, Saul Creek, Cordell Creek, Polecat Creek, Salt Creek, Mill Creek, Sawlog Creek, Darst Creek, Nash Creek, Burroughs Creek, Foster Branch, Watson Creek, Clemens Creek, Answorth Branch, Stevens Creek, Pecan Branch
Aquifer: Edwards Balcones Fault Zone, Carrizo Wilcox
River Segments: 1804, 1803
Cities and Communities: New Braunfels, Seguin, Belmont, Gonzales
Counties: Comal, Guadalupe, Dewitt
EcoRegion: Edwards Plateau, Texas Blackland Prairie, Post Oak Savannah

Climate: Average annual rainfall 34.99 inches, Average annual temperature 20.28°C
Vegetation Cover: Evergreen Forest 16.79%, Deciduous Forest 11.54%, Shrubland 25.38%; Grassland 8.93%; Woody Wetlands: 3.05% Cultivated Crops 10.78% ; Pasture Hay 12.23%
Land Uses: urban, suburban sprawl, light industry, and recreational. Development: Low Intensity 1.85% ; Medium Intensity 0.76%; High Intensity 0.39%; Open Space 6.22%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply
Soils: Dark, calcareous clay, sandy loam, loam with clay subsoils, dark red sandstone, light tan and gray sandstone
Permitted Wastewater Treatment Facilities: Domestic 7, Land Application 2, Industrial 2

available shoreline. Due to proximity of this segment to the recent zebra mussel finding in Canyon Lake, the Texas Parks and Wildlife Department (TPWD) and the GBRA have partnered to proactively perform early detection monitoring for zebra mussel larvae in the hydroelectric lakes. As of the winter of 2018, no live zebra mussel larvae have been found in any of the hydro lakes, but TPWD DNA detections in Lake Dunlap and Lake McQueeney reinforce the need for vigilant monitoring in this area. The river surrounding these impoundments is wide and straight with minimal changes in direction.The portion of the segment downstream of the City of Seguin is less channelized and much more sinuous. The river in this segment experiences more frequent changes in direction and the water clarity decreases as the river transitions from the limestone substrates of the Edwards Plateau to the dark clays and silts of the Texas Blackland Prairie Ecoregion. This portion of the watershed is more sparsely inhabited and much of the land use in the area is associated with farming and ranching. The river also flows into the two hydroelectric impoundments of Lake Gonzales (H-4) and Lake Wood (H-5 Dam), which have are used for recreational fishing and boating.

WATER QUALITY

River segment 1804 has been divided by the TCEQ into five assessment units (AUs) that are each represented by one active monitoring station. The latest approved 2014 Texas Integrated Report of Surface Water Quality does not identify any water quality impairments or concerns in this segment. The historical data from all three active TCEQ monitoring stations were reviewed for statistical trends, comparing each monitoring parameter against time and stream flow for the period between December of 2002 and November of 2016. The stream flows for segment 1804 appeared to be significantly decreasing over time at three of the stations analyzed. The geometric mean of E. coli in all five assessment units of this segment was well below the contact recreation limit of 126 MPN/100 mL, but no statistical trends were observed. The observed geometric means of 51 MPN/100 mL at station 12596, 24 MPN/100 mL at station 15149, 27 MPN/100 mL at station 17134, 41 MPN/100 mL at station 21736 and 27 MPN/100 mL at station 15110, are all below the standard for the designated contact recreational use.

AU 1804_04 comprises the 8.1 mile portion of the River from the confluence with the Comal River to Lake Dunlap Dam. There are three domestic wastewater discharges that contribute to the water quality in this portion of the river. The New Braunfels Utilities (NBU) operates two wastewater treatment facilities (WWTFs) located off Kuehler Avenue in the City of New Braunfels. Both treatment plants discharge into an unnamed tributary that flows into the Guadalupe River approximately 1.2 miles downstream of IH 35. The NBU North Kuehler WWTF is permitted to treat up to 3.1 million gallons per day (MGD). The NBU South Kuehler WWTF is permitted to discharge up to 4.2 MGD. Both wastewater facilities treat the effluent to ensure that the daily average for biochemical oxygen demand (BOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, total phosphorus does not exceed 3 mg/L and E. coli does not exceed 126 MPN/100 mL. The North Kuehler WWTF also confirms that free cyanide concentrations do not exceed a daily average of 0.018 mg/L. In March of 2016 NBU performed a 60 day shutdown of the North Kuehler WWTF in order to construct new dissolved oxygen control system and replace older parts. The South Kuehler plant was temporarily retrofitted with a more powerful aeration system in order to handle any additional loading from the plant. NBU also performed daily effluent monitoring to ensure effective treatment of the effluent into Lake Dunlap. The GBRA also operates one WWTF facility off Farm to Market 725 in this AU. The GBRA facility is permitted to discharge up to 0.95 MGD of effluent into Lake Dunlap approximately 0.7 miles upstream of the Dunlap Dam. The effluent from this plant is treated to ensure that water quality parameters of the discharge do not exceed average daily concentration of 10 mg/L of BOD, 15 mg/L of TSS, 2 mg/L of ammonia nitrogen, 1 mg/L of total phosphorus, and 126 MPN/100 mL of E. coli. The GBRA routinely samples one surface water quality monitoring station in each TCEQ assessment unit. Station 12596 is located on the most upstream assessment unit (AU) 1804_04 on the northwest bank of Lake Dunlap. This station was monitored by the TCEQ from 1980 until 1990, when the GBRA began its current monthly monitoring regime. This segment has an E. coli geometric mean of 51 MPN/100 mL for the data analyzed from December of 2002 to November of 2016, which is below the standard for the current contact recreational use. The only long term trend in water quality that was observed at this station was a significant increase in nitrate nitrogen over time (Figure 1). This increase in nitrate nitrogen concentrations is most likely due to influence from wastewater treatment in this segment as effluent loads rise as a result of population growth. An efficient wastewater treatment facility converts ammonia nitrogen waste into nitrate nitrogen, which is subsequently discharged. Nitrate nitrogen is the form of nitrogen most readily usable by aquatic life. The average nitrate nitrogen concentration for the 164 data points assessed was 1.17 mg/L, which was well below the TCEQ screening criteria of 1.95 mg/L and human health criteria of 10 mg/L.

AU1804_03 is the 7.6 mile portion of segment 1804 located downstream of the Lake Dunlap dam to the Lake McQueeney Dam. This portion of the segment is represented by the routine monitoring station 15149. This station has been monitored monthly by the GBRA since 1997. An analysis of the data from December of 2002 to November of 2016 revealed that chlorophyll a concentrations are significantly increasing over time at this station (Figure 2). Chlorophyll a is a green pigment that is produced by aquatic plants and algae and used by the TCEQ as an indicator of nutrient loading. The chlorophyll a levels also appear to have a significant inverse relationship with stream flow (Figure 3). The stream flow in this AU was also noted to be significantly decreasing over time (Figure 4), which may be responsible for the increase in chlorophyll a levels along with the increase in available nitrate nitrogen that was noted in the upstream AU 1804_04. These slower moving waters and available nutrients may be providing conditions that are more conducive to algae growth. This AU will likely experience increased influence from treated wastewater in the future, as a new treatment facility was constructed by the NBU on the hydroelectric diversion canal for Lake Dunlap. This facility is permitted to discharge up to 4.9 MGD of treated effluent into either the Lake Dunlap hydroelectric diversion canal or the portion or the river channel approximately 0.6 miles downstream of Dunlap Dam. This effluent will be treated to at a daily average of water quality parameter concentrations not to exceed CBOD of 10 mg/L, TSS of 15 mg/L, ammonia nitrogen of 3 mg/L, total phosphorus of 1 mg/L and E. coli of 126 MPN/100 mL. This wastewater facility has been permitted to undergo two future expansions of capacity as demand from population growth in this area continues to increase. Each expansion in treatment capacity will also reduce the average daily permitted total phosphorus concentrations to 0.75 mg/L at 7.5 MGD and 0.5 mg/L at 9.9 MGD.

AU 1804_02 represents the 27 mile long portion of the segment from Lake McQueeney Dam downstream to the confluence with Mill Creek in Guadalupe County. This AU travels through two hydrological impoundments at Lake Placid (TP-4 Dam) and Meadow Lake (Nolte Dam) as well as a historical impoundment on Max Starcke Reservoir in the City of Seguin. This AU receives the wastewater discharges from two treatment facilities operated by the City of Seguin. The Walnut Branch WWTF discharges into the Walnut Branch tributary that flows into the Guadalupe approximately 0.7 miles downstream of State Highway 123. The WWTF is permitted to discharge up to 4.9 MDG of effluent treated to 10 mg/L of CBOD, 15 mg/L of TSS, 3 mg/L of ammonia nitrogen and 126 MPN/100 mL of E. coli. A second WWTF is permitted to discharge up to 2.13 MGD of effluent to the Geronimo Creek tributary of the Guadalupe (1804A) immediately upstream of the confluence with the Guadalupe River. The Geronimo Creek WWTF is permitted to discharge effluent treated to a BOD of 20 mg/L, TSS of 20 mg/L and E. coli of 126 MPN/100 mL. The only active monitoring station in AU 1804_02 is station 17134, which is located at the Farm to Market Road 1117 crossing of the Guadalupe downstream of the City of Seguin. Station 17134 was monitored by TCEQ on a quarterly basis from 1999 to 2015, at which point it monitoring duties were transferred to

CONTINUED ON PAGE 68

GBRA. An analysis of the data at this station identified two notable trends over time. The stream flow at this location is also declining over time (Figure 5). The chloride concentrations are increasing over time and show a significant inverse correlation with stream flow (Figures 6 & 7). The nitrate nitrogen levels are significantly decreasing over time at this station and no correlation was found between this parameter and stream flow (Figure 8) The decrease in nitrate nitrogen may be due to additional nutrient uptake by invasive aquatic plants such as Hydrilla (Hydrilla verticillata) that have covered large portions of the substrate near this monitoring station.

AU 1804_05 is the longest AU in river segment 1804. This AU flows for 33 miles from the confluence with Mill Creek in Guadalupe County to the Confluence with Clemens Creek in Gonzales County. This portion of the segment is much more riverine than the assessment units upstream with faster moving water and many meandering twists and turns. The only impoundment in this AU is Lake Gonzales (H-4 Dam). The H-4 Dam is located approximately 3.5 miles upstream of the confluence with Clemens Creek. This segment of the Guadalupe River has been colonized by several invasive species of plants including Hydrilla (Hydrilla verticillata), Water Hyacinth (Eichhornia crassips) and Water Lettuce (Pistia Stratiotes). The GBRA has actively attempted to remove these species by lowering lake levels on H-4 Dam during freezing temperatures in order to kill Water Hyacinth on the surface. The GBRA has also partnered with the TPWD in order to treat these species by releasing triploid Grass Carp and applying aquatic herbicides. These efforts have provided temporary seasonal suppression, but annual treatments are still needed to prevent the growth and spread of these invasive species. The only active monitoring station in the reach of 1804_05 is station 21736, which is located 200 meters downstream of the H-4 Dam. Quarterly routine monitoring was initiated by the GBRA at this station in September of 2015. The current water quality conditions in this AU were difficult to ascertain because the data set available for analysis was limited to 5 data points. The average concentrations of all water quality monitoring parameters analyzed did not indicate any exceedances of TCEQ stream standards.

The most downstream AU in segment 1804 is AU 1804_01, which represents the 25 mile long portion of the river from the confluence with Clemens Creek to the confluence with the San Marcos River (Segment 1808). The hydrology of this AU is very similar to AU 1804_05, with a twisting river channel and one hydroelectric impoundment on Lake Wood (H-5 Dam). The hydrology of this AU was significantly changed in March of 2016, when flood waters caused one of the gates on the dam that impounds Lake Wood (H-5 Dam) to be damaged. As a result of this damage, Lake Wood drained into the original river channel. Increased velocities were observed in the old channel and previously wetted portions of the lake are now dry. The only active monitoring station in this AU is Station 15110, which is located immediately downstream of the H-5 Dam. Station 15110 has been monitored monthly by GBRA from 1996 till September of 2015 when the sampling interval at this station was decreased to a quarterly basis. This data from station 15110 was analyzed for water quality trends and several changes over time were discovered. The stream flow at this station is significantly decreasing over time (Figure 9). The chloride concentrations at this station are increasing over time and inversely correlate with stream flow (Figures 10 & 11). The dissolved oxygen and nitrate nitrogen concentrations are both decreasing over time (Figures 12 & 13). These parameters are not significantly correlated with stream flow, but are positively correlated with each other (Figure 14). The dissolved oxygen and nitrate nitrogen may both be impacted by the invasive aquatic plants that that have inhabited this AU. The Hydrilla and Water Hyacinth found in Lake Wood may be consuming a portion of the available nitrate nitrogen. Water Hyacinth forms mats on the surface of the water body, which have been documented to block air exchange from the atmosphere and may lead to diminished concentrations in the water column.

GUADALUPE RIVER BELOW COMAL RIVER

Table 1

Station 12596 – Lake Dunlap at AC's Place 12/2002 - 11/2016					
AU 1804_04 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.5	30.6	14.6	164	32.2
pH	7.9	8.4	7.5	164	6.5 – 9.0
Chloride (mg/L)	19.3	41.3	9.42	164	100.00
Sulfate (mg/L)	25.8	35.1	9.7	164	50.00
Total Dissolved Solids (mg/L)	351	458	255	164	400.00
NH3-N (mg/L)	<0.10	0.38	<0.02	93	0.33
Total Phosphorus (mg/L)	<0.05	0.40	<0.02	164	0.69
Chlorophyll-a (µg/L)	2.7	27.5	<1.0	163	14.1
Nitrate Nitrogen (mg/L)	1.17	2.04	0.15	164	1.95
TKN (mg/L)	0.33	1.00	<0.20	77	N/A
AU 1804_04 Recreational Use					
E. coli (MPN/100 mL)	51 Geomean	2400	3	163	126 Geomean
AU 1804_04 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.5	15.3	6.3	163	≥3.0 Minimum & ≥5.0 Average

Table 2

Station 15149 – Lake McQueeney at Hot Shot's 12/2002 - 11/2016					
AU 1804_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	23.0	33.0	11.8	169	32.2
pH	7.9	13.5	4.9	169	6.5 – 9.0
Chloride (mg/L)	19.1	33.5	5.6	165	100.00
Sulfate (mg/L)	25.6	35.3	11.2	165	50.00
Total Dissolved Solids (mg/L)	336	389	174	169	400.00
NH3-N (mg/L)	<0.10	0.70	<0.02	90	0.33
Total Phosphorus (mg/L)	<0.05	0.52	<0.02	164	0.69
Chlorophyll-a (µg/L)	7.3	43.4	<1.0	164	14.1
Nitrate Nitrogen (mg/L)	0.88	1.82	0.05	164	1.95
TKN (mg/L)	0.4	1.2	<0.2	77	N/A
AU 1818_03 Recreational Use					
E. coli (MPN/100 mL)	24 Geomean	43.4	<1	164	126 Geomean
AU 1818_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.2	13.5	4.9	168	≥3.0 Minimum & ≥5.0 Average

Table 3

Station 17134 – Guadalupe River at FM 1117 02/2003 - 10/2016					
AU 1804_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	23.2	31.1	10.5	53	32.20
pH	8.1	8.4	7.5	52	6.5 – 9.0
Chloride (mg/L)	19.8	27.0	11.0	54	100.00
Sulfate (mg/L)	27.0	33.0	15.0	54	50.00
Total Dissolved Solids (mg/L)	330	394	124	53	400.00
NH3-N (mg/L)	<0.10	0.21	<0.05	53	0.33
Total Phosphorus (mg/L)	0.09	0.19	<0.02	50	0.69
Chlorophyll-a (µg/L)	6.0	15.8	1.0	40	14.1
Nitrate Nitrogen (mg/L)	1.27	2.13	<0.04	53	1.95
TKN (mg/L)	0.35	1.02	<0.2	52	N/A
AU 1804_02 Recreational Use					
E. coli (MPN/100 mL)	27 Geomean	920	3	48	126 Geomean
AU 1804_02 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.3	14.8	6.7	53	≥3.0 Minimum & ≥5.0 Average

Table 4

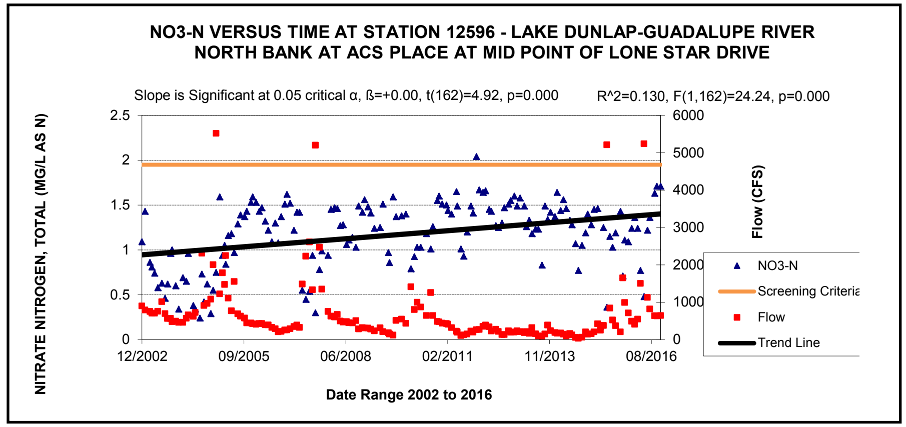
Station 21736 – Guadalupe River at H-4 Dam 09/2015 - 09/2016					
AU 1804_05 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.7	28.4	15.2	5	32.20
pH	8.0	8.0	7.9	5	6.5 – 9.0
Chloride (mg/L)	20.1	24.8	15.8	5	100.00
Sulfate (mg/L)	25.0	31.4	19.5	5	50.00
Total Dissolved Solids (mg/L)	332	357	284	5	400.00
NH3-N (mg/L)	<010	<0.10	<0.10	5	0.33
Total Phosphorus (mg/L)	<0.05	0.10	<0.04	5	0.69
Chlorophyll-a (µg/L)	4.7	14.5	1.5	5	14.1
Nitrate Nitrogen (mg/L)	0.99	1.34	0.53	5	1.95
TKN (mg/L)	0.43	0.62	0.34	5	N/A
AU 1804_05 Recreational Use					
E. coli (MPN/100 mL)	41 Geomean	100	11	5	126 Geomean
AU 1804_05 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.1	9.2	6.5	5	≥3.0 Minimum & ≥5.0 Average

GUADALUPE RIVER BELOW COMAL RIVER

Table 5

Station 15110 – Guadalupe River Downstream of H-5 Dam SW of Gonzales 12/2002 - 09/2016					
AU 1804_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.3	31.5	9.1	153	32.20
pH	7.9	8.4	7.2	152	6.5 - 9.0
Chloride (mg/L)	21.6	36.3	8.6	153	100.00
Sulfate (mg/L)	28.6	38.0	14.8	153	50.00
Total Dissolved Solids (mg/L)	326	395	200	152	400.00
NH3-N (mg/L)	<0.10	0.33	<0.02	82	0.33
Total Phosphorus (mg/L)	<0.05	0.70	<0.02	152	0.69
Chlorophyll-a (µg/L)	3.8	13.5	<1.0	152	14.1
Nitrate Nitrogen (mg/L)	0.78	1.83	<0.05	153	1.95
TKN (mg/L)	0.38	1.97	<0.2	64	N/A
AU 1804_01 Recreational Use					
E. coli (MPN/100 mL)	27 Geomean	4100	<1	151	126 Geomean
AU 1804_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.6	12.9	5.2	152	≥3.0 Minimum & ≥5.0 Average

Figure 1



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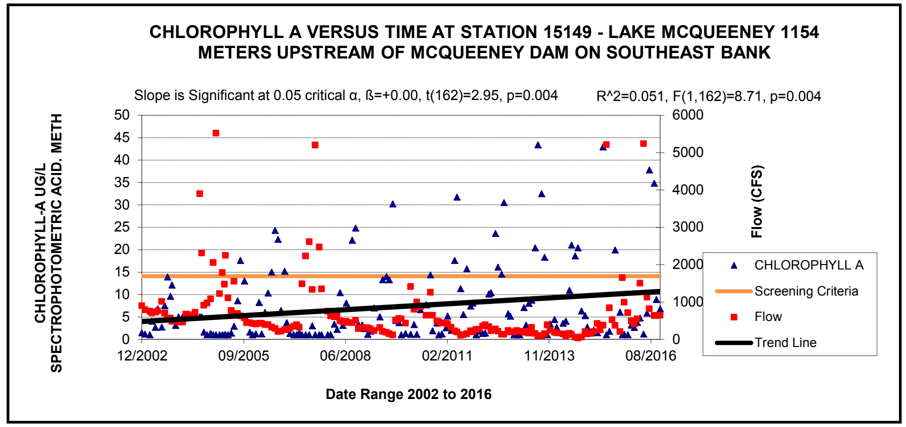

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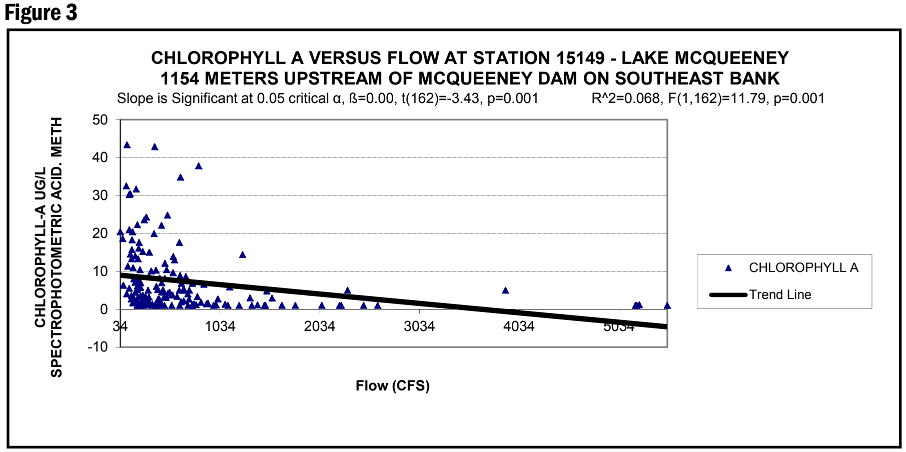
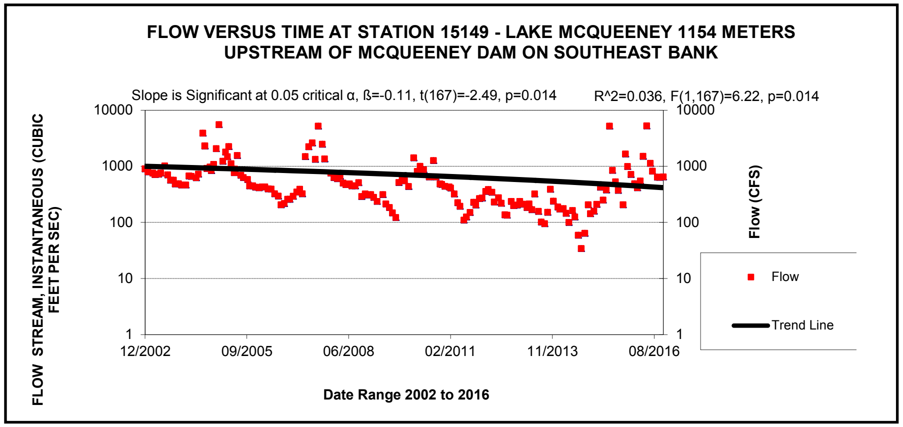


GUADALUPE RIVER BELOW COMAL RIVER

Figure 4



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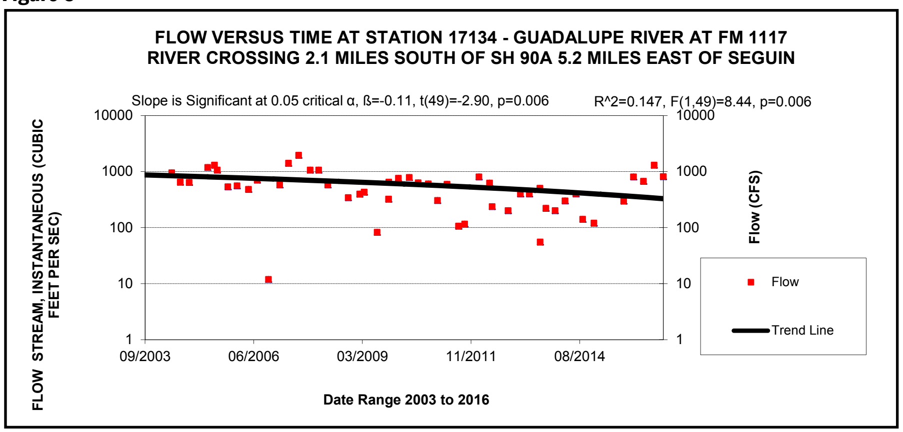

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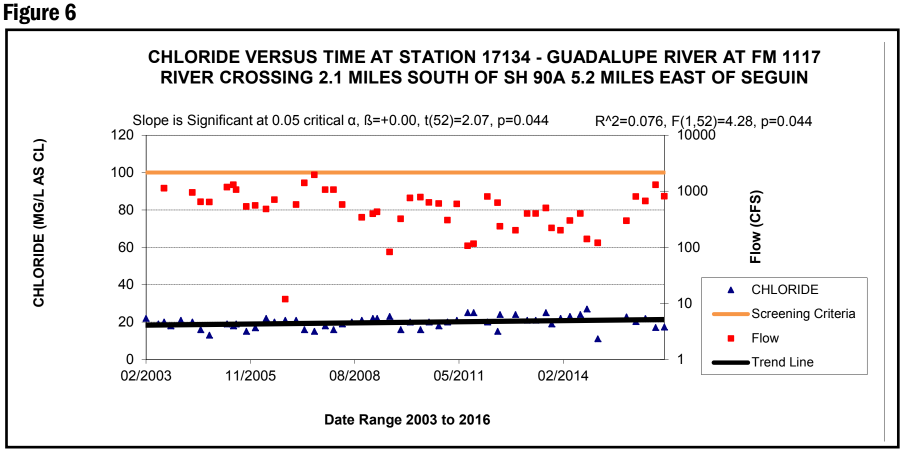

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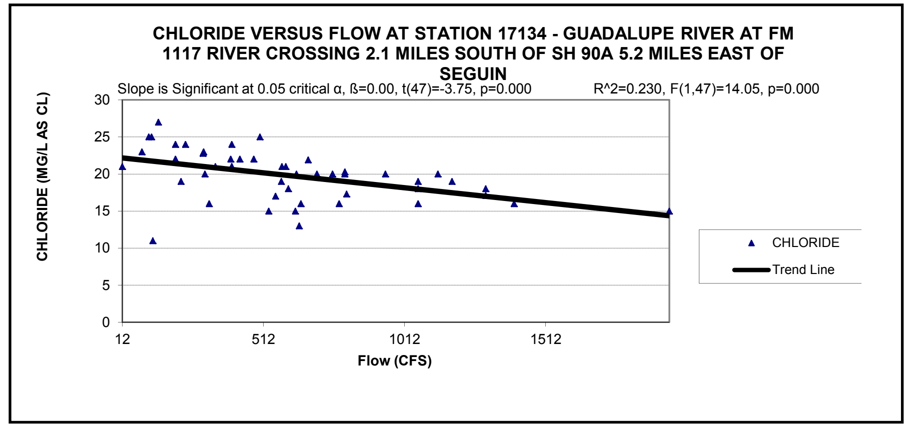

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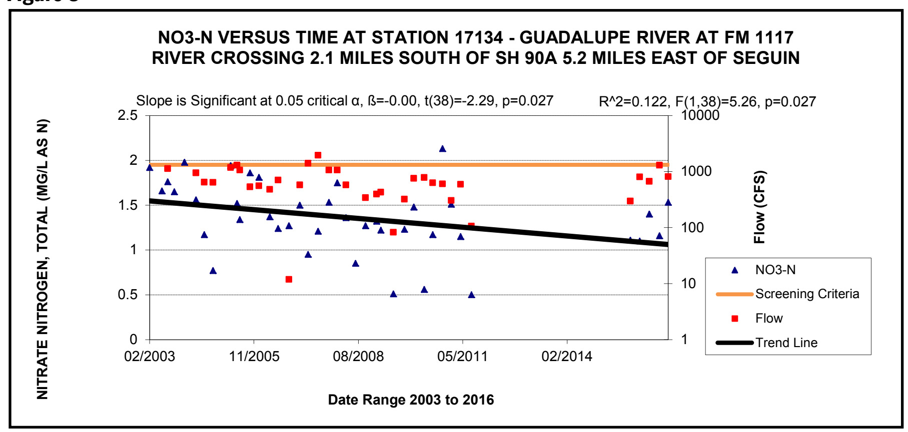

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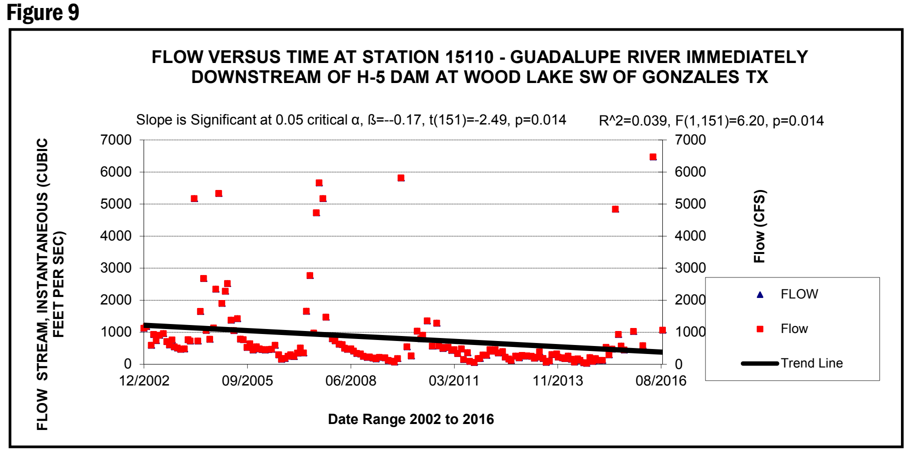
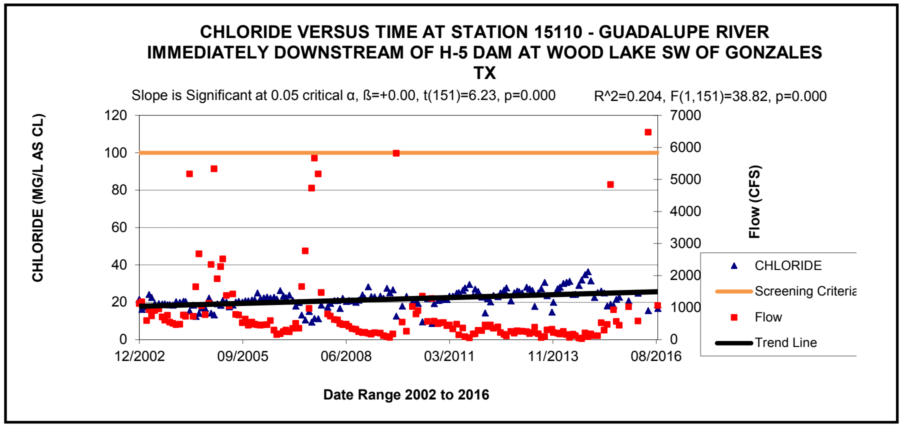


GUADALUPE RIVER BELOW COMAL RIVER

Figure 10



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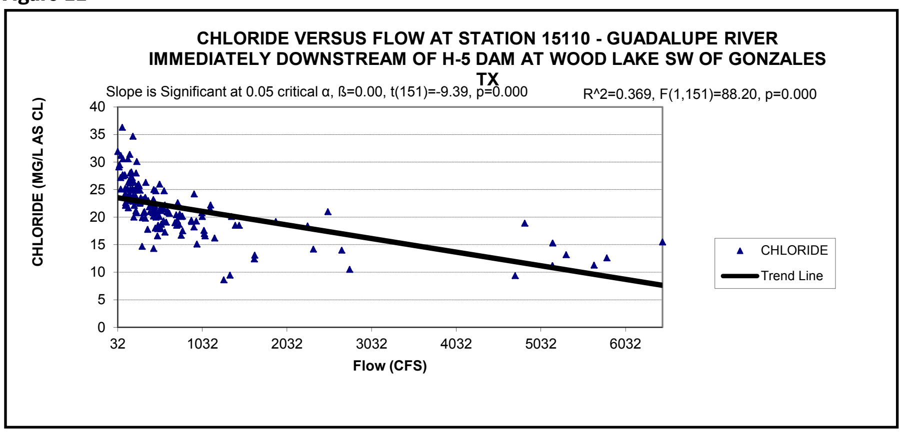

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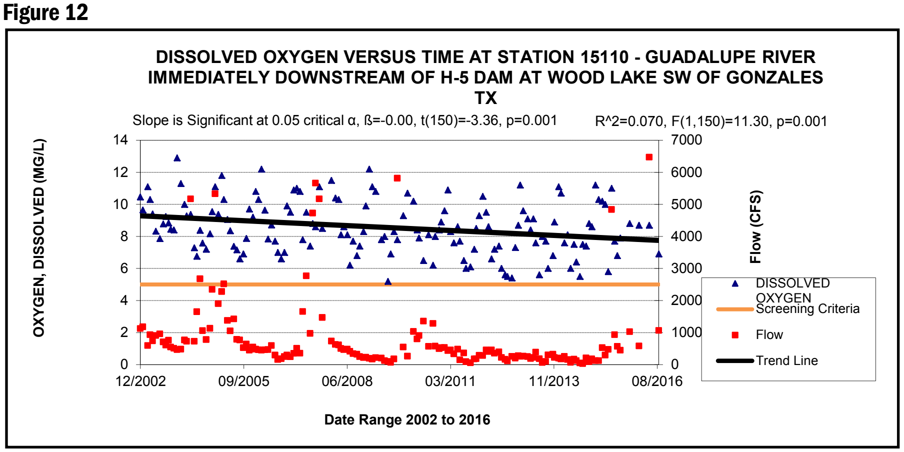

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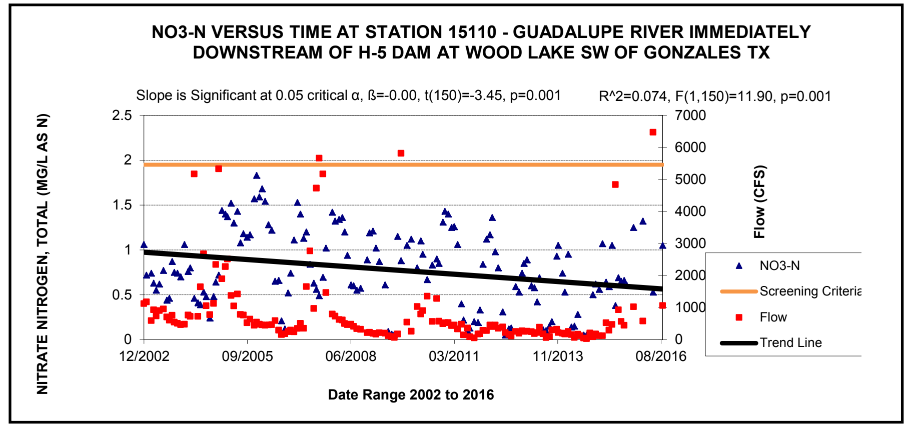

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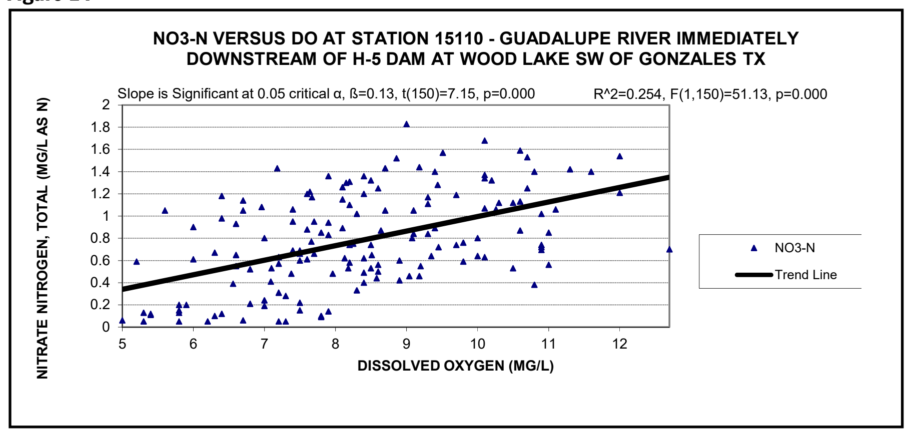
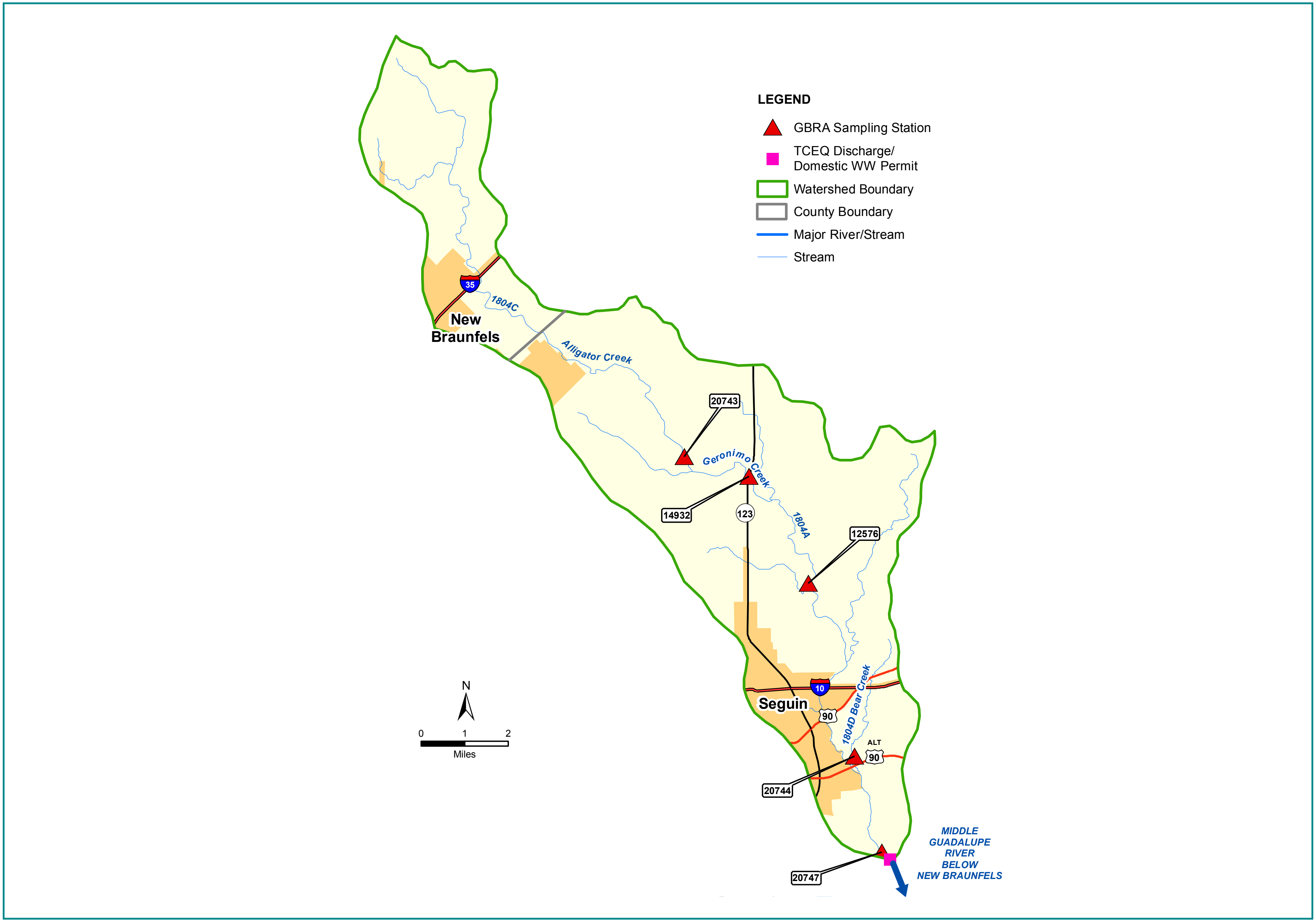


GUADALUPE RIVER BELOW COMAL RIVER

GERONIMO CREEK



GERONIMO CREEK

Segment 1804A (Geronimo Creek): Geronimo Creek and its tributary, Alligator Creek, are located in Comal and Guadalupe Counties, almost entirely within the Extra-territorial jurisdictions (ETJ) of the cities of New Braunfels and Seguin. ETJs are the unincorporated areas contiguous to the Cities, in which some municipal regulatory authority may be exercised. The almost 70-square mile watershed has its headwaters in southeastern Comal County. Alligator Creek is intermittent with pools. Geronimo Creek's flow is sustained by two major springs, the Timmermann Spring and an unnamed spring, coming from the Leona Aquifer and the alluvium. The creek flows through the Blackland Prairies Ecoregion. Land use in the watershed is transitioning from predominantly agriculture to urban development.

The GBRA began monitoring in Geronimo Creek near the confluence with Alligator Creek at State Highway 123 (station 14932) in October of 1996 for the Clean Rivers Program. Monitoring at station 14932 was discontinued in September of 2003, when the GBRA began monitoring at a new station approximately 4.0 miles downstream on Haberle Road (station 12576). GBRA monitoring activities were relocated to station 12576 in 2003 because the TCEQ designated this station as an ecoregion reference location. The GBRA continues to maintain routine monthly CRP monitoring at this station.

The Geronimo Creek Segment 1804A was listed on the Texas 303(d) list of impaired water bodies, as required by Clean Water Act Sections 303(d) and 305(b) in 2006. The entire water body was found to be impaired for contact recreation with an E. coli geometric mean of 162 MPN/100 mL. The stream was also noted to have concerns for Nitrate Nitrogen at this time because all measurements exceed the screening criteria of 1.95 mg/L. In 2008, the Texas State Soil and Water Conservation Board (TSSWCB), GBRA and Texas AgriLife Extension began working with local stakeholders to develop a Watershed Protection Plan (WPP) for the Geronimo Creek and contributing Alligator Creek tributary. The TSSWCB also funded additional water quality monitoring in the watershed to facilitate the development of the WPP by filling data gaps to supplement the existing CRP monitoring program. This plan was designed to address the known water quality impairments and concerns in the watershed. In September 2012, the WPP became only the third plan in the state of Texas to be accepted by the EPA as meeting all guidance requirements. The plan identified a number of implementation activities that could be voluntarily undertaken by stakeholders in order to reduce bacteria and nutrient loading in the watershed, including nutrient management training, pet waste management, and storm system convenience system assessments. Following the acceptance of the plan the TSSWCB has funded additional monitoring projects that have been used to quantitatively track the effectiveness of water quality restoration implementation activities over time. The latest 2014 Texas Integrated Report of Surface Water Quality lists a geometric mean of E. coli concentrations of 187

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Geronimo Creek
Drainage Area: 69 square miles
Length: 17 miles
Tributaries: Alligator Creek (1804C), Bear Creek (1804D),
Aquifer: Edwards Balcones Fault Zone, Carrizo Wilcox
River Segments: 1804A, 1804C, 1804D
Cities and Communities: New Braunfels, Seguin, Geronimo
Counties: Comal, Guadalupe
EcoRegion: Edwards Plateau, Texas Blackland Prairie
Climate: Average annual rainfall 34.48 inches, Average annual temperature 20.8°C
Vegetation Cover: Evergreen Forest 7.82%, Deciduous Forest 3.70%, Shrubland 13.06%; Grassland 21.25%; Woody Wetlands: 0.43% Cultivated Crops 40.45% ; Pasture Hay 6.34%
Land Uses: urban, suburban sprawl, light industry, and recreational.
Development: Low Intensity 0.79% ; Medium Intensity 0.41%; High Intensity 0.65%; Open Space 4.93%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and agriculture.
Soils: Dark, calcareous clay, clay with rocky outcrops,
Permitted Wastewater Treatment Facilities: Domestic 1, Land Application 0, Industrial 0

MPN/100 mL. This value has increased from the initial impairment in 2006. Nitrate nitrogen also remains a concern with an assessed mean of 9.54 mg/L. The TSSWCB also funded a nitrate isotope study, in which the GBRA and USGS conducted monitoring of the surface water, shallow groundwater and springs from the contributing Leona aquifer in order to determine the sources of nitrate nitrogen in the watershed. The results of this study showed that the majority of nitrate nitrogen in this watershed resulted from a mixture of nitrogen fertilizers and septic waste.

The only domestic wastewater permit in the watershed is operated by the City of Seguin. The outfall for this plant is located immediately upstream of the confluence of the Geronimo Creek with the Guadalupe River. The Geronimo Creek WWTF is permitted to discharge up to 2.13 million gallons per day (MGD) of effluent water that has been treated to permitted limits of 20 mg/L of biochemical oxygen demand (BOD), 20 mg/L of total suspended solids (TSS) and 126 MPN/100 mL of E. coli. The Geronimo Creek WPP stakeholders determined that this facility was not a major influence on the water quality of the creek due to its location at the bottom of the watershed.

Water quality data was analyzed from the two historical Clean Rivers Program monitoring stations near the headwaters of the Geronimo Creek (station 14932 & 12576). Additional data analysis was also performed on the TSSWCB routine monitoring stations near the confluence with Guadalupe River (station 20747) and stations representative of the two major contributing tributaries of Alligator Creek (station 20743) and Bear Creek (station 20744). An analysis of the latest available data from these stations revealed that although the previously identified E. coli impairment was persistent throughout the Geronimo Creek watershed and its contributing Bear Creek tributary (185 MPN/100 mL), the Alligator Creek tributary was well below the contact recreation standard with a geometric mean of 69 MPN/100mL. The geometric mean for E. coli at the most upstream station (14932) was also more than twice the concentration (411 MPN/100 mL) of stations 12576 (182 MPN/100 mL) and 20747 downstream (194 MPN/100 mL). The nitrate nitrogen concentrations were highest at station 12576 (10.6 mg/L) and diminished near the confluence with the Guadalupe River (6.94 mg/L).

Several notable trends were identified at each of the monitoring stations analyzed. The dissolved oxygen levels at the most upstream station (14932) on Geronimo Creek are significantly decreasing with time and these concentrations are significantly correlated with changes in streamflow (Figures 1 & 2). The dissolved oxygen concentrations were also significantly decreasing over time at station 12576 downstream, which was also strongly correlated with stream flow (Figures 3 & 4). The most downstream station (20747) showed a significant increase in nitrate nitrogen over time (Figure 5) which was not explained by changes in stream flow, but may be an indicator of additional runoff in the area. The Bear Creek tributary at station 20744 is significantly increasing in conductivity over time (Figure 6). The Alligator Creek tributary at station 20743 on Huber Road is also significantly increasing in conductivity over time (Figure 7). The TKN concentration at station 20744 is also significantly decreasing over time (Figure 8). The decrease in TKN may be an early indicator that nutrient management implementation efforts associated with the WPP may be reducing fertilizer runoff in the upper agricultural dominant portions of the watershed. Additional implementation activities associated with WPP continue to be implemented throughout the watershed, but water quality improvements associated with these activities have been difficult to quantify due to the competing changes in water quality associated with rapid urbanization in the upper portion of the watershed.

GERONIMO CREEK

Table 1

Station 14932 – Geronimo Creek at SH 123 12/2002 - 06/2017					
AU 1804A_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.1	27.6	11.6	80	32.2
pH	7.6	8.3	7.2	80	6.5 – 9.0
Chloride (mg/L)	35.0	50.2	15.7	79	100.00
Sulfate (mg/L)	56.1	50.2	15.7	79	50.00
Total Dissolved Solids (mg/L)	508	590	255	80	400.00
NH3-N (mg/L)	<0.10	0.94	<0.02	71	0.33
Total Phosphorus (mg/L)	<0.05	0.34	<0.02	79	0.69
Chlorophyll-a (µg/L)	1.6	13.2	<1.0	74	14.1
Nitrate Nitrogen (mg/L)	7.90	11.3	0.09	66	1.95
TKN (mg/L)	<0.2	0.99	<0.2	77	N/A
AU 1804A_01 Recreational Use					
E. coli (MPN/100 mL)	411 Geomean	12,000	72	75	126 Geomean
AU 1804A_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.2	12.3	5.2	79	≥3.0 Minimum & ≥5.0 Average

Table 3

Station 20747 – Geronimo Creek at Hollub Road near Guadalupe Confluence 05/2009 – 06/2017					
AU 1804A_01 General Use					
Parameter Table 3	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.8	29.6	7.4	66	32.20
pH	7.8	8.1	7.1	66	6.5 – 9.0
Chloride (mg/L)	31.8	51.9	8.7	66	100.00
Sulfate (mg/L)	62.9	93.1	16.2	66	50.00
Total Dissolved Solids (mg/L)	455	610	188	66	400.00
NH3-N (mg/L)	<0.10	0.45	<0.10	66	0.33
Total Phosphorus (mg/L)	0.10	2.87	<0.02	66	0.69
Chlorophyll-a (µg/L)	1.6	17.2	<1.0	65	14.1
Nitrate Nitrogen (mg/L)	6.9	13.7	<0.05	66	1.95
TKN (mg/L)	0.3	1.5	<0.2	52	N/A
AU 1804A_01 Recreational Use					
E. coli (MPN/100 mL)	194 Geomean	11,000	24	66	126 Geomean
AU 1804A_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.1	13.8	4.7	65	≥3.0 Minimum & ≥5.0 Average

Table 2

Station 12576 – Geronimo Creek at Haberle Road 12/2002 – 06/2017					
AU 1804A_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.3	28.9	8.8	168	32.2
pH	7.8	8.2	7.3	168	6.5 – 9.0
Chloride (mg/L)	36.2	48.9	4.7	159	100.00
Sulfate (mg/L)	62.1	85.0	7.4	159	50.00
Total Dissolved Solids (mg/L)	521	715	147	166	400.00
NH3-N (mg/L)	<0.10	1.13	<0.02	109	0.33
Total Phosphorus (mg/L)	<0.05	0.66	<0.02	160	0.69
Chlorophyll-a (µg/L)	1.6	12.5	<1.0	155	14.1
Nitrate Nitrogen (mg/L)	10.6	17.4	0.05	155	1.95
TKN (mg/L)	0.4	4.0	<0.2	87	N/A
AU 1804A_01 Recreational Use					
E. coli (MPN/100 mL)	182 Geomean	16,000	44	154	126 Geomean
AU 1804A_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.7	13.0	6.6	168	≥3.0 Minimum & ≥5.0 Average

Table 4

Station 20743 – Alligator Creek at Huber Road near Geronimo Confluence 05/2009 – 06/2017					
AU 1804C_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.5	34.0	6.5	66	32.20
pH	7.6	8.7	6.9	66	6.5 – 9.0
Chloride (mg/L)	12.3	25.6	3.2	66	100.00
Sulfate (mg/L)	23.0	84.9	3.4	66	50.00
Total Dissolved Solids (mg/L)	345	509	133	66	400.00
NH3-N (mg/L)	<010	0.94	<0.10	66	0.33
Total Phosphorus (mg/L)	<0.08	0.27	<0.05	66	0.69
Chlorophyll-a (µg/L)	68.8	30.8	<1.0	66	14.1
Nitrate Nitrogen (mg/L)	3.08	18.2	<0.05	66	1.95
TKN (mg/L)	0.8	1.8	<0.2	66	N/A
AU 1804C_01 Recreational Use					
E. coli (MPN/100 mL)	69 Geomean	24,000	<1	66	126 Geomean
AU 1804C_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.1	17.6	1.6	65	≥3.0 Minimum & ≥5.0 Average

GERONIMO CREEK

Table 5

Station 20744 – Bear Creek at East Walnut Street 05/2009 – 06/2017					
AU 1804D_01 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (°C)	18.9	28.3	7.5	37	32.20
pH	7.6	8.6	7.2	37	6.5 – 9.0
Chloride (mg/L)	46.8	148	4.1	37	100.00
Sulfate (mg/L)	73.6	272	6.6	37	50.00
Total Dissolved Solids (mg/L)	434	1,053	103	37	400.00
NH3-N (mg/L)	0.17	0.43	<0.10	37	0.33
Total Phosphorus (mg/L)	0.14	0.55	0.03	37	0.69
Chlorophyll-a (µg/L)	4.1	17.8	<1.0	36	14.1
Nitrate Nitrogen (mg/L)	0.50	8.36	<0.05	37	1.95
TKN (mg/L)	0.8	1.6	<0.2	24	N/A
AU 1804D_01 Recreational Use					
E. coli (MPN/100 mL)	185 Geomean	12,000	4	37	126 Geomean
AU 1804D_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	5.9	12.1	1.1	36	≥3.0 Minimum & ≥5.0 Average

Figure 1

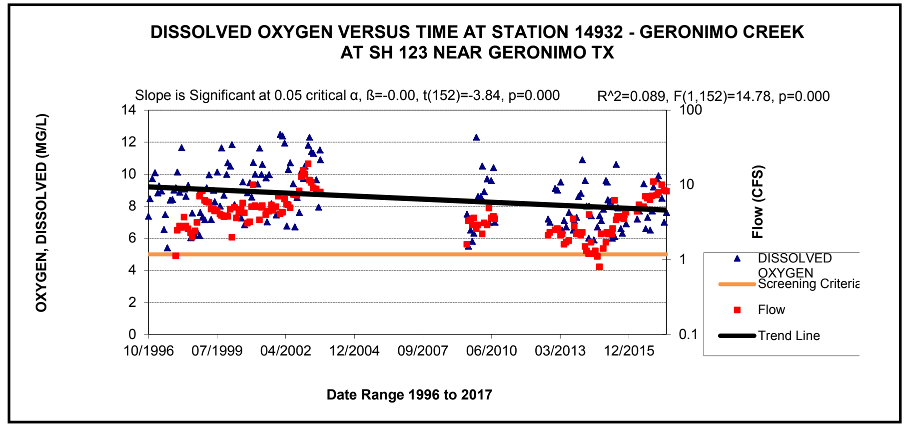


Figure 2

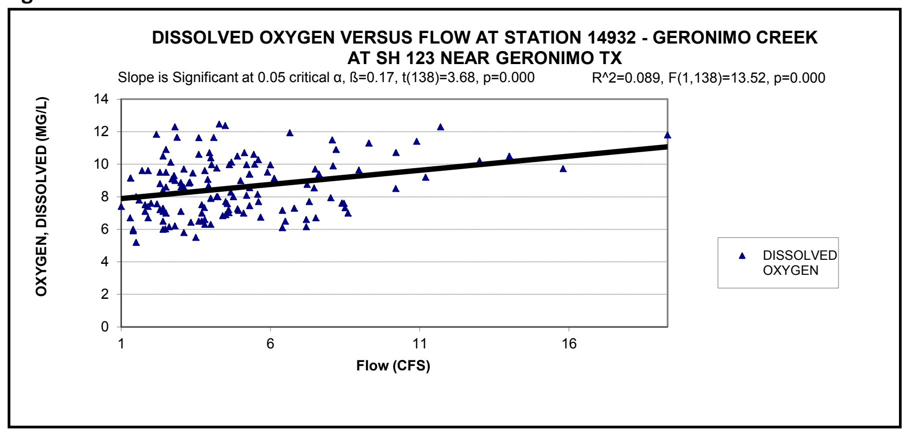
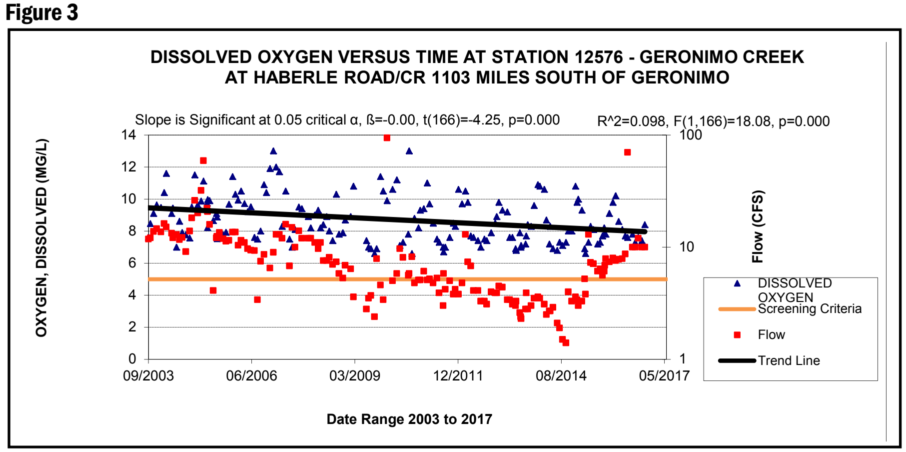


Figure 3



GERONIMO CREEK

Figure 4

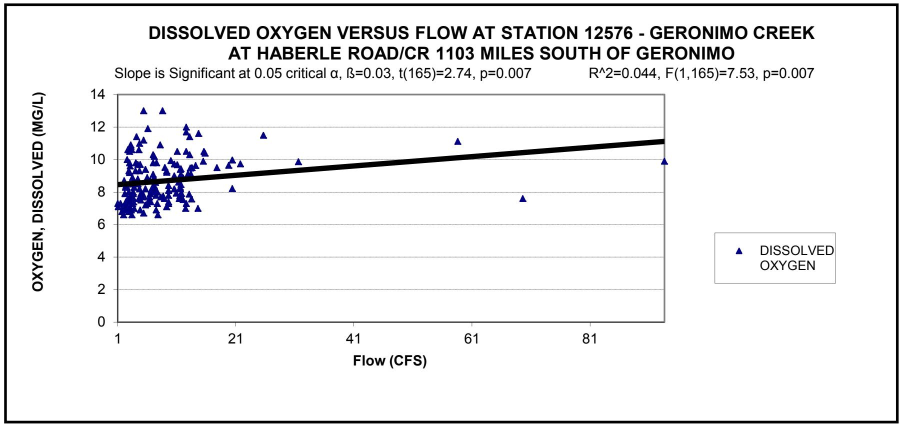
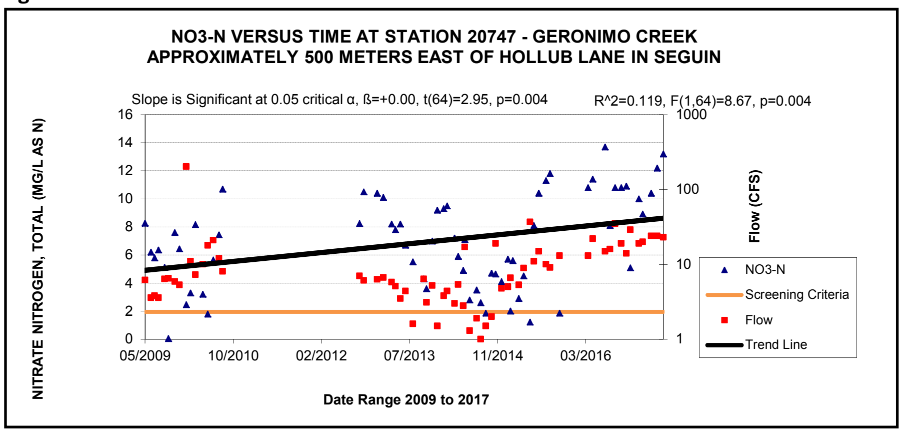


Figure 5



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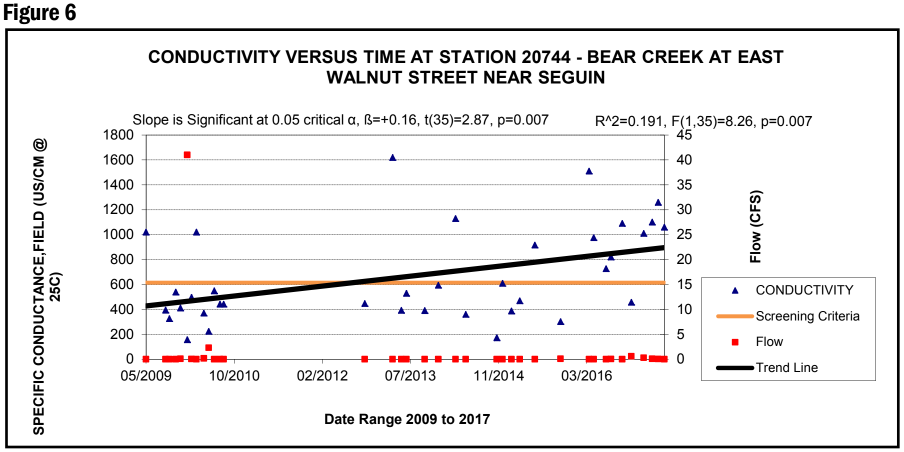

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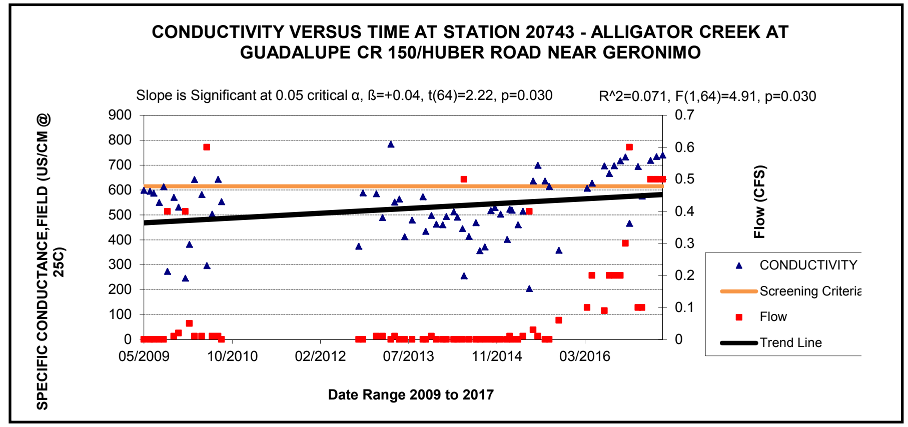

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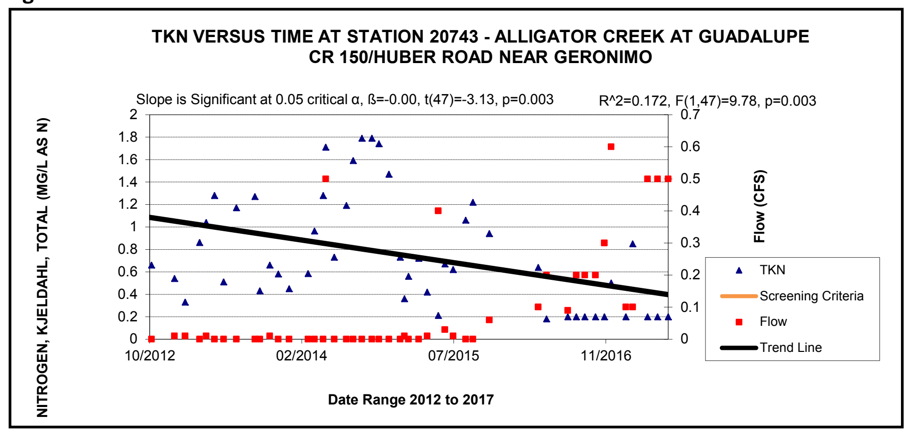
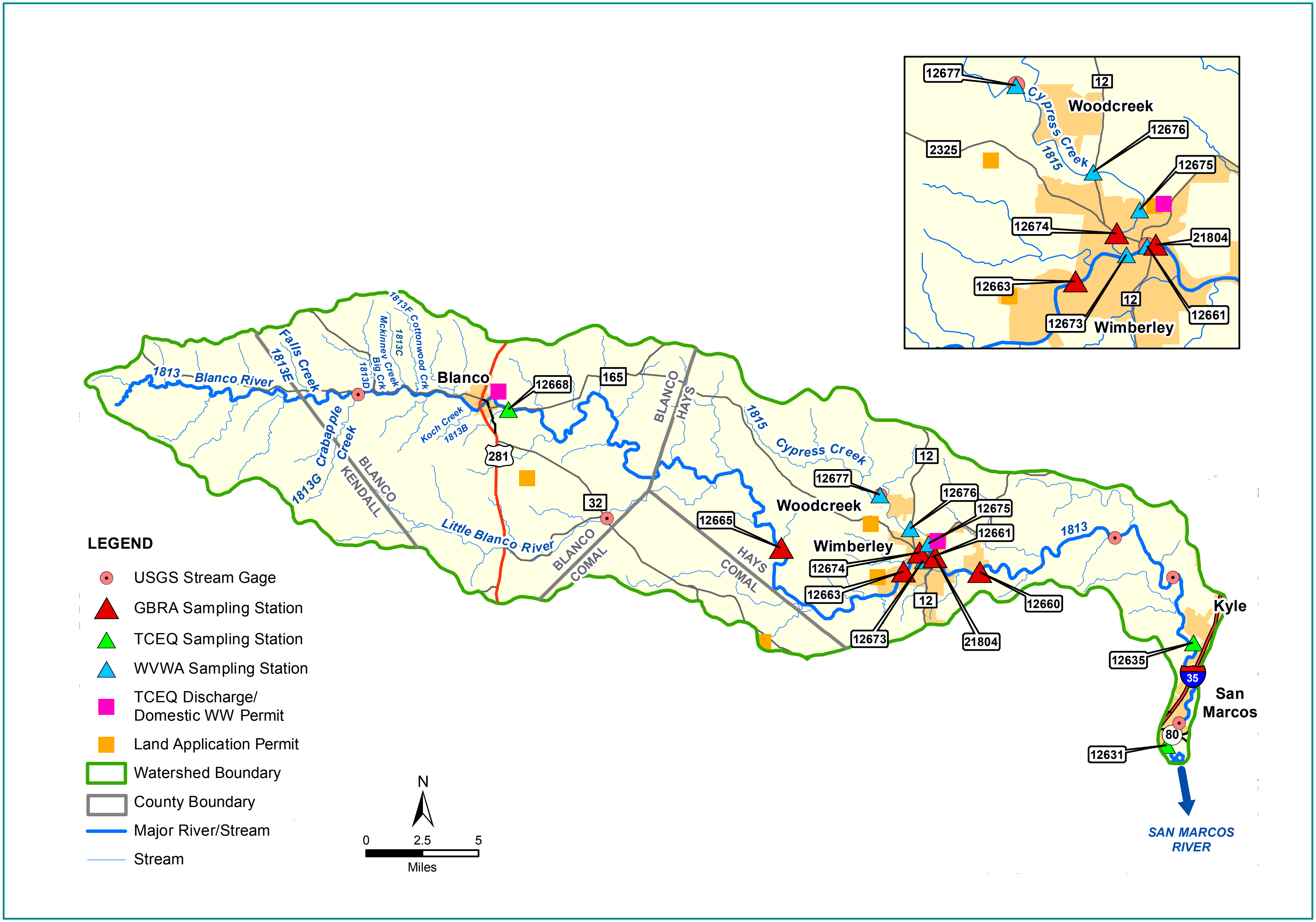



12677
12
Woodcreek
Cypress Creek
1815
12676
2325
12675
12674
21804
12663
12
12673
Wimberley
12661
1813
Blanco River
Falls Creek
1813E
1813F Cottonwood Crk
1813C
Mckinney Creek
Big Crk
1813D
Blanco
12668
165
Koch Creek
1813B
Crabapple Creek
1813G
BLANCO
KENDALL
281
32
Little Blanco River
BLANCO
COMAL
BLANCO
HAYS
1815
Cypress Creek
12
12677
12676
12675
12661
Woodcreek
12665
Wimberley
12674
12663
HAYS
COMAL
12
12673
21804
12660
1813
Kyle
12635
35
San Marcos
80
12631
SAN MARCOS RIVER
LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Sampling Station
WVWA Sampling Station
TCEQ Discharge/ Domestic WW Permit
Land Application Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream
N
0
2.5
5
Miles

BLANCO RIVER

Segment 1813 is the 71 mile long Upper Segment of the Blanco River. This spring-fed stream is located entirely on the Edwards Plateau. The majority of the segment exhibits limestone substrate with occasional gravel, silt, or clay strata. The limestone is known to contain gypsum deposits, which can contribute to high sulfate concentrations in groundwater. The stream has historically displayed exceptional water quality and usually exhibits extremely clear water as it travels from Kendall County to Lime Kiln Road in Hays County. In general, most water quality concerns in this segment of the Blanco River are linked to changes in stream flow. The upper portions of the river have been known to go dry during prolonged periods of drought and the banks and substrate of the entire segment exhibit significant scouring during extended wet periods. This stream segment also accepts the discharge from the classified Cypress Creek (1815) tributary in the City of Wimberley.

Segment 1815 represents Cypress Creek, which is a 15.7 mile long spring fed creek that flows through the City of Wimberley and accepts 38.3 square miles of drainage area before merging with the Upper Blanco River (1813). This stream is known for exceptional water quality with frequent contact recreational use in the many swimming holes along its length. The bald cypress that cover much of the riparian zone provide picturesque views and help to maintain a moderate temperature throughout out its length.

CONTINUED ON PAGE 82

Blanco River Watershed
Drainage Area: 435 square miles
Length: 89 miles
Tributaries: Meier Creek, Blackberry Creek, Delaware Creek, South Fork Blanco River, Falls Creek (1813E), Crabapple Creek (1813G), West Prong Big Creek (1813A), Clear Creek (1813I), East Prong Big Creek (1813H), McKinney Creek (1813C), Cottonwood Creek (1813F), Blasingame Creek, Hinds Branch, Koch Branch (1813B), Durham Branch, Flat Creek, Rogers Branch, Boardhouse Creek, Cove Branch, Rocky Creek, Little Blanco River, Wanslow Creek, Cedar Fork, Carpers Creek, Dutch Branch, Elm Creek, Pinoak Creek, Cypress Creek (1815), Deer Creek, Pierce Creek, Sycamore Creek , Lone Man Creek
Aquifer: Edwards Plateau
River Segments: 1813, 1815, 1809
Cities and Communities: Blanco, Fischer, Wimberley, Kyle, San Marcos
Counties: Kendall, Comal, Blanco, Hays
EcoRegion: Edwards Plateau, Texas Blackland Prairies
Climate: Average annual rainfall 34.83 inches, Average annual temperature 65.35°F
Vegetation Cover: Evergreen Forest 32.04%, Deciduous Forest 11.34%, Shrubland 38.43%; Grassland 14.30%; Woody Wetlands: 0.30% Cultivated Crops 0.57% ; Pasture Hay 0.64%

Land Uses: urban, agricultural crops (wheat, hay, oats, peaches and pecans), sheep, cattle, goat and turkey production; light manufacturing and recreation
Development: Low Intensity 0.57% ; Medium Intensity 0.19%; High Intensity 0.05%; Open Space 1.19%
Water Body Uses: Aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils: Thin limestone to black waxy, chocolate, and grey loam, calcareous, stony, and clay loams
Permitted Wastewater Treatment Facilities: Domestic 3, Land Application 0, Industrial 0
522 square miles
Length: 75 miles
Tributaries: Sink Creek, Sessom Creek, Purgatory Creek, Willow Springs Creek, Blanco River (1809), Morrison Creek, Dickerson Creek, Callihan Creek, York Creek, Brushy Creek, Highsmith Creek, Plum Creek (1810), Mule Creek, Canoe Creek, Smith Creek
Aquifer: Edwards-Balcones Fault Zone, Carrizo-Wilcox
River Segments: 1814, 1808
Cities and Communities: San Marcos, Maxwell, Martindale, Fentress, Prairie Lee, Luling, Ottine, Gonzales
Counties: Hays, Guadalupe, Caldwell, Gonzales,
EcoRegion: Edwards Plateau, Texas Blackland Prairies, Post Oak Savannah

BLANCO RIVER

Segment 1809 is the lower portion of the Blanco River that is primarily located on the Edwards Plateau, but enters the Blackland Prairies on the eastern edge of Hays County. This segment consists of limestone substrate with occasional stony and clay loams. The changes in elevation as the river crosses the Balcones fault increase the streamflow, but there are also several slow moving stretches throughout the segment before it merges with the San Marcos River. The water is primarily used for aquatic life, contact recreation and fish consumption. The land in the segment is used for farming, ranching, recreation, light manufacturing and urban development. The urban development of this segment is increasing at a rapid pace due to the river's location in the middle of the IH 35 corridor and its close proximity to the rapidly expanding cities of San Marcos and Kyle. The fast growing population in this area raises concerns about the growing amount of impervious cover and subsequent potential for non-point source pollution.

The Upper Blanco River, Segment 1809, has three permitted domestic wastewater discharges. The City of Blanco WWTF is permitted to discharge up to 0.225 MGD of treated effluent into the Blanco River. This effluent must meet permit limit concentrations of 30 mg/L of carbonaceous biochemical oxygen demand (CBOD), 90 mg/L of total suspended solids (TSS), 3 mg/L of ammonia nitrogen and 126 MPN/100 mL of E.coli. The Blanco water treatment plant is also permitted to discharge up to 0.050 MGD of filter backwash, which has a permitted TSS that does not exceed 20 mg/L and a permitted pH between 6.5 and 9.0 standard units. The Blue Hole wastewater treatment facility (WWTF) is was previously permitted to perform subsurface irrigation in order to dispose of treated effluent. The facility is undergoing construction and has been permitted to discharge up to 0.075 million gallons per day (MGD) into the Deer Creek tributary of the Blanco River downstream of the Ranch Road 12 crossing. This WWTF ensures that effluent concentrations do not exceed 5 mg/L of carbonaceous biochemical oxygen demand (CBOD), 5 mg/L of total suspended solids (TSS), 2 mg/L of ammonia nitrogen, 0.5 mg/L of total phosphorus, 126 MPN/100 mL of E. coli. The Wimberley Valley Watershed Association (WVWA) has added an additional monitoring (station 21804) 150 meters downstream of the Deer Creek confluence in order to record any changes in water quality as a result of this new wastewater influence. The WVWA also began monitoring TKN at station 12661 upstream of Deer Creek and 12660 downstream of Deer Creek, in order to gage any changes in Total Nitrogen of the river.

The Upper Blanco segment 1813 is divided into five assessment units (AUs) by the TCEQ. AU 1813_01 represents the portion of the river from a point 0.2 miles upstream of Lime Kiln Road in Hays County to the confluence with Spoke Pile Creek. The only monitoring station in this AU is station 12660 on the Blanco River at Hays CR 174 (Fulton Ranch Road). Station 12660 has been historically monitored by the TCEQ from 1983 until 2003, at which time the WVWA began monitoring this station. AU 1813_02 is the portion of the segment from the confluence with Spoke Pile Creek up to the confluence with Cypress Creek in Wimberley. This AU has been monitored on a quarterly basis since 2003 by the WVWA at station 12661. Station 12661 is located at the Ranch Road 12 crossing in Wimberley and was previously monitored by the TCEQ since 1968. Located immediately upstream of the Cypress Creek confluence, AU 1813_05 covers the portion of the segment between the confluence with Cypress Creek in Wimberley to the confluence with Rogers Branch in Hays County. AU 1813_05 has one active monitoring station 12663 at Hays CR 1492 at Pioneer Town. Station 12663 has been actively monitored by the WVWA since 2003 and station 12665 at Fischer Store Road has been monitored since 2011. AU1813_03 comprises the portion of the river between Rogers Branch and Hinds Branch in Blanco County. This AU has been monitored at station 12668 on Farm to Market Road 165, 0.5 miles east of the city of Blanco. Station 12668 has been alternatively monitored by the TCEQ and GBRA since 1983 and is currently monitored quarterly by the TCEQ. AU1813_04 is the upper portion of the segment between Hinds Branch in Blanco County and Meier Creek in Kendall County. This AU does not have any active monitoring stations. In the most recently published 2014 Texas Integrated Report of Surface Water Quality, no known water quality impairments or concerns were assessed in this river segment. An analysis of the data by GBRA from all four active monitoring stations in the segment revealed that several significant changes over time were occurring in this segment. The most upstream station 12668 showed significant change in pH over time, as well as a significant increase in chlorides and sulfates over time (Figures 1, 2, & 3). All three parameters showed an inverse relationship with streamflow (Figures 4, 5, & 6). Station 12660 upstream of the Cypress Creek confluence also showed a significant increase in pH over time that was inversely correlated with spring flow (Figures 7 & 8). Station 12661 downstream of the Cypress Creek confluence also showed an increase in pH over time, but temperature over time was also significantly increasing at this station (Figures 9 & 10). Station 12663 is the most downstream in this this segment, and has showed a significant increase in dissolved oxygen concentrations over time (Figure 11). All of the changes in this segment are most likely traceable due to slower moving water as a result of several years of drought conditions. The slower moving water and higher temperatures were conducive to the growth of green algae in the clear waters of the Blanco River. The increased pH and dissolved oxygen levels are consistent with a stream with increased photosynthetic activity, as carbonic acid is removed from the water column and dissolved oxygen is released.

The lower Blanco River Segment 1809 has been divided into two assessment units (AUs) by the TCEQ. AU 1809_01 covers the lower 7 miles of the segment from the confluence with the San Marcos River to International Highway 35. AU 1809_02 covers the upper 8 miles of the segment from IH 35 to Lime Kiln Road in Hays County. The only active surface water quality monitoring station for this segment is located in this AU. Station 12631 is located at the Hays County Road 295 crossing on the Blanco River. This station has been monitored by the TCEQ on a quarterly basis since 1983. In the most recently published 2014 Texas Integrated Report of Surface Water Quality, no known water quality impairments or concerns were identified in this river segment. The GBRA examined the water quality data from this station and discovered two notable trends over time. The specific conductance and dissolved oxygen at station 12631 were both increasing over time (Figures 12 & 13). These trends were also likely due to reduced influence from rainfall runoff as a result years of drought.

The Cypress Creek Segment 1815 is a spring fed tributary of the Upper Blanco that is assessed as two assessment units by the TCEQ. All of the monitoring stations in this segment are located in AU 1815_01, which is the flowing portion of Cypress Creek downstream of the headwater springs. The remaining AU 1815_02 comprises the upper 7 miles of the segment which is characterized by intermittent stream flows. Cypress Creek has five active monitoring stations in the perennial portion of the stream. The most downstream monitoring station 12673 is located at the confluence with the Blanco River. This station has been monitored by the Wimberley Valley Watershed Association (WVWA) since 2003. The next station upstream is 12674, which is located at the Ranch Road 12 crossing in the middle of the Wimberley town center. This station was monitored by the TCEQ and its predecessor agencies from 1973 to 1998, at which point monitoring was transferred to the GBRA under the Clean Rivers Program. Station 12675 has been monitored by the WVWA since 2005 at the Blue Hole Campground in the city of Wimberley. The WVWA has monitored station 12676 at the Ranch Road 12 crossing 1 mile north of Wimberley since 2002. The WVWA also monitored station 12677 at the Jacob's Well Spring near the headwaters of the creek since 2003. A watershed protection plan has been developed by the Meadows Center for Water and the Environment and local stakeholders to outline methods to maintain water quantity and quality of the Cypress Creek watershed in the face of rapid urbanization and development in Hays County. The plan was accepted by the EPA in 2016 and immediately became eligible for Clean Water Act Section 319 Grants. A three year, 1.34 million dollar implementation project began in 2017 with intent to reduce nonpoint source pollution runoff. The project included additional modeling and data collection efforts to determine future management efforts. The majority of the homes and businesses along the Cypress Creek are served by aging septic tanks and stakeholder concerns have been raised regarding a possible non-point source influence on the creek as these systems begin to fail. The 2014 Texas Integrated Report of Surface Water Quality identified aquatic life use concerns for depressed dissolved oxygen and impaired biological habitat. Both of these concerns may be traced to data collected by the GBRA during an aquatic life monitoring (ALM) event conducted during drought conditions. The ALMs performed in from 2011 to 2013 showed that the Index of Biotic Integrity for Habitat did not meet the exceptional designated aquatic life use for the Creek. The creek was

CONTINUED ON PAGE 84

experiencing intermittent spring flows during this time period, due to a prolonged period of drought and this event was not representative of normal flow conditions. The GBRA analyzed the water quality data from all five stations and found several trends over time. The most downstream station 12673 showed significant increases in specific conductance and nitrate nitrogen concentrations over time (Figures 14 & 15). Nitrate concentrations were also directly correlated with changes in stream flow (Figure 16). The next upstream station (12674) also had significant increases in conductivity, nitrates and E. coli over time (Figures 17, 18, & 19). The E. coli concentrations showed an inverse relationship with stream flow (Figure 20). This station is located closest to the Wimberley town center and the increasing E. coli numbers at this station may be the result of an urban influence from this immediate area, such as water fowl or septic tanks. The Blue Hole recreational area on the Cypress Creek was purchased by the City of Wimberley in 2005 and converted from private ranch land to a 126 acre master planned park, which finished construction in 2011.The Blue Hole station 12675 in Wimberley also showed an increase in conductivity over time (Figure 21). The conductivity change at this station may be the result sediment being suspended from increased use of the park. The Ranch Road 12 station 12676 (upstream of the influence from the town center) showed a decrease in dissolved oxygen over time (Figure 22), which may be due to reduced spring flows following several years of drought. The station 12677 at the Jacob Well headwater spring had a significant increase in dissolved oxygen over time and temperature over time (Figures 23 & 24). These changes were most likely due to changes in spring flow following several years of drought.

Table 1

Station 12660– Blanco River at CR 174 Fulton Ranch Road 02/2003 – 09/2016					
AU 1813_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.2	32.7	9.7	104	33.30
pH	8.2	9.3	7.3	103	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	300	499	222	104	400.00
NH3-N (mg/L)	<0.10	0.30	<0.02	89	0.33
Total Phosphorus (mg/L)	<0.05	0.13	<0.02	88	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.24	0.90	<0.02	93	1.95
TKN (mg/L)	0.23	0.29	<0.20	10	N/A
AU 1813_01 Recreational Use					
E. coli (MPN/100 mL)	39 Geomean	4,800	2	93	126 Geomean
AU 1813_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.1	12.8	0.6	101	≥4.0 Minimum & ≥6.0 Average

Table 2

Station 12661 – Blanco River at FM 12 at Wimberley 02/2003 – 09/2016					
AU 1813_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.5	36.5	10.7	96	33.30
pH	8.0	8.7	7.0	93	6.5 – 9.0
Chloride (mg/L)	12.7	13.0	12.0	3	50.00
Sulfate (mg/L)	24.7	27.0	23.0	3	50.00
Total Dissolved Solids (mg/L)	312	545	233	94	400.00
NH3-N (mg/L)	<0.10	0.28	<0.02	95	0.33
Total Phosphorus (mg/L)	<0.05	0.20	<0.02	100	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.25	1.01	<0.02	99	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1813_02 Recreational Use					
E. coli (MPN/100 mL)	61 Geomean	2,450	3	97	126 Geomean
AU 1813_02 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.9	13.7	3.5	95	≥4.0 Minimum & ≥6.0 Average

Table 3

Station 12663 – Blanco River at CR 1492 at Pioneer Town 02/2003 – 09/2016					
AU 1813_05 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.2	30.9	9.1	104	33.30
pH	8.0	8.8	6.8	103	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	311	489	235	104	400.00
NH3-N (mg/L)	<0.10	0.27	<0.02	90	0.33
Total Phosphorus (mg/L)	<0.05	0.65	<0.02	96	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.28	1.02	0.03	94	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1813_05 Recreational Use					
E. coli (MPN/100 mL)	95 Geomean	2,910	9	94	126 Geomean
AU 1813_05 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.0	8.8	6.8	103	≥4.0 Minimum & ≥6.0 Average

Table 4

Station 12668 – Blanco River at FM 165 near Blanco 12/2002 – 06/2017					
AU 1813_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.1	32.0	5.4	136	33.30
pH	8.1	8.7	7.4	135	6.5 – 9.0
Chloride (mg/L)	13.7	81.8	5.4	133	50.00
Sulfate (mg/L)	34.1	133	16.1	133	50.00
Total Dissolved Solids (mg/L)	308	505	202	135	400.00
NH3-N (mg/L)	<0.10	0.33	<0.02	77	0.33
Total Phosphorus (mg/L)	<0.05	0.31	<0.02	131	0.69
Chlorophyll-a (µg/L)	1.8	8.3	<1.0	113	14.10
Nitrate Nitrogen (mg/L)	0.23	1.17	<0.01	132	1.95
TKN (mg/L)	0.44	1.95	<0.10	50	N/A
AU 1813_03 Recreational Use					
E. coli (MPN/100 mL)	24 Geomean	1,700	<1	134	126 Geomean
AU 1813_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.6	15.7	4.6	133	≥4.0 Minimum & ≥6.0 Average

BLANCO RIVER

Table 5

Station 12631– Blanco River at Hays CR 295 02/2003 – 08/2017					
AU 1809_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.7	29.3	10.0	55	33.30
pH	7.8	8.6	7.1	55	6.5 – 9.0
Chloride (mg/L)	17.8	50.0	11.0	53	50.00
Sulfate (mg/L)	29.6	44.0	18.0	54	50.00
Total Dissolved Solids (mg/L)	330	418	239	54	400.00
NH3-N (mg/L)	<0.05	0.08	<0.02	52	0.33
Total Phosphorus (mg/L)	<0.05	0.07	<0.02	52	0.69
Chlorophyll-a (µg/L)	6.0	10.0	1.2	32	14.10
Nitrate Nitrogen (mg/L)	0.38	1.75	<0.02	54	1.95
TKN (mg/L)	0.24	0.62	<0.10	50	N/A
AU 1809_01 Recreational Use					
E. coli (MPN/100 mL)	34 Geomean	1,600	2	50	126 Geomean
AU 1809_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.5	14.6	4.5	54	≥3.0 Minimum & ≥5.0 Average

Table 6

Station 12673– Cypress Creek at Confluence with Blanco River 02/2003 – 09/2016					
AU 1815_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.7	32.4	11.0	94	30.00
pH	7.8	8.3	7.0	91	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	357	595	265	92	400.00
NH3-N (mg/L)	<0.10	0.53	<0.02	92	0.33
Total Phosphorus (mg/L)	<0.05	0.12	<0.02	91	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.20	1.37	<0.02	96	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1815_01 Recreational Use					
E. coli (MPN/100 mL)	156 Geomean	3,800	9	96	126 Geomean
AU 1815_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.9	11.4	1.7	93	≥4.0 Minimum & ≥6.0 Average

Table 7

Station 12674– Cypress Creek at FM 12 at Wimberley 01/2003 – 10/2016					
AU 1815_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	19.9	26.4	8.4	64	30.00
pH	7.7	8.1	7.1	64	6.5 – 9.0
Chloride (mg/L)	19.8	34.4	12.0	56	50.00
Sulfate (mg/L)	22.2	36.6	16.0	54	50.00
Total Dissolved Solids (mg/L)	370	463	244	64	400.00
NH3-N (mg/L)	<0.10	0.27	<0.02	34	0.33
Total Phosphorus (mg/L)	<0.05	0.22	<0.02	56	0.69
Chlorophyll-a (µg/L)	1.4	5.0	<1.0	53	14.10
Nitrate Nitrogen (mg/L)	0.23	1.37	<0.02	55	1.95
TKN (mg/L)	0.23	0.51	<0.20	34	N/A
AU 1815_01 Recreational Use					
E. coli (MPN/100 mL)	216 Geomean	2,000	19	56	126 Geomean
AU 1815_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.4	11.7	1.4	63	≥4.0 Minimum & ≥6.0 Average

Table 8

Station 12675 – Cypress Creek at Blue Hole Campground 12/2005 – 09/2016					
AU 1815_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.7	26.6	11.7	64	30.00
pH	7.6	8.2	6.8	61	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	375	515	285	62	400.00
NH3-N (mg/L)	<0.10	0.34	<0.02	64	0.33
Total Phosphorus (mg/L)	<0.05	0.10	<0.02	68	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.27	1.42	<0.02	68	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1815_01 Recreational Use					
E. coli (MPN/100 mL)	59 Geomean	2,400	<1	67	126 Geomean
AU 1815_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	5.5	9.4	1.5	63	≥4.0 Minimum & ≥6.0 Average

Table 9

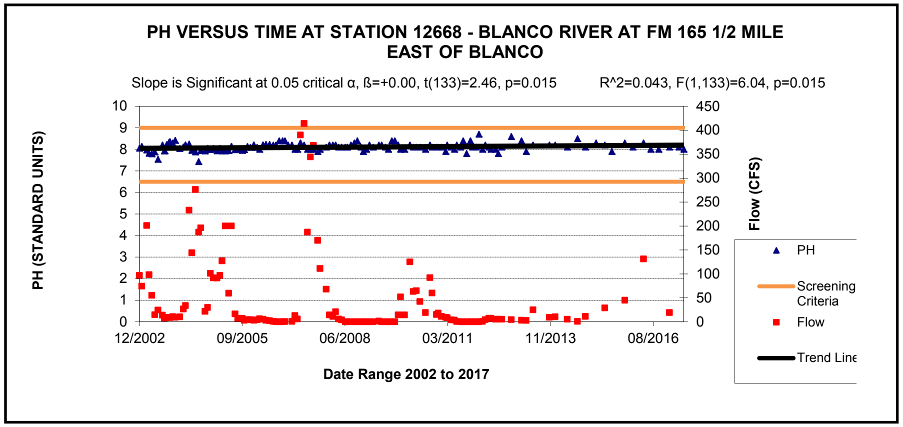
Station 12676 – Cypress Creek at RR12 1 Mile North of Wimberley 02/2003 – 12/2015					
AU 1815_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.6	27.3	11.9	95	30.00
pH	7.5	8.2	6.7	92	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	355	583	240	93	400.00
NH3-N (mg/L)	<0.10	0.30	<0.02	92	0.33
Total Phosphorus (mg/L)	<0.05	0.12	<0.02	92	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.22	1.56	<0.02	97	1.95
TKN (mg/L)	0.11	0.11	0.11	1	N/A
AU 1815_01 Recreational Use					
E. coli (MPN/100 mL)	84 Geomean	2,400	10	96	126 Geomean
AU 1815_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	6.1	9.3	0.7	94	≥4.0 Minimum & ≥6.0 Average

Table 10

Station 12677 – Cypress Creek at Jacob's Well Spring 02/2003 – 09/2016					
AU 1815_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.6	23.1	16.5	96	30.00
pH	7.0	7.8	6.3	92	6.5 – 9.0
Chloride (mg/L)	N/A	N/A	N/A	N/A	50.00
Sulfate (mg/L)	N/A	N/A	N/A	N/A	50.00
Total Dissolved Solids (mg/L)	373	566	303	93	400.00
NH3-N (mg/L)	<0.10	0.27	<0.02	93	0.33
Total Phosphorus (mg/L)	<0.05	0.11	<0.02	92	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.10
Nitrate Nitrogen (mg/L)	0.53	1.73	0.03	97	1.95
TKN (mg/L)	N/A	N/A	N/A	N/A	N/A
AU 1815_01 Recreational Use					
E. coli (MPN/100 mL)	8.4 Geomean	2,400	<1	97	126 Geomean
AU 1815_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	6.0	9.8	3.8	94	≥4.0 Minimum & ≥6.0 Average

BLANCO RIVER

Figure 1



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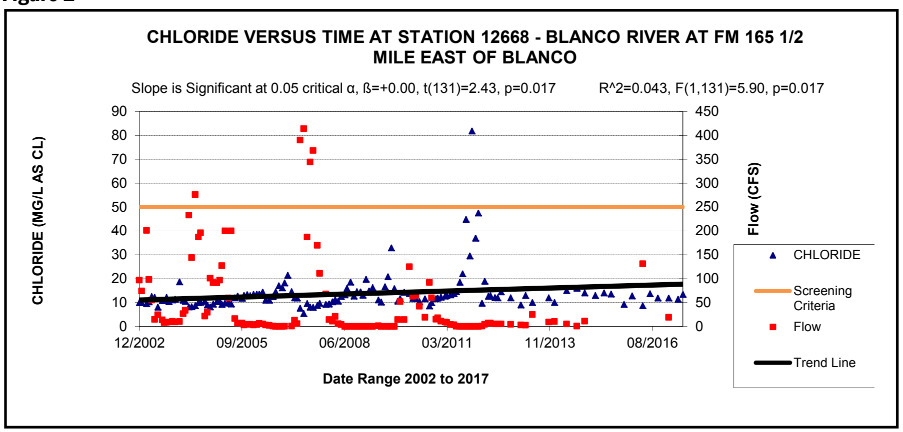

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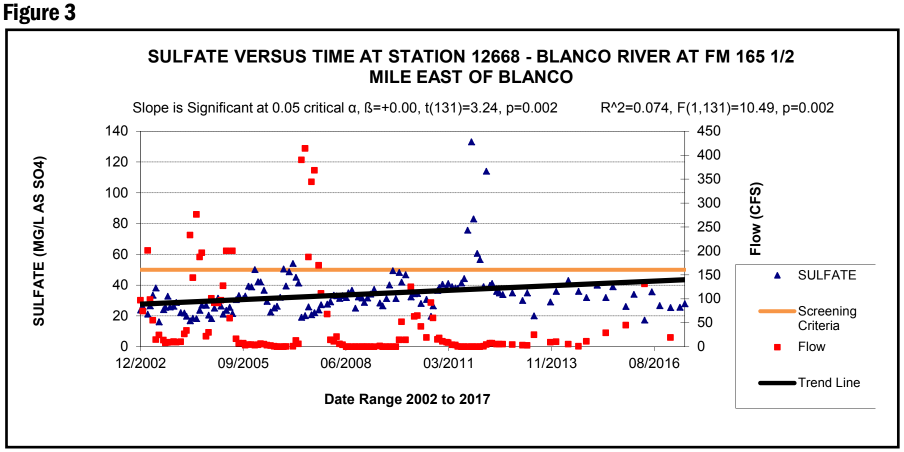

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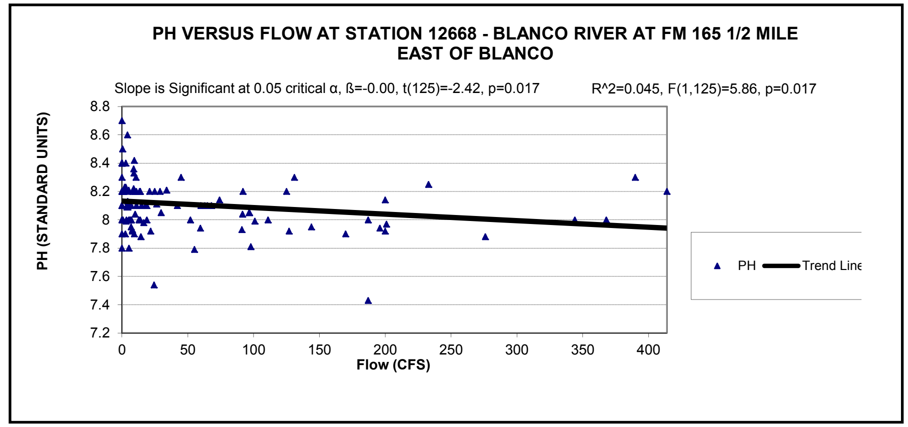

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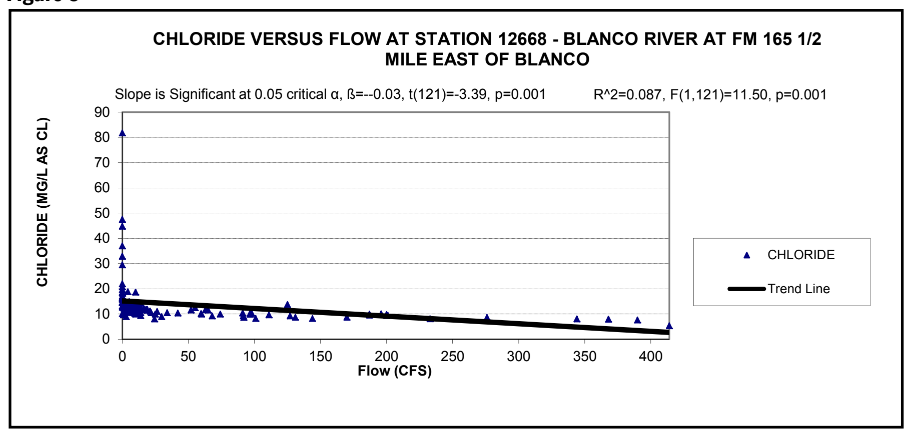

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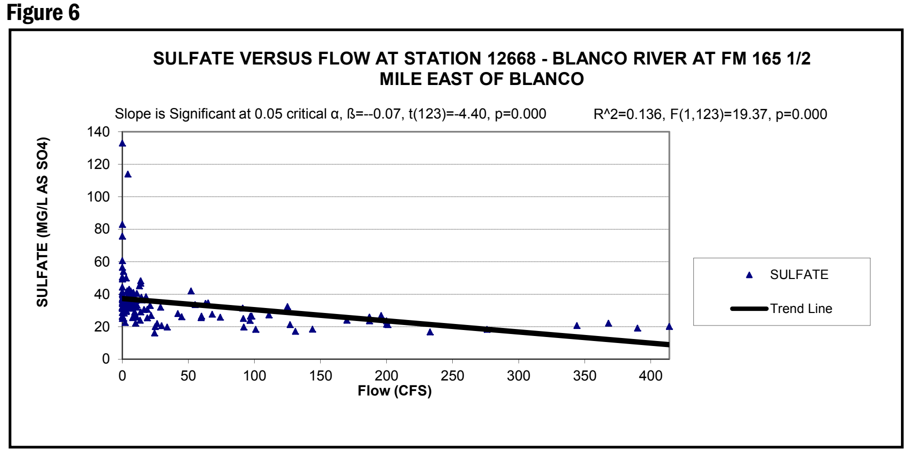
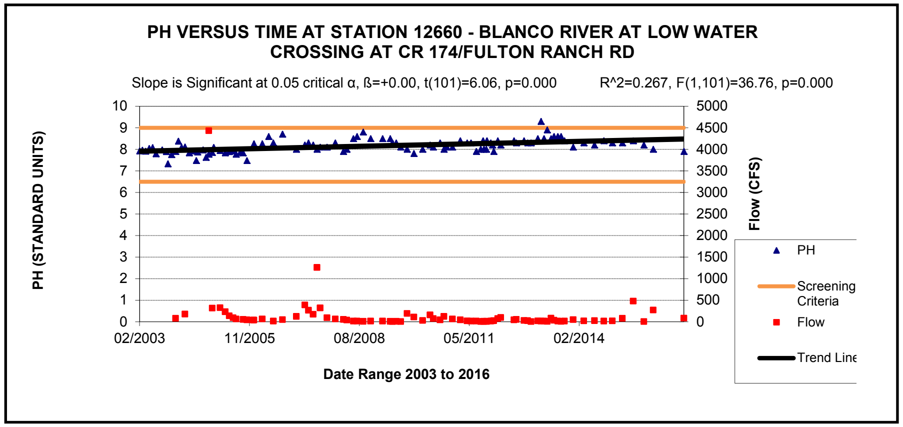


BLANCO RIVER

Figure 7



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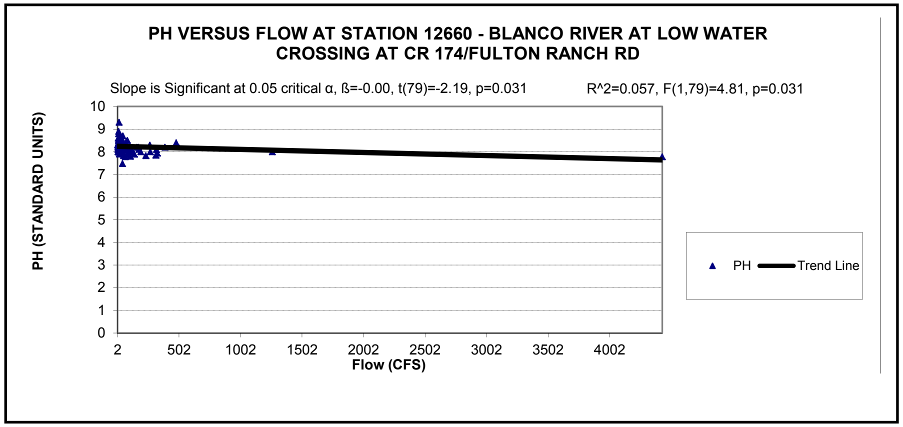

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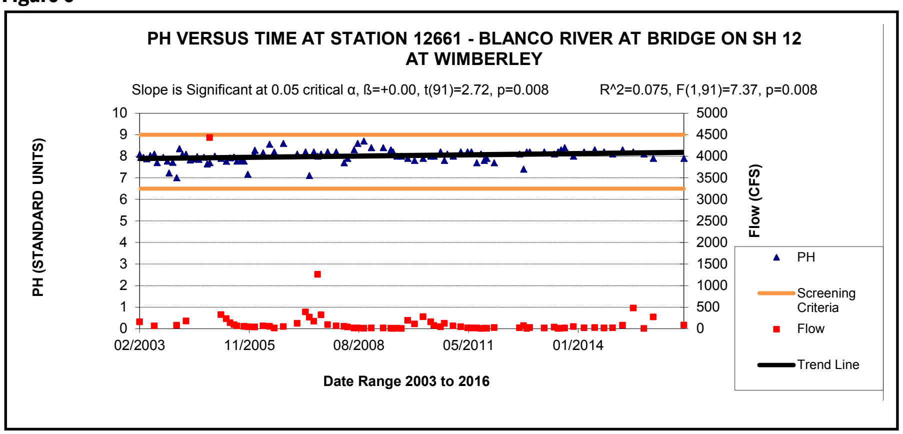

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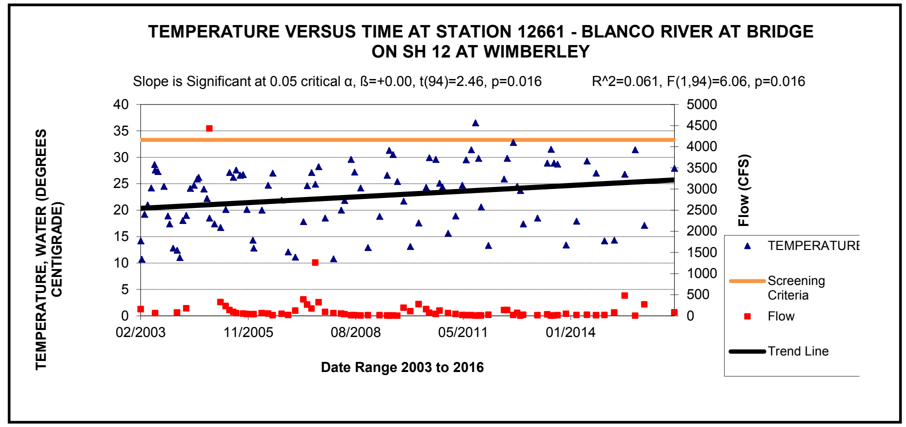

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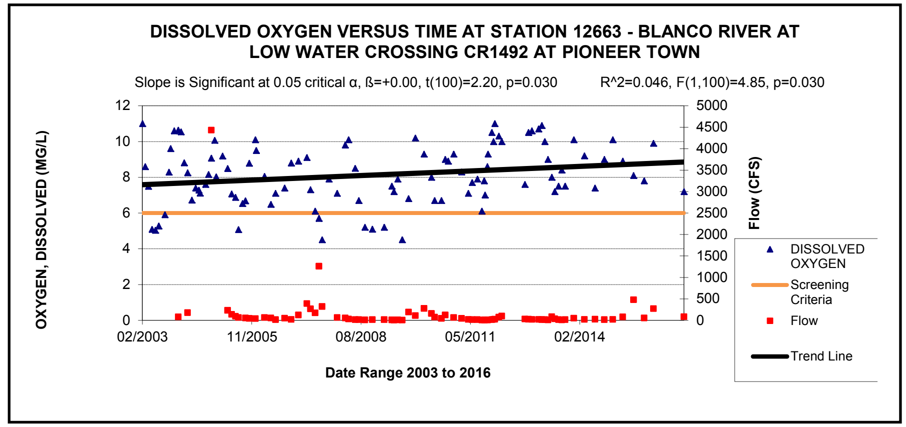

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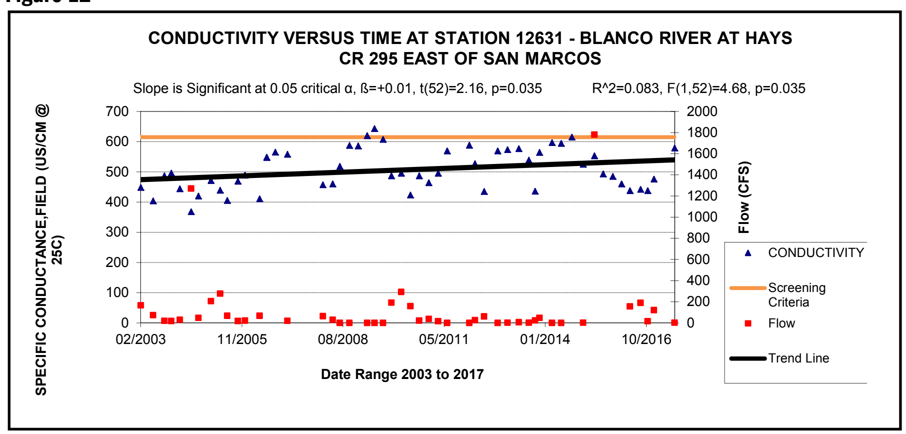
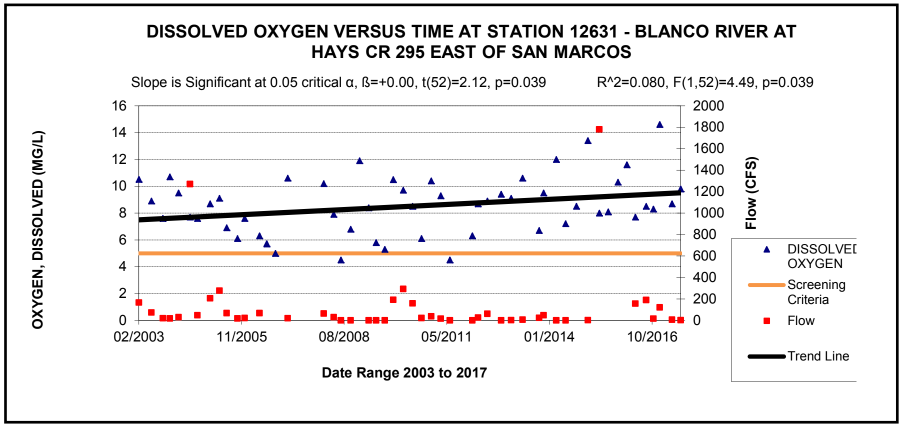


BLANCO RIVER

Figure 13



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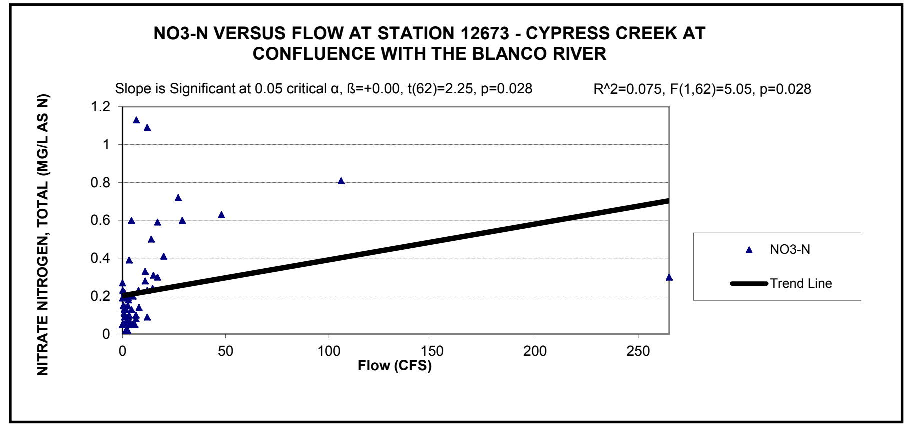

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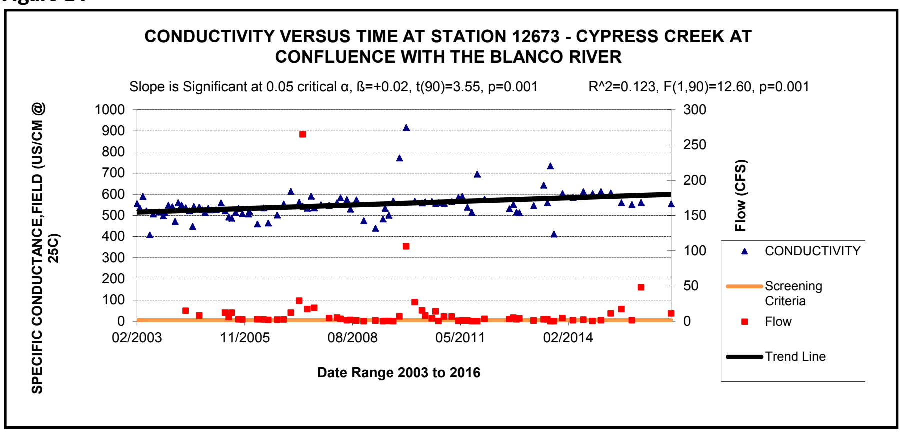

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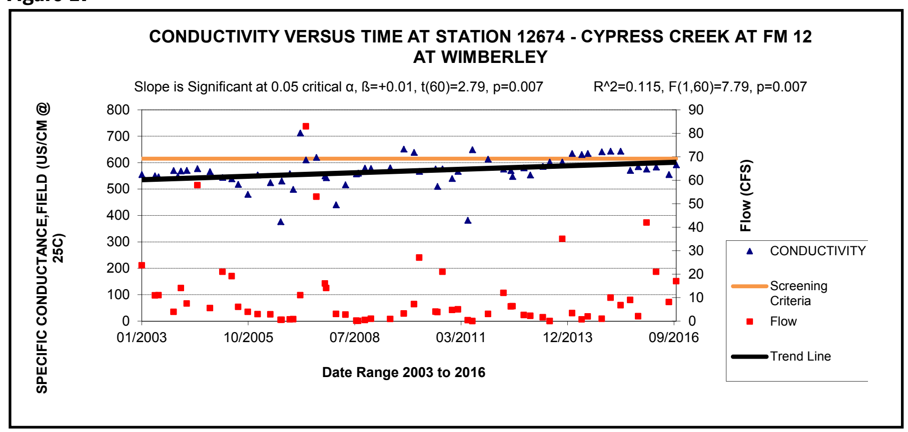

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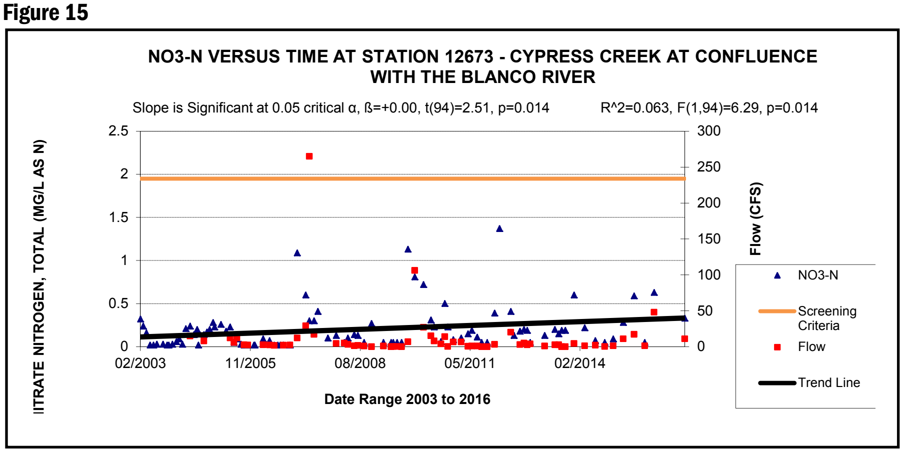

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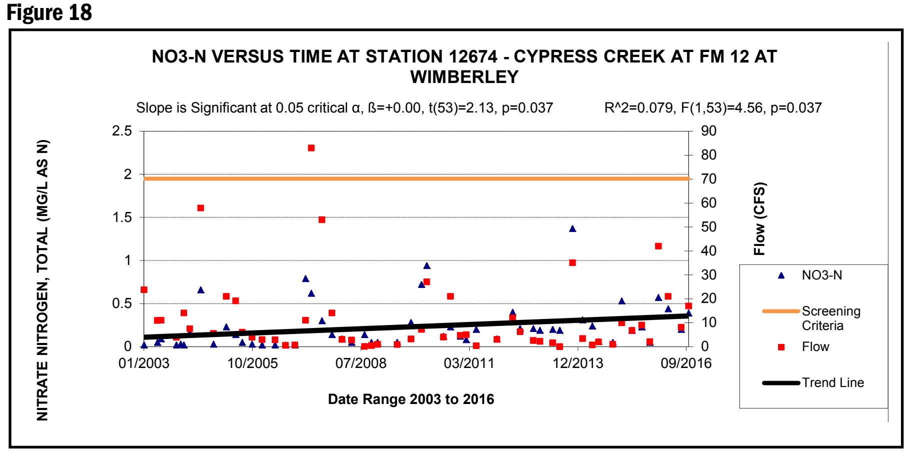
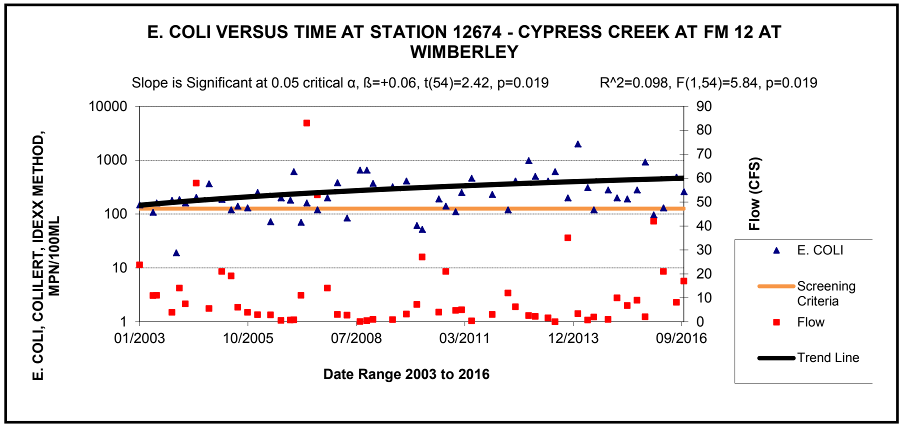


BLANCO RIVER

Figure 19



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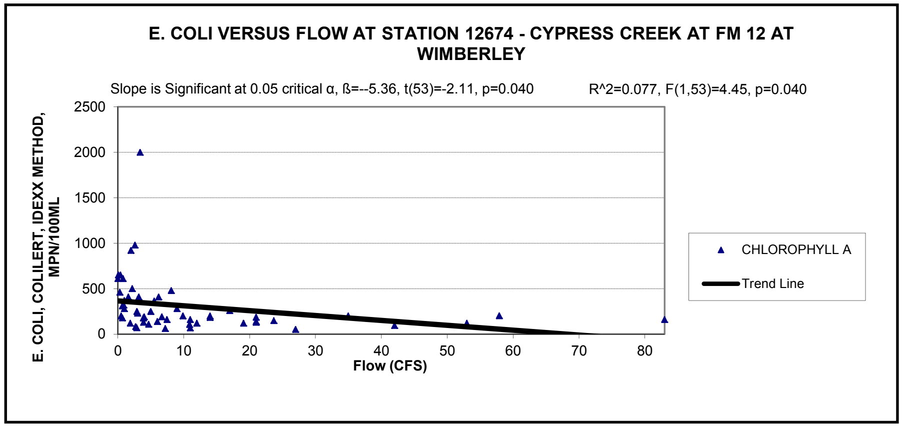

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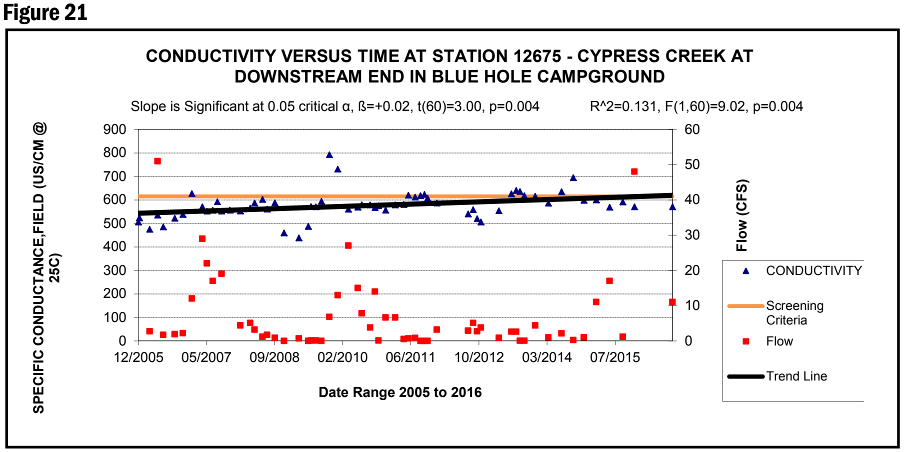

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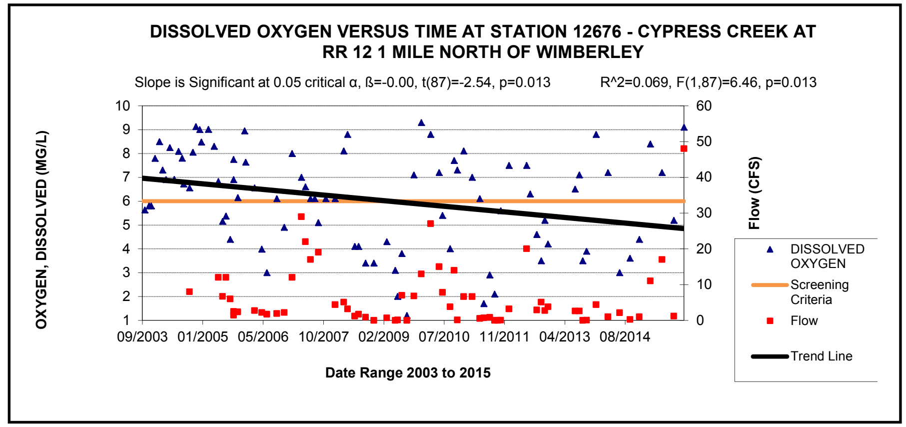

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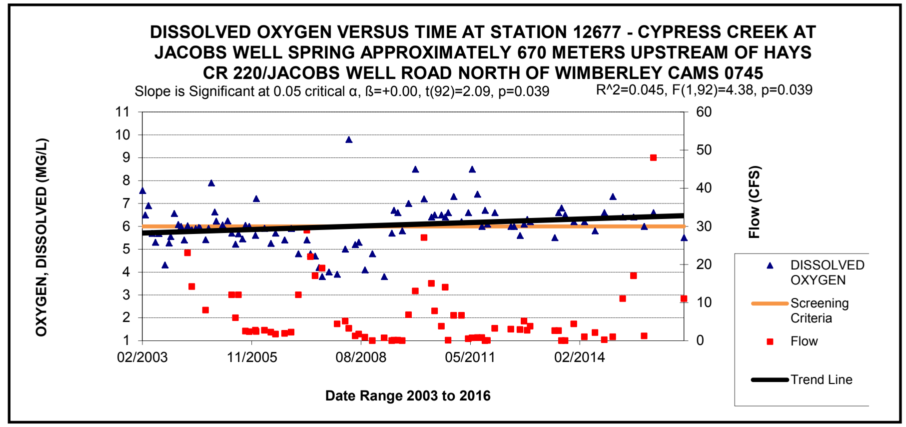
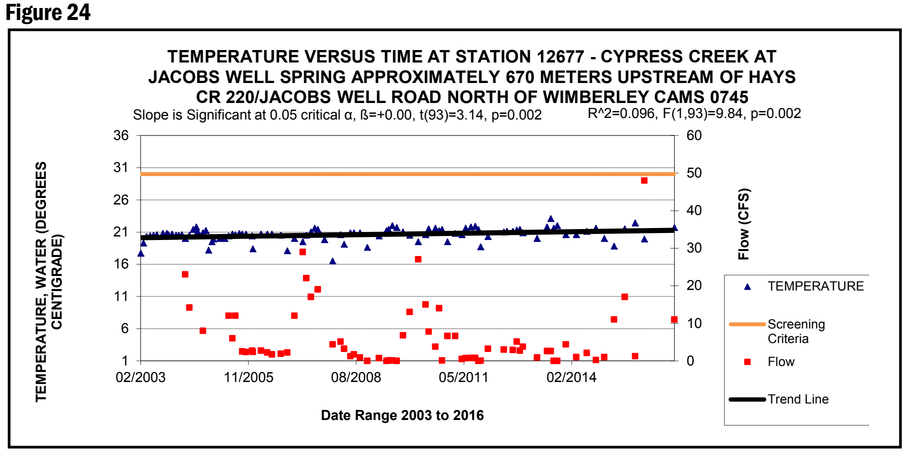
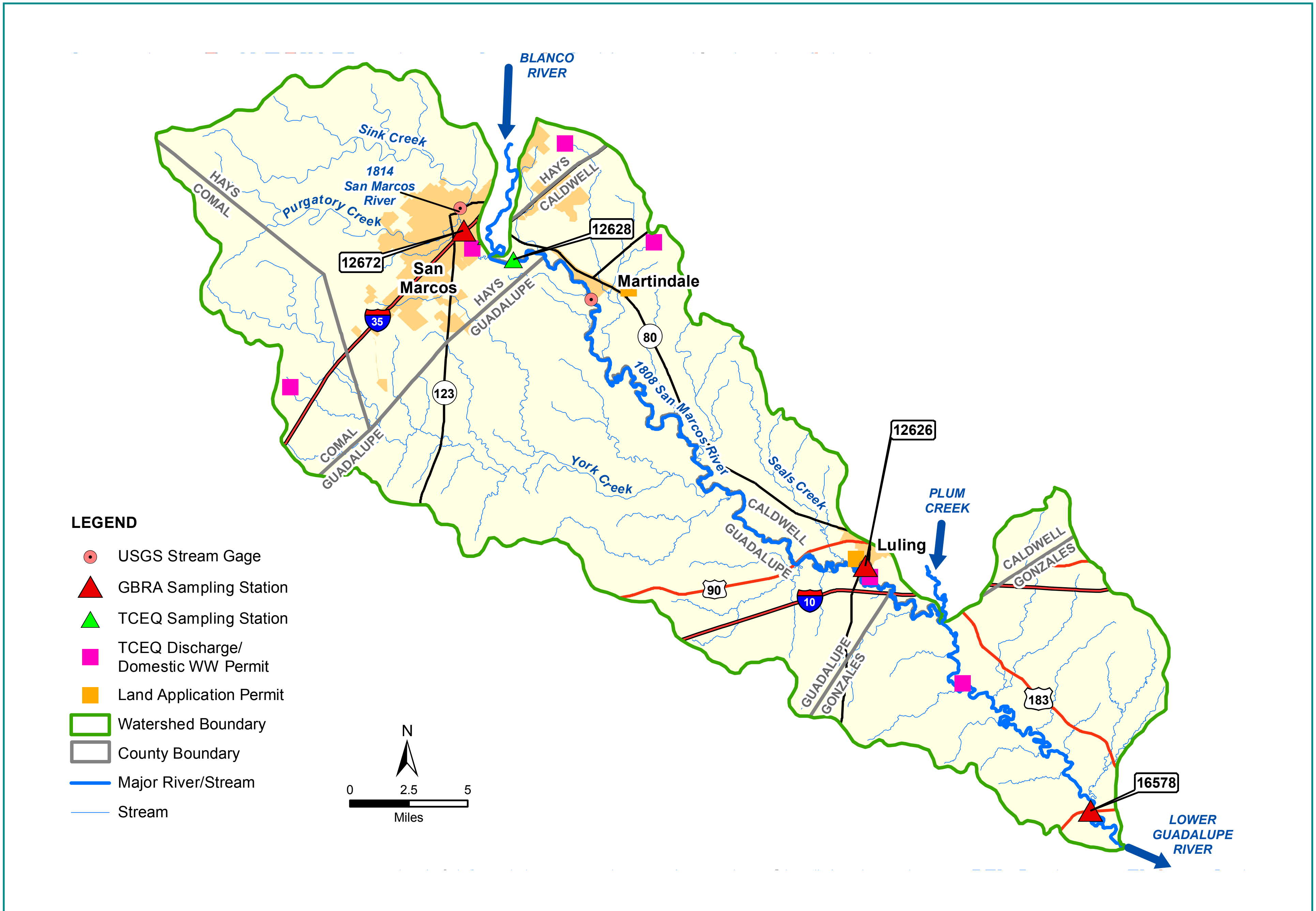


Figure 24




BLANCO RIVER
Sink Creek
1814 San Marcos River
Purgatory Creek
HAYS
COMAL
HAYS
CALDWELL
12628
12672
San Marcos
Martindale
HAYS
GUADALUPE
35
80
123
1808 San Marcos River
COMAL
GUADALUPE
York Creek
Seals Creek
12626
PLUM CREEK
CALDWELL
GUADALUPE
Luling
CALDWELL
GONZALES
90
10
GUADALUPE
GONZALES
183
16578
LOWER GUADALUPE RIVER
LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Sampling Station
TCEQ Discharge/ Domestic WW Permit
Land Application Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream
N
0
2.5
5
Miles

SAN MARCOS RIVER

Segment 1814 (Upper San Marcos River) is a spring-fed stream that flows through the limestone substrates of the Edwards Plateau. The portion of the stream downstream of the springs is very clear and keeps a consistent temperature near 22 degrees Celsius, which makes it an ideal spot for recreational uses such as swimming and fishing. The Upper San Marcos is also home to a number of endangered species that are dependent upon the constancy of clean spring flow for their survival. This portion of the watershed is surrounded by rapidly urbanizing land and topics such as depletion of the springs, restoration of riparian habitat and non-point source runoff from the surrounding land are currently being addressed by concerned stakeholders.

Segment 1808 (Lower San Marcos River) transitions from a swift moving clear stream in the limestone of the Edwards Plateau to a slow, meandering, turbid river as it passes over through the black clays of the Texas Blackland Prairies Ecoregion. This segment of the San Marcos accepts the discharges from the Blanco River (1809) and Plum Creek classified tributaries. The cool, clear waters between the cities of San Marcos and Martindale are heavily trafficked by recreational users for swimming and tubing. As the river moves away from the influence of the urbanized areas along the IH 35 corridor, the stream is much more rural with land uses including the production of agricultural row crops, pasture hay, and livestock.

The San Marcos River is assessed by the TCEQ as two classified stream segments. Segment 1814 represents the 4.5 mile long upper portion of the San Marcos River before its confluence with the Blanco River. This portion of the San Marcos River is a spring fed system that provides a unique ecosystem that is home to a number of endangered species. The upper portions of the river provide habitat for the endangered Fountain Darter (Etheostoma fonticola), Texas Blind Salamander (Typhlomolge rathbuni), Texas Wild Rice (Zizania texana) and the likely extinct San Marcos Gambusia (Gambusia georgei). The San Marcos Salamander (Eurycea nana) is also found within this reach and is considered a threatened species. The spring flows that feed the San Marcos River originate from the Edwards Aquifer, which also feeds the springs at the headwaters of the Comal River. The conservation and recovery of these endangered species is highly dependent upon the continued consistency and purity of these spring flows. In order to protect these spring flows a number of efforts are being made to prevent the pollution and overuse of the groundwater during rapid development of the area. The USFWS approved an Edwards Aquifer Habitat Conservation Plan (EAHCP) to that introduced minimization and mitigation activities designed to protect the endangered species in 2013. This plan was developed by stakeholders in the Edwards Aquifer Recovery

CONTINUED ON PAGE 92

San Marcos River
Drainage Area: 522 square miles
Length: 75 miles
Tributaries: Sink Creek, Sessom Creek, Purgatory Creek, Willow Springs Creek, Blanco River (1809), Morrison Creek, Dickerson Creek, Callihan Creek, York Creek, Brushy Creek, Highsmith Creek, Plum Creek (1810), Mule Creek, Canoe Creek, Smith Creek
Aquifer: Edwards-Balcones Fault Zone, Carrizo-Wilcox
River Segments: 1814, 1808
Cities and Communities: San Marcos, Maxwell, Martindale, Fentress, Prairie Lee, Luling, Ottine, Gonzales
Counties: Hays, Guadalupe, Caldwell, Gonzales,
EcoRegion: Edwards Plateau, Texas Blackland Prairies, Post Oak Savannah

Climate: Average annual rainfall 35.75 inches, Average annual temperature 68.45°F
Vegetation Cover: Evergreen Forest 14.51%, Deciduous Forest 11.77%, Shrubland 33.49%; Grassland 12.19%; Woody Wetlands: 2.15% Cultivated Crops 5.61% ; Pasture Hay 13.22%
Land Uses: Urban, suburban sprawl, agricultural crops, cattle, hog and poultry production, oil production, and recreation
Development: Low Intensity 0.69% ; Medium Intensity 0.35%; High Intensity 0.14%; Open Space 4.49%
Water Body Uses: Aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils: Thin limestone to black, waxy, chocolate and grey loam
Permitted Wastewater Treatment Facilities: Domestic 4, Land Application 0, Industrial 0

Implementation Program (EARIP). When the measures of this plan are fully implanted, they should provide a way to sustain spring flows in the San Marcos River during periods of increased water demand and drought. These measures focus on water conservation, alternative water supply and removal of non-native species. The ecosystem of the San Marcos River is especially susceptible to invasive species introduction from home aquariums. Removal activities focusing on Water Trumpet, Elephant Ears, and Water Hyacinth, along with limitations to recreational uses in State Scientific Areas designated by the Texas Parks and Wildlife Department, have substantially improved the outlook for the Texas Wild Rice and San Marcos Fountain Darter. The Texas Wild Rice Enhancement program undertaken by the city of San Marcos and Texas State University has been particularly successful at restoring this species and enhancing the riparian habitat by restoring native species in this portion of the San Marcos River. The city of San Marcos has also developed a Municipal Separate Storm Sewer System (MS4) permit with the TCEQ. This permit enhances the city's storm management plan to increase public awareness of runoff and nonpoint source pollution while improving storm water runoff controls. In a further effort to protect the water quality of this stream segment, the Meadows Center for Water and the Environment has organized a group of stakeholders to develop a watershed protection plan (WPP) for the Upper San Marcos River. This plan utilizes the 9 key elements WPP format provided by the EPA in order to become eligible for Clean Water Act section 319 funding. This plan characterizes and provides recommended best management practices (BMPs) for stakeholders in order to improve water quality, including additional public education regarding water conservation, aquatic habitat improvements and reduction of non-point source pollutant loading. This stream segment also receives the wastewater discharge from the city of San Marcos wastewater treatment facility (WWTF). This facility is permitted to discharge up to 9.0 million gallons per day (MGD) of treated wastewater effluent. This effluent meets permit limits not to exceed concentrations of carbonaceous biochemical oxygen demand (CBOD) of 5 mg/L, total suspended solids (TSS) of 5 mg/L, ammonia nitrogen of 2 mg/L, total phosphorus of 1 mg/L and E. coli of 126 MPN/100 mL.

Segment 1814 is divided in to four assessment units (AUs) by the TCEQ. AU 1814_01 represents the 1.5 mile flowing portion of the river from 0.6 miles upstream of the Blanco River. AU 1814_02 represents the portion of the river from 1814_01 to IH 35. AU 1814_03 represents the portion of the river between IH 35 and Spring Lake and contains the only current monitoring location at station 12672, which is upstream of the IH 35 crossing. This station has been historically monitoring by the TCEQ since 1992 until monitoring duties were transferred to the GBRA under the Clean Rivers Program in 1998. The final AU 1814_04 includes the portion of the stream upstream of Spring Lake to the headwaters of the river. In a previous 2010 Integrated Report the Upper San Marcos River was listed on the Texas 303(d) list of impaired water bodies, as required by Clean Water Act Sections 303(d) and 305(b) for average total dissolved solids (TDS) of 406 mg/L, which was above the TCEQ stream standard of 400 mg/L. This listing persisted in the 2012 Texas Integrated report, in which the average concentration for TDS was reduced to 402 mg/L. In the latest 2014 Texas Integrated Report average TDS concentrations were assessed below the criterion with an average concentration of 365 mg/L. In 2014, the TCEQ removed segment 1814 from the list of impaired water bodies as it was determined that it was meeting all of its designated uses. The TDS parameter serves as an estimate of dissolved constituents such as salt cations, anions and metals in the water column and is calculated by multiplying the in-situ specific conductance by a factor of 0.65. The GBRA began performing laboratory analysis for TDS from 2010 to 2013 at the IH 35 crossing (station 12672) in order to evaluate the effectiveness of the standard conversion factor for determining TDS in this segment. An analysis of the side by side comparison between the 34 laboratory data and field conductivities collected at this station over the same time period indicated that the calculated average TDS conversion factor of 0.53 would provide a value much closer to the laboratory methodology. TCEQ standards has not adopted a segment specific conversion factor in the upper San Marcos to date, but the additional laboratory data collected during this study significantly lowered the assessed TDS average and ultimately contributed to removal of the impairment. An analysis of the water quality data at station 12672 from 2002 to 2016 identified several interesting trends. The specific conductance and calculated TDS at this station did not show a significant change over time but this parameter does have a significant positive correlation with stream flow (Figures 1 & 2). Based on this analysis, TDS concentrations may increase above the water quality standard in the future if there is an increase in stream flows from additional runoff in the watershed. Dissolved oxygen at this station is significantly decreasing over time and nitrate nitrogen is significantly increasing over time (Figures 3 & 4). These trends may be related, as dissolved oxygen may be reduced in the water column through nitrification in order to form nitrates from other forms of nitrogen. The additional nitrogen in the segment may be a result of additional nonpoint source runoff as the precipitation increases following several years of drought conditions.

Segment 1808 represents the lower portion of the River from 0.6 miles upstream of the confluence with the Blanco River to the confluence with the Guadalupe River. No assessed impairments or concerns are currently known in this segment. This stream segment has been divided into five assessment units (AUs) by the TCEQ. AU 1808_01 comprises the lower 18 miles of the segment from the confluence with the Guadalupe River upstream to the confluence with Mule Creek. This segment has been monitored by the GBRA at station 16578 on the US Highway 90A road crossing since 1999. AU 1808_02 covers the portion of the segment from the confluence with Mule Creek upstream to the confluence with Plum Creek near the city of Luling. No surface water quality monitoring stations are present in this AU. AU 1808_03 represents the portion of the San Marcos River from the confluence with Plum Creek upstream to the Old Bastrop Highway (Guadalupe CR 239) road crossing. This segment contains one monitoring location at station 12626, which is upstream of the US highway 80 road crossing in the city of Luling. Station 12626 was first monitored by the TCEQ in 1968 and has been monitored by the GBRA on a monthly basis since 1990. The final AU in this segment is 1808_04, which comprises the portion of the river from Old Bastrop Highway to 1 kilometer upstream of the Blanco River confluence. This AU has been monitored by the TCEQ at station 12628 upstream of Guadalupe County Road 239 on a quarterly basis since 1973. All three active monitoring stations were analyzed by the GBRA to assess trends in water quality over time and several changes were identified. At the most downstream station 12678 stream flows was significantly decreasing over time and nitrate nitrogen concentrations were significantly increasing over time (Figures 5 & 6). Station 12626 shows a significant decrease in dissolved oxygen over time and a significant increase in nitrate nitrogen over time (Figures 7 & 8). Changes in the oxygen and nitrate concentrations over time may indicate additional nonpoint source nitrogen loading in this portion of river as dissolved oxygen used to produce additional nitrates through nitrification. At station 12628, near the upper end of the segment, the specific conductivity is significantly increasing over time and this parameter shows a significant inverse relationship with stream flow (Figures 9 & 10). This flow relationship is opposite of what was seen in the spring fed portion of the river upstream. The differences in flow effects from these two segments may indicate that the TDS concentrations in the upper San Marcos are associated with discharges from the springs, while the conductivity in the lower portion of the watershed is more greatly influenced by dilution from the larger drainage area.

SAN MARCOS RIVER

Table 1

Station 16578 – San Marcos River at US 90A 12/2002 – 10/2016					
AU 1808_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.2	30.8	9.4	57	32.20
pH	8.0	8.3	7.4	57	6.5 – 9.0
Chloride (mg/L)	40.8	115	11.6	56	60.00
Sulfate (mg/L)	36.6	116	12.7	56	50.00
Total Dissolved Solids (mg/L)	387	699	161	57	400.00
NH3-N (mg/L)	<0.10	0.67	<0.02	56	0.33
Total Phosphorus (mg/L)	0.10	0.83	<0.02	56	0.69
Chlorophyll-a (µg/L)	2.3	10.7	<1.0	56	14.10
Nitrate Nitrogen (mg/L)	0.92	1.58	0.38	56	1.95
TKN (mg/L)	0.41	2.23	<0.20	36	N/A
AU 1808_01 Recreational Use					
E. coli (MPN/100 mL)	87 Geomean	9,200	19	56	126 Geomean
AU 1808_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.3	11.3	5.6	57	≥3.0 Minimum & ≥5.0 Average

Table 2

Station 12626 – San Marcos River in Luling 12/2002 – 11/2016					
AU 1808_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.2	31.2	10.3	164	32.20
pH	7.9	8.3	7.5	164	6.5 – 9.0
Chloride (mg/L)	25.3	56.5	9.6	163	60.00
Sulfate (mg/L)	30.9	63.8	21.1	163	50.00
Total Dissolved Solids (mg/L)	358	488	255	164	400.00
NH3-N (mg/L)	<0.10	0.34	<0.02	81	0.33
Total Phosphorus (mg/L)	<0.05	0.51	<0.02	163	0.69
Chlorophyll-a (µg/L)	1.6	9.2	<1.0	162	14.10
Nitrate Nitrogen (mg/L)	1.05	1.84	0.08	162	1.95
TKN (mg/L)	0.28	0.91	<0.20	52	N/A
AU 1808_03 Recreational Use					
E. coli (MPN/100 mL)	71 Geomean	9,680	13	161	126 Geomean
AU 1808_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.4	14.5	5.2	164	≥3.0 Minimum & ≥5.0 Average

Table 3

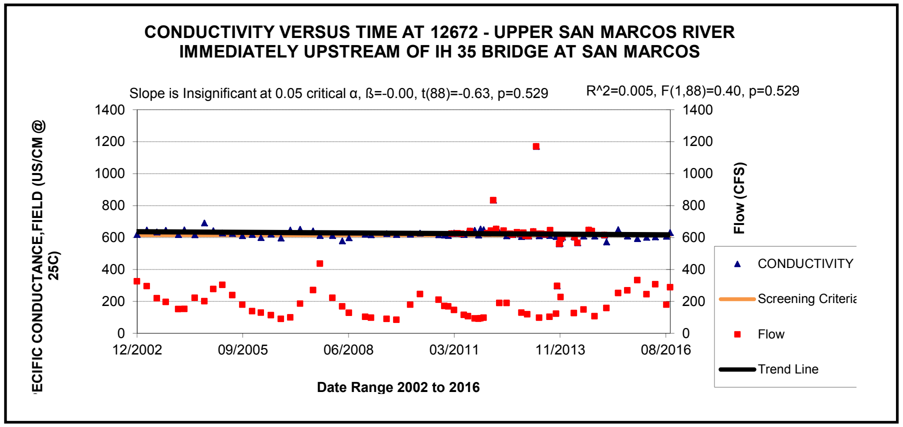
Station 12628 – San Marcos River at Old Bastrop Highway 12/2002 – 10/2016					
AU 1808_04 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.1	26.9	13.3	74	32.20
pH	8.0	8.6	7.3	74	6.5 – 9.0
Chloride (mg/L)	19.6	25.0	10.0	56	60.00
Sulfate (mg/L)	25.9	34.0	15.0	56	50.00
Total Dissolved Solids (mg/L)	385	433	294	73	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.05	0.24	<0.02	53	0.69
Chlorophyll-a (µg/L)	5.4	10.0	<1.0	33	14.10
Nitrate Nitrogen (mg/L)	1.52	2.20	0.66	56	1.95
TKN (mg/L)	0.24	0.64	<0.20	50	N/A
AU 1808_04 Recreational Use					
E. coli (MPN/100 mL)	109 Geomean	2,420	27	67	126 Geomean
AU 1808_04 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.3	12.1	7.4	70	≥3.0 Minimum & ≥5.0 Average

Table 4

Station 12672 – San Marcos River at IH 35 12/2002 – 10/2016					
AU 1814_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	22.4	25.2	19.2	57	26.70
pH	7.7	8.7	7.3	57	6.5 – 9.0
Chloride (mg/L)	18.7	24.1	15.0	54	50.00
Sulfate (mg/L)	26.5	33.6	23.0	54	50.00
Total Dissolved Solids (mg/L)	385	761	193	134	400.00
NH3-N (mg/L)	<0.10	0.51	<0.02	62	0.33
Total Phosphorus (mg/L)	<0.05	0.46	<0.02	60	0.69
Chlorophyll-a (µg/L)	1.4	5.0	<1.0	38	14.10
Nitrate Nitrogen (mg/L)	1.15	1.69	0.29	64	1.95
TKN (mg/L)	0.33	0.79	<0.10	43	N/A
AU 1814_03 Recreational Use					
E. coli (MPN/100 mL)	109 Geomean	2,420	27	67	126 Geomean
AU 1814_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	10.2	13.0	8.1	56	≥3.0 Minimum & ≥5.0 Average

SAN MARCOS RIVER

Figure 1



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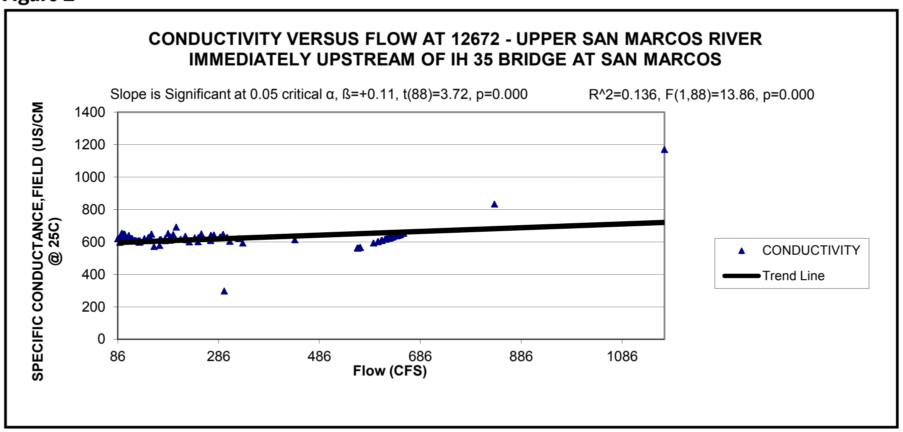

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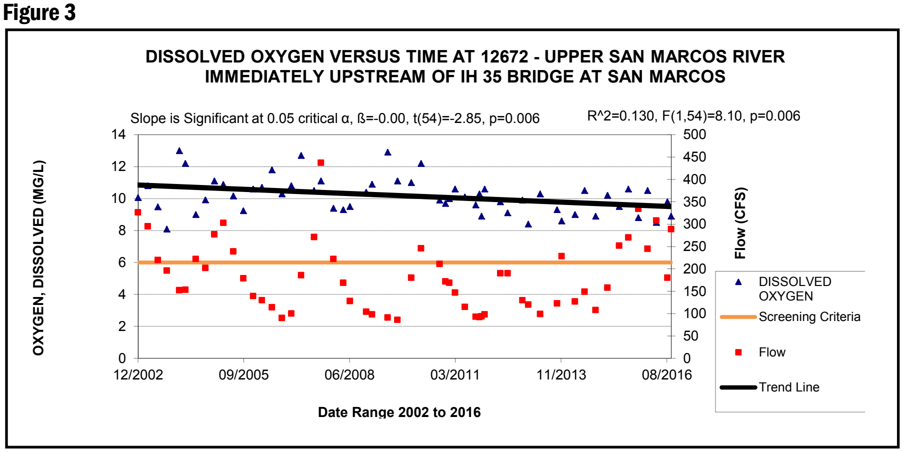

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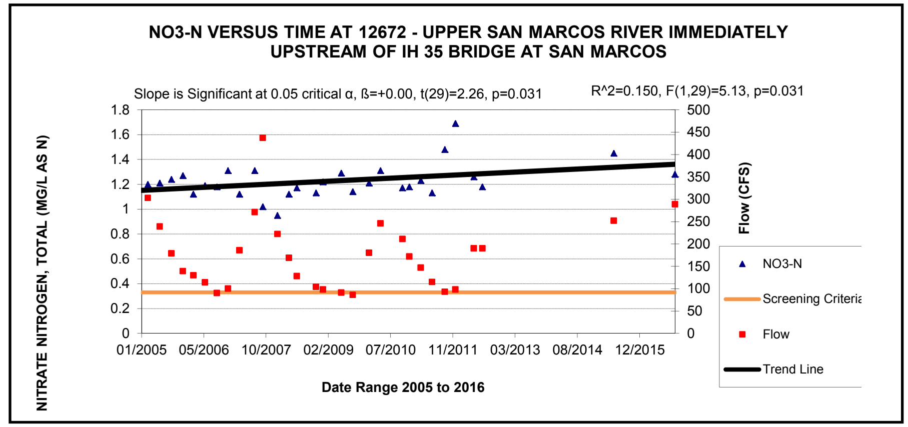

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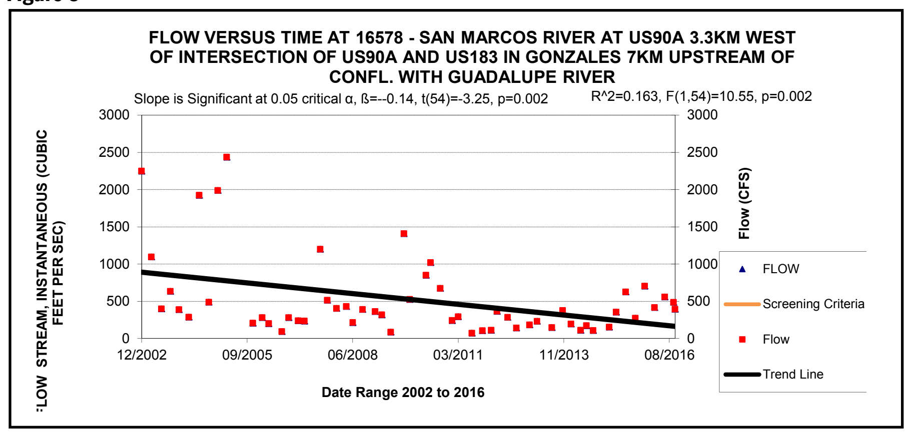

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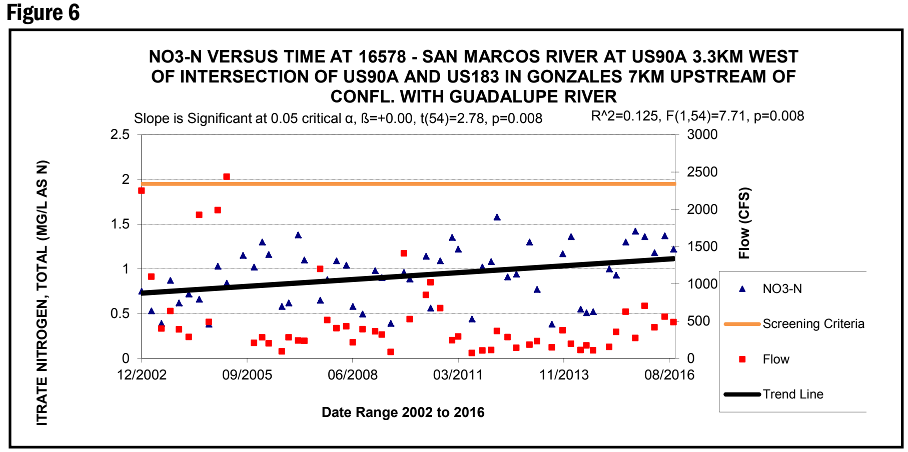


SAN MARCOS RIVER

Figure 7

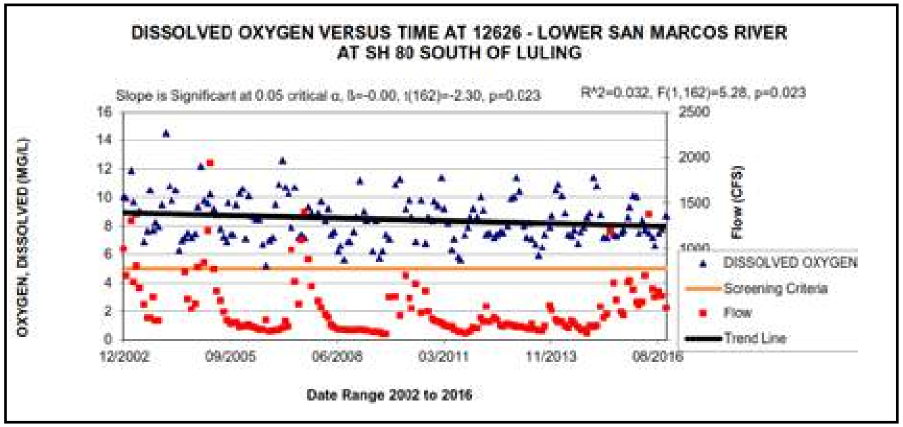


Figure 8

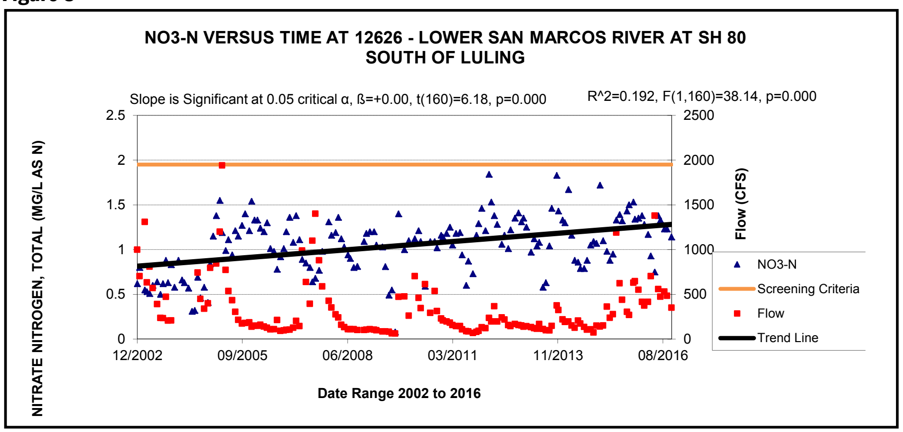
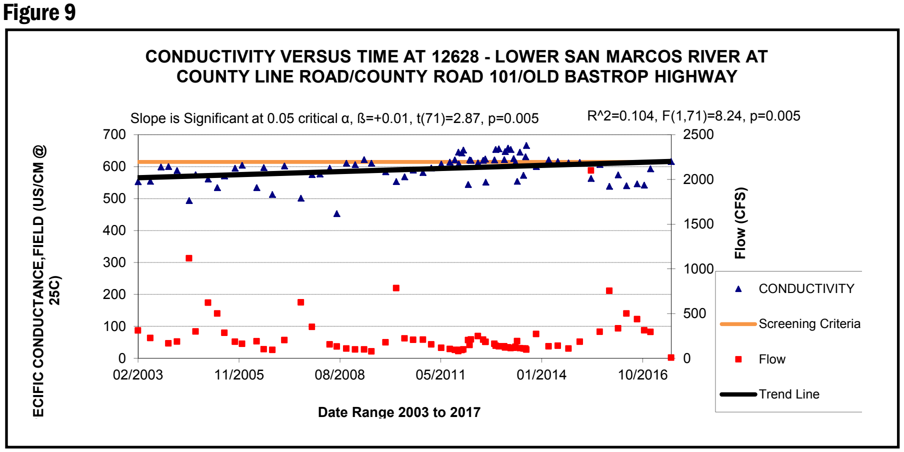


Figure 9



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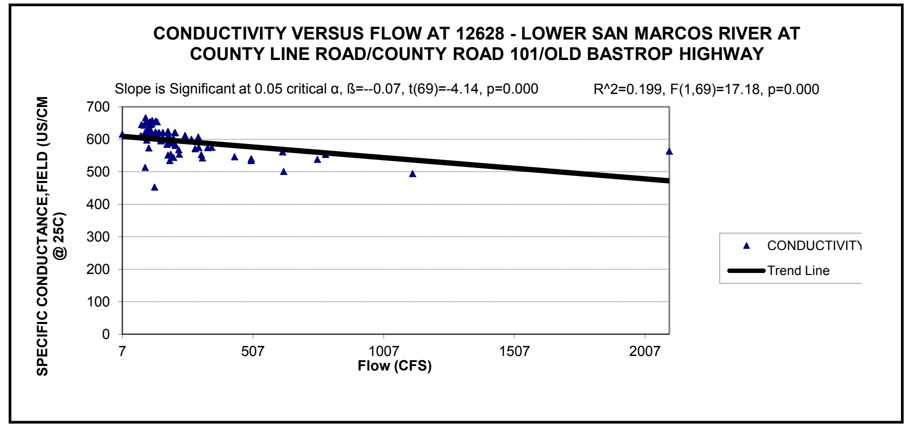
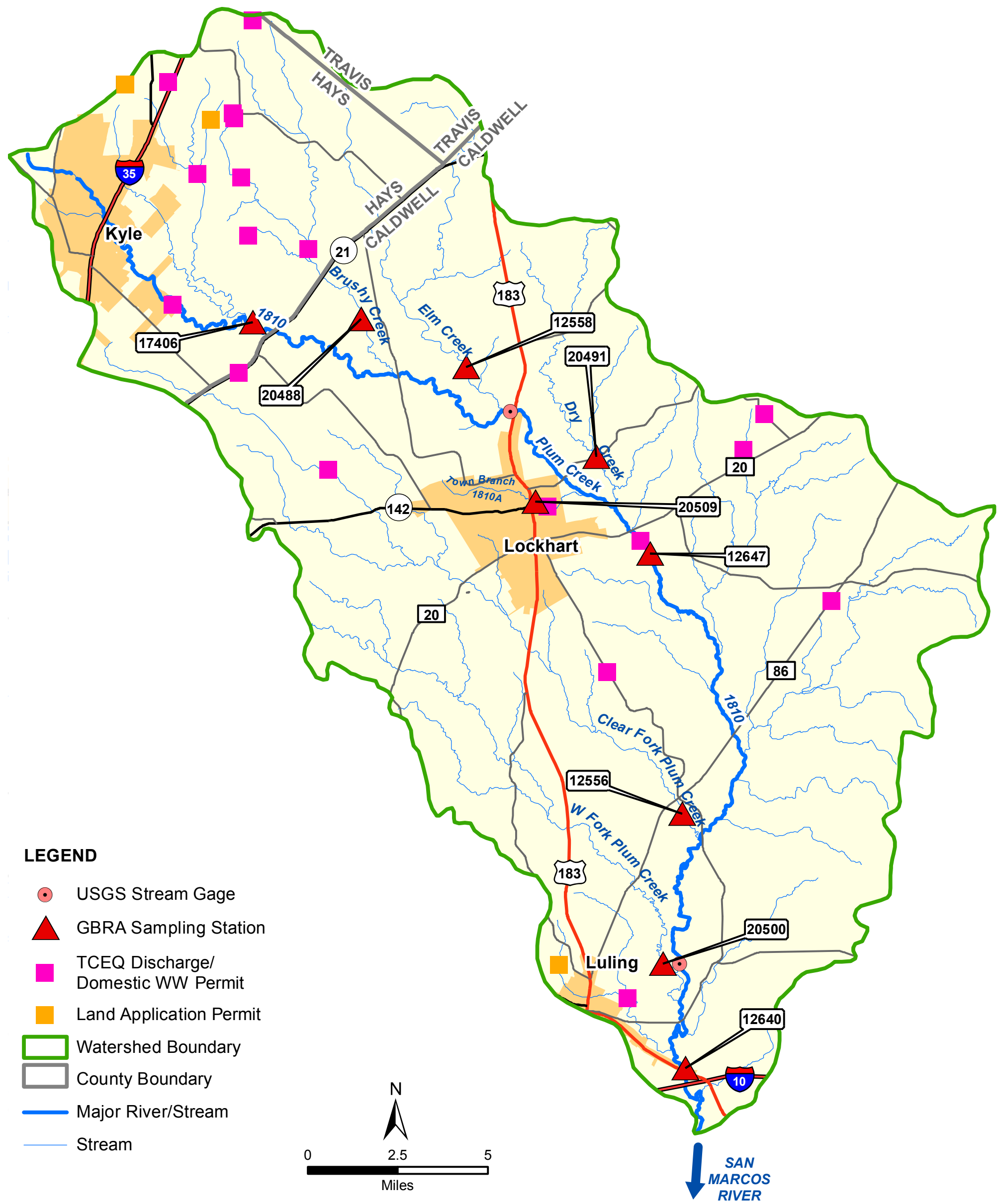


PLUM CREEK



TRAVIS
HAYS
TRAVIS
CALDWELL
HAYS
CALDWELL
35
Kyle
21
Brushy Creek
1810
17406
20488
183
Elm Creek
12558
20491
Dry Creek
Plum Creek
20
Town Branch
1810A
142
20509
Lockhart
12647
20
86
1810
Clear Fork Plum Creek
12556
W Fork Plum Creek
183
20500
Luling
12640
10
SAN MARCOS RIVER
N
0
2.5
5
Miles
LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Discharge/ Domestic WW Permit
Land Application Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream

PLUM CREEK

Segment 1810 represents the 52 mile long Plum Creek tributary of the San Marcos River. Plum Creek has a large 389 square mile drainage area that encompasses the cities of Buda, Kyle, Uhland, Lockhart and Luling. This watershed has been historically dominated by agricultural land use, but is rapidly urbanizing as the population of the area increases. The headwaters of Plum Creek are fed by natural springs from the Leona aquifer, with additional contributing springs arising throughout the watershed. The stream is largely wastewater dominant, as it receives the treated effluent discharge of twelve permitted wastewater treatment facilities.

Plum Creek is a historically intermittent creek with contributing flows from several springs along its length. The creek become perennial as the surrounding communities of Buda, Kyle, Lockhart and Luling have developed in the watershed. These four cities contribute the bulk of the base flow to the stream by discharging wastewater effluent from five major discharges along its length. The Plum Creek Segment 1810 was listed on the Texas 303(d) list of impaired water bodies, as required by Clean Water Act Sections 303(d) and 305(b) in 2004. The middle and upper end of the water body from below Lockhart at CR 202 to the upper end of the segment were found to be impaired for contact recreation with an E. coli geometric mean of 183 MPN/100 mL. The stream was also noted to have concerns for Nitrate+Nitrite Nitrogen at this time because over 25% of all measurements exceed the screening criteria of 1.95 mg/L. In 2006, the Texas State Soil and Water Conservation Board (TSSWCB), GBRA and Texas AgriLife Extension began working with local stakeholders to develop a Watershed Protection Plan (WPP) for the Plum Creek waterhshed. The TSSWCB also funded additional water quality monitoring in the watershed to facilitate the development of the WPP by filling data gaps to supplement the existing CRP monitoring program. This plan was designed to address the known water quality impairments and concerns in the watershed. The WPP became the first plan in the state of Texas to be accepted by the EPA as meeting all guidance requirements and implementation of the plan began in 2008. In addition to identifying the sources of bacteria and nutrient loading in the watershed, the plan also identified a number of implementation activities that could be voluntarily undertaken by stakeholders in order to reduce targeted bacteria and nutrient loading. These activities include feral hog removal, addressing leaking septic tanks, nutrient management training, pet waste management, and storm system conveyance assessments. In 2010, the TCEQ moved the watershed from assessment category 5a, which would require a regulatory TMDL to address the impairments in the watershed to category 4b, which would allow for the WPP to attempt to address the impairment with best management practices that are expected to result in attainment of the water quality

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Plum Creek
Drainage Area: 389 square miles
Length: 52 miles
Tributaries: Bunton Branch, Porter Creek, Andrew's Branch, Richmond Branch, Cowpen Creek, Brushy Creek, Elm Creek, Dry Creek, Town Creek (1810A), Clear Fork, West Fork,
Aquifer: Edwards Balcones Fault Zone, Leona Aquifer, Carrizo-Wilcox Aquifer
River Segments: 1810, 1810A
Cities and Communities: Buda, Kyle, Uhland, Lockhart, Luling
Counties: Hays, Caldwell
EcoRegion: Edwards Plateau, Texas Blackland Prairie, Post Oak Savannah
Climate: Average annual rainfall 34.43 inches, Average annual temperature 70.64°F

Vegetation Cover: Evergreen Forest 1.21%, Deciduous Forest 11.64%, Shrubland 34.12%; Grassland 12.10%; Woody Wetlands: 3.07% Cultivated Crops 7.20% ; Pasture Hay 20.92%
Land Uses: urban, suburban sprawl, light industry, and recreational.
Development: Low Intensity 0.59% ; Medium Intensity 0.36%; High Intensity 0.09%; Open Space 6.52%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and agriculture and ranching.
Soils: Dark, waxy soil to sandy loam, limestone to black waxy chocolate and grey loam
Permitted Wastewater Treatment Facilities: Domestic 12, Land Application 2, Industrial 2

standard. Following the acceptance of the plan the TSSWCB has funded several additional monitoring projects that have been used to quantitatively track the effectiveness of water quality restoration implementation activities over time. In the latest 2014 Texas Integrated Report of Surface Water Quality the geometric mean for E. coli in all three assessment units of the watershed has increased since the initial listing in 2004. Total Phosphorus and dissolved oxygen have also been added to nitrate nitrogen as ongoing concerns in the watershed. The TSSWCB funded a nitrate isotope study, in which the GBRA and USGS conducted monitoring of the surface water, shallow groundwater and springs from the contributing Leona aquifer in order to determine the sources of nitrate nitrogen in the watershed. The results of this study showed that the majority of nitrate nitrogen in this watershed came from a wastewater source during normal and low flows, but during high flows additional contributions occurred from a mixture of nitrogen fertilizers and septic waste. This study eliminated past supposition that nitrate could be entering the watershed from atmospheric deposition or naturally occurring nitrate deposits. The TSSWCB also funded a bacterial source tracking study conducted by the GBRA and the Texas A&M Soil and Microbiology Laboratory (TAMU SAML). The results of this study showed that the majority of bacteria samples collected during the twelve month long study came from wildlife sources and less than 10% of the bacteria came from a source that could be identified as human. The TCEQ has divided the creek into three assessment units that represent the upper, middle and lower portions of the watershed. Each section of the watershed was examined for water quality trends over time.

Assessment Unit 1810_01 represents the lower portion of the watershed from the confluence with the San Marcos River to 2.5 miles upstream of the Clear Fork tributary. This AU has been historically monitored at station 12640 at the County Road 135 crossing southeast of the city of Luling, TX. This station was monitored by the TCEQ and its predecessor agencies from 1983 until 1998, when monitoring duties were transferred to the GBRA under the Clean Rivers Program. This AU receives the discharges from the Clear Fork and West Fork tributaries of Plum Creek, as well as the discharge of the Salt Branch tributary, which receives the effluent from one of the two wastewater treatment facilities in the City of Luling. The Luling North WWTF is permitted to discharge up to 0.9 million gallons per day (MGD). This facility treats the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, ammonia nitrogen

does not exceed 3 mg/L and E. coli does not exceed 126 MPN/100 mL. Recently, several large wastewater permits to serve subdivisions near the City of Uhland have been issued to the Walton Group. These WWTFs are permitted to discharge into the Clear Fork tributary of this AU, but to date no construction has begun on these projects. In the most recent 2014 Texas Integrated Report of Surface Water Quality this AU had an assessed geometric mean of E. coli concentrations of 156.78 MPN/100 mL. This AU also had assessed concerns for dissolved oxygen grab and 24 hour average concentrations, below the screening criteria of 5.0 mg/L. The 2014 report also identified nutrient concerns for nitrate nitrogen and total phosphorus above the respective screening criteria of 1.95 mg/L and 0.69 mg/L. The assessed average of total phosphorus was 1.17 mg/L and the assessed average for nitrate nitrogen was 3.75 mg/L. The GBRA analyzed the most recent data from this AU and discovered several notable trends. The dissolved oxygen concentrations at this station are significantly decreasing over time, and this parameter correlates directly with stream flow (Figures 1 & 2). Total phosphorus concentration are also significantly increasing over time, and this parameter has an inverse relationship with stream flow (Figures 3 & 4).

Assessment Unit 1810_02 encompasses the middle portion of the watershed from 2.5 miles upstream of the Clear Fork tributary to 0.5 miles upstream of state highway 21. Historically, this AU has been monitored at station 12647 at the County Road 202 crossing southeast of the city of Lockhart. This station was monitored by the TCEQ from 1981 and its predecessor agencies until 2005, when monitoring duties were transferred to the GBRA under the Clean Rivers Program. This AU receives the discharges from the Brushy Creek, Elm Creek, Dry Creek and Town Creek (1810A) tributaries. This AU also receives the discharges from both wastewater treatment facilities in the City of Lockhart, as well as permitted treatment plants for the Shadow Creek and Sunfield neighborhoods. The Lockhart #2 FM20 WWTF is permitted to discharge up to 1.5 million gallons per day (MGD). The Lockhart #1 Larremore WWTF is permitted to discharge up to 1.1 million gallons per day (MGD). Both facilities treat the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, ammonia nitrogen does not exceed 3 mg/L and E. coli does not exceed 126 MPN/100 mL. The 2014 Texas Integrated Report of Surface Water Quality reported that this AU had an assessed geometric mean of E. coli concentrations of 200.13 MPN/100 mL. This AU also assessed nutrient concentrations for nitrate nitrogen of 7.69 mg/L and total phosphorus of 1.52 mg/L, which were above the respective screening criteria of 1.95 mg/L and 0.69 mg/L. The 2014 report also identified a concern for impaired biological habitat because the average index of biological integrity (IBI) for 5 screening events at this station was 24.40, which fell below the 29.00 IBI score needed to meet a high aquatic life use. Several of these screening events occurred during drought conditions and a full aquatic life monitoring event during normal stream flow conditions may be warranted in order to confirm this concern. The unclassified Town Creek (1810A) tributary to Plum Creek was also assessed in the 2014 report and the TCEQ identified concerns for the geometric mean of E. coli bacteria and average concentration of nitrate nitrogen and dissolved oxygen grabs over the 6 data points analyzed. GBRA reviewed all of the data available at station 20509 in Lockhart City Park through December of 2016. The GBRA found that the assessed concerns were justified for E. coli and nitrate nitrogen with a calculated geometric mean of E. coli of 273 MPN/100 mL, and an average nitrate nitrogen concentration of 10.0 mg/L over the 26 data points examined. This creek is heavily influenced by spring flows from the Leona aquifer, which has historically high nitrate nitrogen concentrations and the E. coli concentrations in this segment are most likely due to wildlife influences in this park setting. An aquatic life monitoring (ALM) event was performed at this station in 2017 to determine whether the dissolved oxygen concern was impacting the life in this stream. During the first day of the ALM, a trail of horses traveled through the middle of the stream bed, which visibly disturbed the substrate and fish nesting areas. This disturbance may have contributed to the intermediate fish and macroinvertebrate community scores observed on that day, but a successive monitoring event two months later confirmed that the fish community had recovered to high levels and the macroinvertebrate community were exceptional. The GBRA also identified several water quality trends in AU 1810_02. The nitrate nitrogen concentrations in this AU are significantly decreasing over time and are also inversely correlated with stream flow (Figures 5 & 6). This trend indicates that nitrate levels are diluted in the water column as flows increase following several years of drought conditions in the watershed. The E. coli concentrations for which there is an impairment in this AU, are not significantly changing over time (Figure 7).

Assessment Unit 1810_03 encompasses the middle portion of the watershed from 0.5 miles upstream of of State Highway 21 to the upper end of the segment above FM 150 in the City of Kyle. This AU has been monitored at station 17406 on Plum Creek Road upstream of the city of Uhland by the GBRA under the Clean Rivers Program. This AU receives the discharge from the Porter Creek tributary, which receives the wastewater discharge from the city of Buda. This AU also receives the effluent discharge from the city of Kyle. The Buda WWTF is permitted to discharge up to 1.5 million gallons per day (MGD). The Kyle WWTF is

CONTINUED ON PAGE 102

permitted to discharge up to 4.5 million gallons per day (MGD). The Buda WWTF treats the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 5 mg/L, total suspended solids (TSS) does not exceed 12 mg/L, ammonia nitrogen does not exceed 2 mg/L and total phosphorus does not exceed 0.8 mg/L, and E. coli does not exceed 126 MPN/100 mL. The Kyle WWTF treats the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, ammonia nitrogen does not exceed 3 mg/L, and E. coli does not exceed 126 MPN/100 mL. The 2014 Integrated Report identified impairment for E. coli bacteria in this segment, as well as screening concerns for nitrate nitrogen and total phosphorus. The position of this AU upstream of the majority of the spring influences in the watershed cause it to experience a greater influence from wastewater effluent than the downstream AUS. The assessed E.coli bacteria geometric mean concentration of 306.54 MPN/100 mL, average nitrate nitrogen concentration of 14.17 mg/L and average total phosphorus concentration of 2.83 mg/L are also greater than in any of the downstream AUS. The nutrient loading in this AU is most likely directly linked to the effects of wastewater effluent according to the nitrate nitrogen isotope study performed by the GBRA and USGS. The E. coli loading does not appear to be from human sources according to the bacterial source tracking study performed by the GBRA and TAMU SAML, but the rapid urbanization of this AU be contributing to additional use of the riparian corridors along the stream segment by contributing native wildlife. The wildlife are potentially being crowded closer to the stream in order to avoid human contact in the more urbanized portions of the watershed. Several water quality trends were identified by the GBRA in this AU. The nitrate nitrogen concentrations are significantly increasing and this parameter is inversely correlated with stream flow (Figures 8 & 9). The chloride concentrations were also significantly increasing over time and inversely correlated with stream flow (Figures 10 & 11). The nutrient and salt concentrations will likely continue to increase as additional wastewater is discharged into this portion of the creek from an expanding population.

Table 1

Station 12640 – Plum Creek at CR 135 12/2002 - 11/2016					
AU 1810_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.1	29.3	6.2	181	32.2
pH	7.8	8.3	7.0	180	6.5 – 9.0
Chloride (mg/L)	152	444	9.4	161	350.00
Sulfate (mg/L)	77	163	14.9	163	150.00
Total Dissolved Solids (mg/L)	731	1729	155	180	1120.00
NH3-N (mg/L)	0.15	0.66	<0.02	132	0.33
Total Phosphorus (mg/L)	0.60	2.69	<0.05	176	0.69
Chlorophyll-a (µg/L)	2.5	19.2	<1.0	161	14.1
Nitrate Nitrogen (mg/L)	1.83	7.96	<0.05	174	1.95
TKN (mg/L)	0.85	1.92	0.42	87	N/A
AU 1810_01 Recreational Use					
E. coli (MPN/100 mL)	198 Geomean	13,000	9	173	126 Geomean
AU 1810_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.4	14.6	3.4	180	≥3.0 Minimum & ≥5.0 Average

Table 2

Station 12647 – Plum Creek at CR 202 12/2002 - 11/2016					
AU 1810_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.0	28.8	8.1	135	32.2
pH	7.9	8.5	7.4	135	6.5 – 9.0
Chloride (mg/L)	86	139	5.0	116	350.00
Sulfate (mg/L)	76	319	5.0	116	150.00
Total Dissolved Solids (mg/L)	556	741	145	134	1120.00
NH3-N (mg/L)	0.17	1.43	<0.05	116	0.33
Total Phosphorus (mg/L)	1.03	2.69	0.14	133	0.69
Chlorophyll-a (µg/L)	3.2	15.5	<1.0	108	14.1
Nitrate Nitrogen (mg/L)	5.99	51.6	0.32	129	1.95
TKN (mg/L)	0.77	2.69	<0.2	106	N/A
AU 1810_02 Recreational Use					
E. coli (MPN/100 mL)	264 Geomean	>24,000	16	119	126 Geomean
AU 1810_02 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.2	13.6	3.9	135	≥3.0 Minimum & ≥5.0 Average

Table 3

Station 17406 – Plum Creek at Plum Creek Road 02/2003 - 10/2016					
AU 1804_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.2	28.4	6.03	181	32.20
pH	7.8	8.7	7.0	181	6.5 – 9.0
Chloride (mg/L)	108	267	16.3	166	350.00
Sulfate (mg/L)	92	173	36.0	166	150.00
Total Dissolved Solids (mg/L)	640	1040	214	181	1120.00
NH3-N (mg/L)	0.74	15.5	<0.02	131	0.33
Total Phosphorus (mg/L)	1.90	5.26	<0.04	177	0.69
Chlorophyll-a (μg/L)	2.64	11.6	<1.0	162	14.1
Nitrate Nitrogen (mg/L)	9.41	34.8	0.22	171	1.95
TKN (mg/L)	1.07	8.13	<0.2	89	N/A
AU 1810_03 Recreational Use					
E. coli (MPN/100 mL)	348 Geomean	17,000	36	171	126 Geomean
AU 1810_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.6	14.1	2.2	181	≥3.0 Minimum & ≥5.0 Average

Table 4

Station 20509 – Town Branch at Lockhart City Park 03/2008 - 10/2016					
AU 1810A_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.5	26.6	11.2	26	32.20
pH	7.9	8.1	7.3	26	6.5 – 9.0
Chloride (mg/L)	30.0	40.9	21.8	26	350.00
Sulfate (mg/L)	64.0	78.6	48.2	26	150.00
Total Dissolved Solids (mg/L)	509	582	366	26	1120.00
NH3-N (mg/L)	0.16	0.60	<0.10	26	0.33
Total Phosphorus (mg/L)	<0.05	0.17	<0.02	26	0.69
Chlorophyll-a (μg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	10.0	15.2	3.07	26	1.95
TKN (mg/L)	0.26	0.48	<0.20	22	N/A
AU 1804_05 Recreational Use					
E. coli (MPN/100 mL)	273 Geomean	1400	59	26	126 Geomean
AU 1804_05 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.2	14.0	3.6	26	≥3.0 Minimum & ≥5.0 Average

Table 5

Station 12556 – Clear Fork at Salt Flat Road 12/2008 - 12/2016					
AU 1810_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	19.4	28.7	6.5	109	32.20
pH	7.7	8.2	6.6	110	6.5 – 9.0
Chloride (mg/L)	263	2690	<1.0	92	350.00
Sulfate (mg/L)	61	124	15.6	92	150.00
Total Dissolved Solids (mg/L)	867	5213	167	110	1120.00
NH3-N (mg/L)	0.18	0.65	<0.10	110	0.33
Total Phosphorus (mg/L)	0.11	0.90	<0.02	110	0.69
Chlorophyll-a (μg/L)	6.8	157	<1.0	92	14.1
Nitrate Nitrogen (mg/L)	0.94	5.69	<0.05	41	1.95
TKN (mg/L)	0.78	2.96	<0.2	74	N/A
AU 1810_01 Recreational Use					
E. coli (MPN/100 mL)	225 Geomean	12,000	3	110	126 Geomean
AU 1810_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.8	13.1	1.2	110	≥3.0 Minimum & ≥5.0 Average

PLUM CREEK

Figure 1

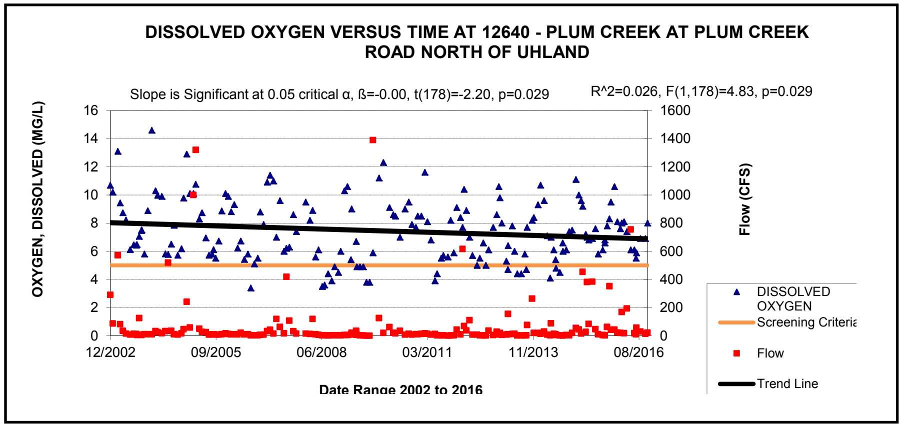


Figure 4

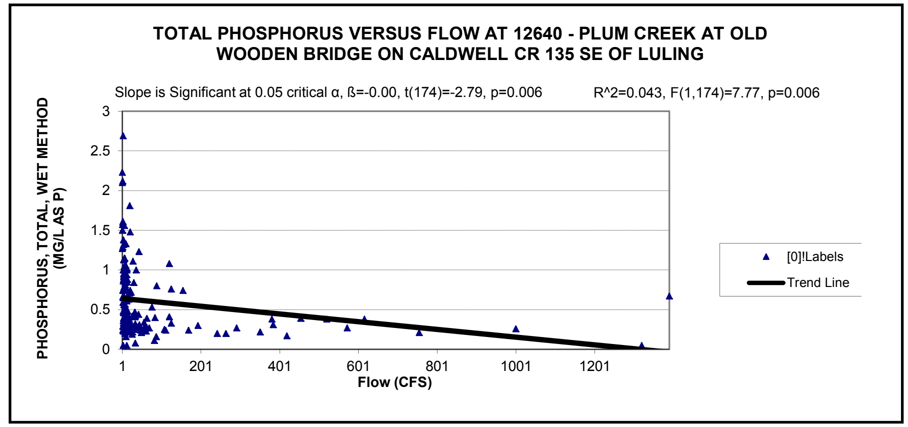


Figure 2

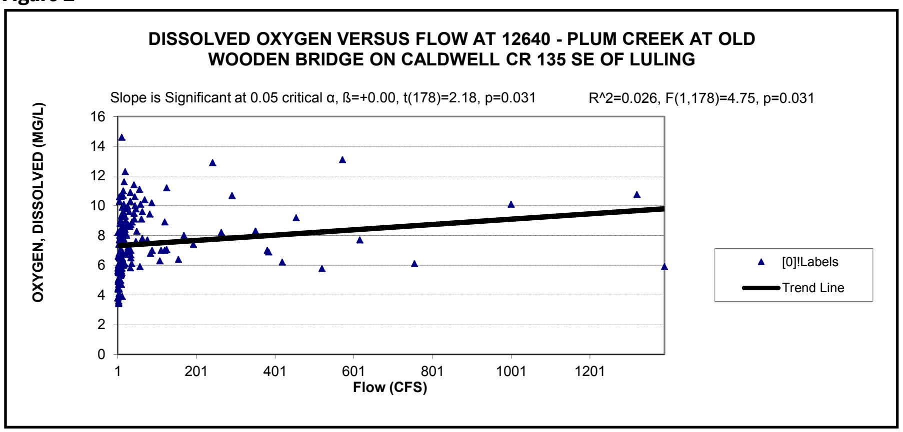
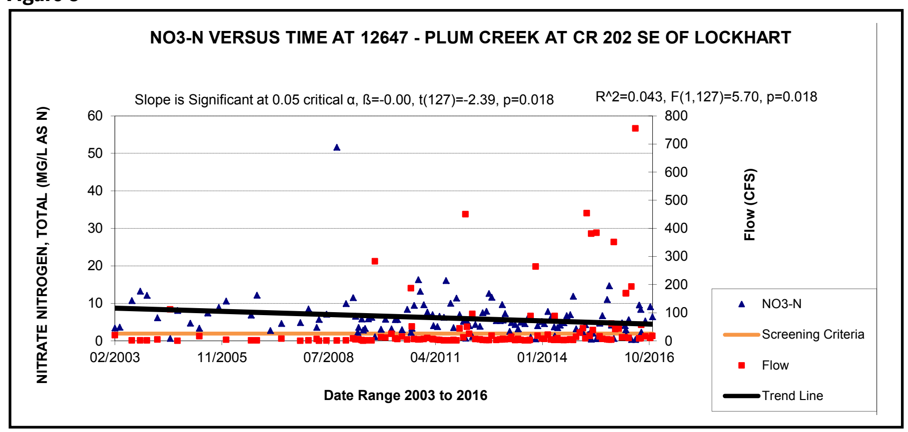


Figure 5



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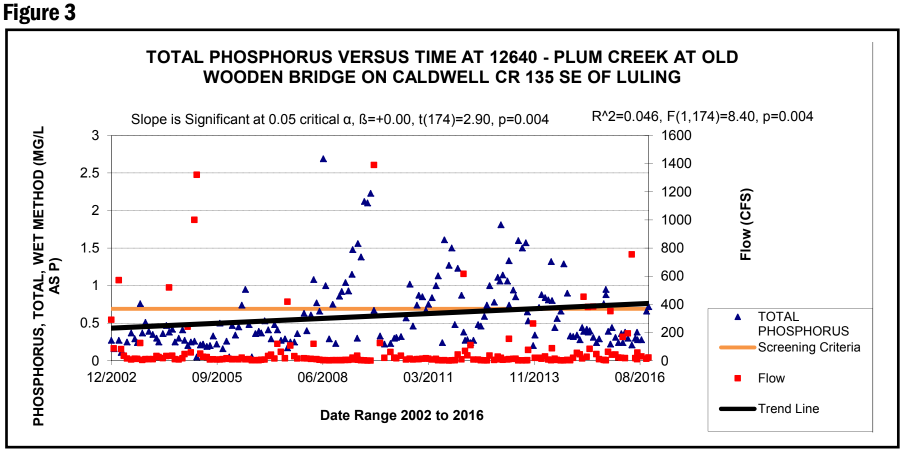

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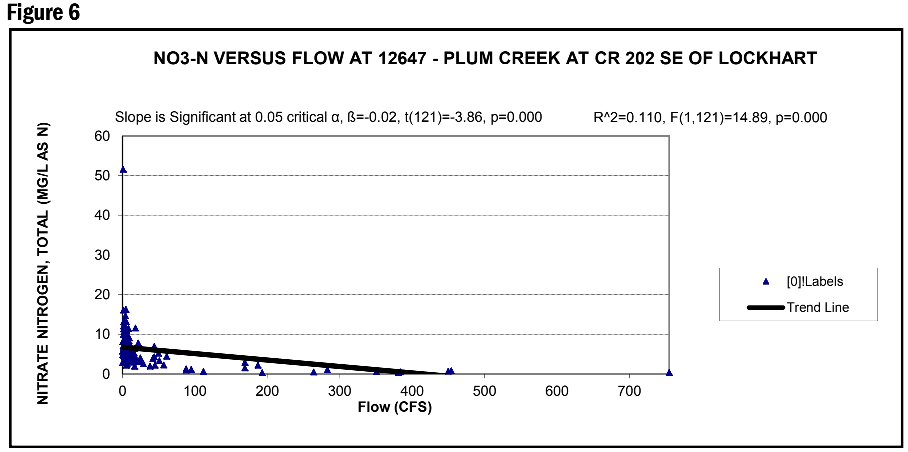


PLUM CREEK

Figure 7

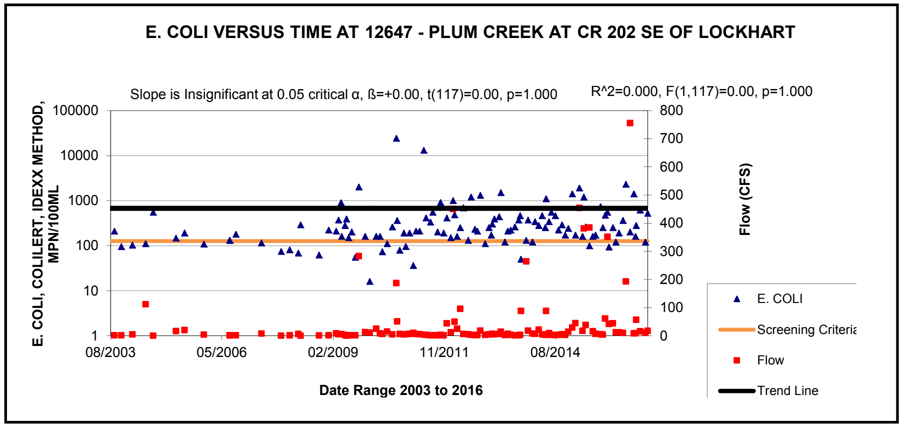


Figure 8

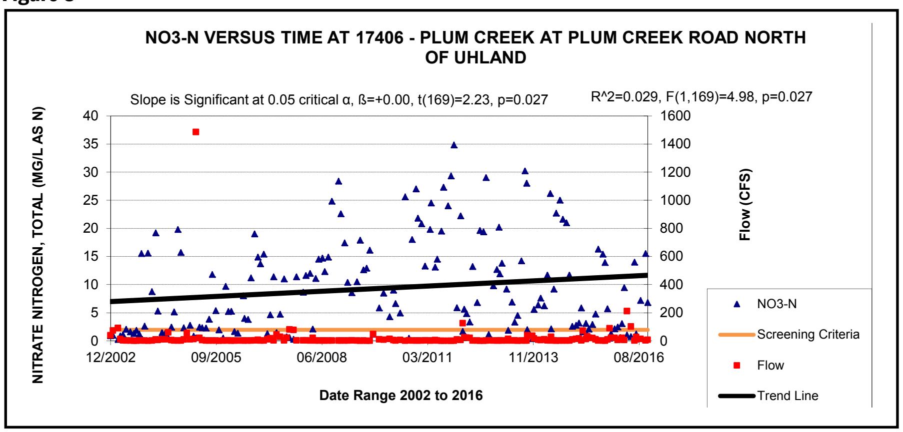


Figure 9

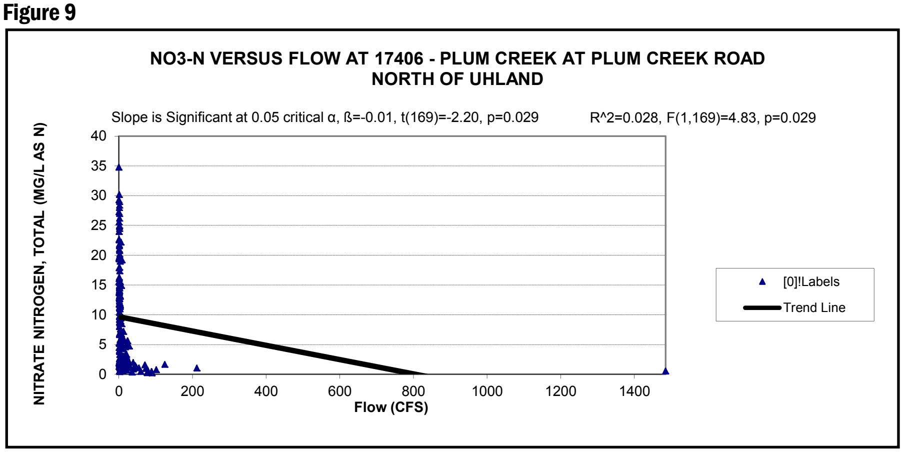


Figure 10

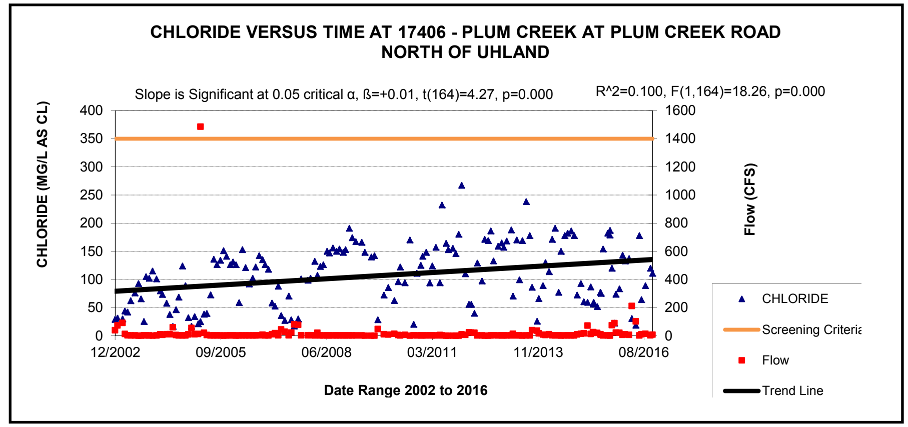
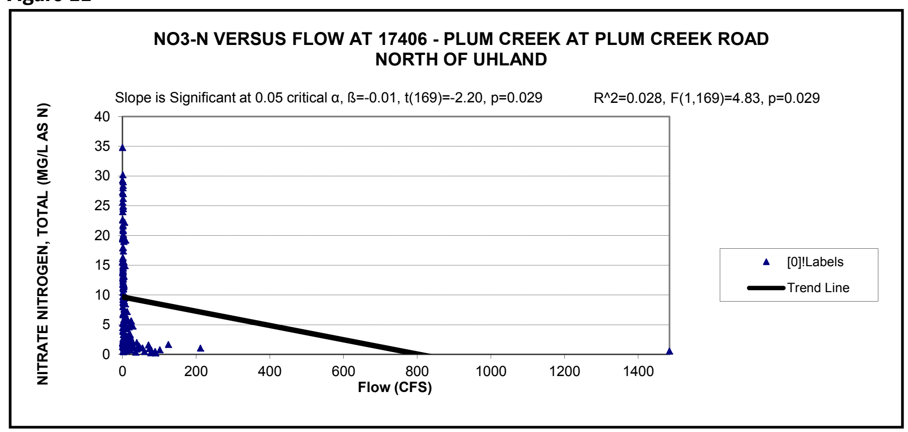
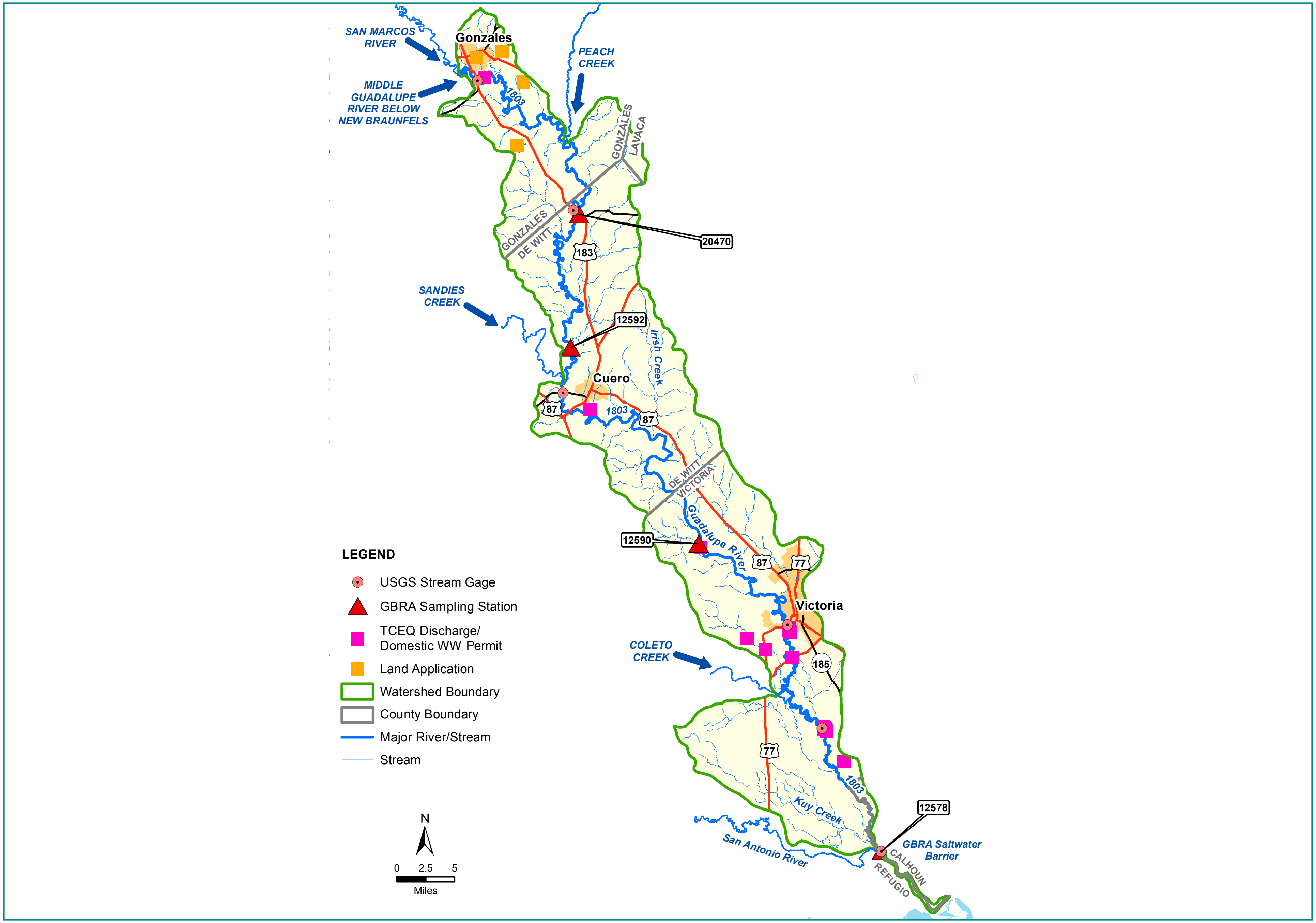


Figure 11



LOWER GUADALUPE RIVER



LOWER GUADALUPE RIVER

Lower Guadalupe River Below San Marcos River *Segment 1803 (Guadalupe River below San Marcos River) begins at the confluence of the San Marcos River west of Gonzales, and travels 161.5 miles to the confluence with the San Antonio River. This portion of the Guadalupe River is a large, slow moving river with minimal elevation changes and a low stream gradient. Frequent twists and bends are common and rapids are greatly reduced from the upstream portions of the river. Segment 1803 flows south past the cities of Cuero in Dewitt County and Victoria in Victoria County, to immediately upstream of the confluence with the San Antonio River in Calhoun County. Numerous minor tributaries combine with the Guadalupe River in this portion of the watershed including Peach Creek and Sandies Creek. The Strahler Stream Order is a hydrological calculation used to estimate the complexity of a stream segment based upon the branching of its contributing tributaries. This stream segment transitions from a fifth order stream to a sixth order stream when it combines with Sandies Creek in Dewitt County. The river segment begins in the sandy soils of the Southern Post Oak Savannah ecoregion and flows through the moisture retaining clays of the southern Texas Blackland Prairie before it transitions to the sandy clay of the Gulf Coastal Plains ecoregion. Land use consists of cropland, hay pasture, rangeland and poultry farming with deciduous forests of live oak, elm and ash. Native grasses such as big bluestem, little bluestem and switchgrass are abundant in the rangeland prairies. Invasive tree species such as the Chinese Tallow and Chines Privet have been found in many areas of the watershed.*

Lower Guadalupe River Below San Antonio River *Segment 1802 (Guadalupe River below San Antonio River) is the 0.4 mile long stretch between the confluence of the San Antonio and Guadalupe Rivers to the GBRA Salt Water Barrier. This segment is a typical slow moving coastal river. Following the confluence with the San Antonio River the watershed drainage expands from 5,979 square miles to 10,172 square miles and the average yearly flow of the Guadalupe River below this point increases by approximately 40%. This is the most downstream stream segment of the Guadalupe River that is not influenced by tidal waters. This portion of the western gulf coastal plain ecoregion is characterized by floodplains and low terraces comprised of alluvial sediments. Land cover typically includes lowland forests of elms, water oak and ash trees as well as grazed pasture and cropland.*

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Lower Guadalupe River Watershed
Drainage Area: 488 square miles
Length: 167 miles
Tributaries: Kerr Creek, Cross Timber Creek, Cottle Creek, Black Creek, Peach Creek, Freeman Creek, Kokernot Creek, Rocky Creek, Boggy Creek, Fulcher Creek, Willow Branch, McCoy Creek, Cuero Creek, Sandies Creek (1803B) , Lost Creek, Gohlke Creek, Oaxley Branch, Cattail Creek, Irish Creek, Reeds Branch, Carlisle Creek, Price Creek, Rocky Creek Mission Creek, Wright Creek, Spring Bayou, Blue Bayou, New River, Coleto Creek (1807), Black Bayou and Kuy Creek
Aquifer: Carrizo-Wilcox, Gulf Coast
River Segments: 1803, 1802, 1801, 1701
Cities and Communities: Gonzales, Hocheim, Cuero, Nursery, Victoria, Tivoli
Counties: Gonzales, Dewitt, Victoria, Calhoun, Refugio

EcoRegions: Texas Blackland Prairie, Post Oak Savannah, Gulf Coastal Plains, East Central Texas Plains
Climate: Average annual rainfall 44.22 inches, Average annual temperature 70.1°FVegetation Cover: Evergreen Forest 0.21%, Deciduous Forest 5.88%, Shrubland 34.39%; Grassland 3.49%; Woody
Wetlands: 3.68% Cultivated Crops 6.89% ; Pasture Hay 39.16%
Land Uses: urban, suburban sprawl, heavy industry, agriculture, ranching and recreational.
Development: Low Intensity 1.33% ; Medium Intensity 0.18%; High Intensity 0.03%; Open Space 3.41%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils: Cracking clay subsoil, sandy, sandy and clay loam
Permitted Wastewater Treatment Facilities: Domestic 6, Land Application 0, Industrial 3

LOWER GUADALUPE RIVER

Guadalupe River Tidal *Segment 1801 (Guadalupe River Tidal) comprises the 10 mile portion of the Guadalupe River from the GBRA Salt Water Barrier to the confluence with the Guadalupe Bay. This tidally influenced portion of the river is prone to frequent log jams. The logs that travel downstream catch on bridges, railroad crossings and other obstructions creating restrictions to water flow, changes in the river channel, and producing new ecosystems. The floodplain can often extend several miles outside of the stream banks.*

Segment 1803 consists of five TCEQ assessment units (AUs) confluence with the San Marcos River to the confluence with the San Antonio River. This stream segment has three current routine monitoring stations that are sampled by the GBRA at FM 447 west of Nursery (12590), FM 766 west of Cuero (12592), and US 183 in Hochheim (20470). This segment is not currently impaired for any of its designated uses, although several of its contributing subwatersheds have been listed as impaired (1803A Elm Creek, 1803B Sandies Creek, 1803C Peach Creek). Water quality monitoring parameters are analyzed against water quality standards for each of the designated uses, in the AUs of this stream segment. A general use nitrate-nitrogen concern was identified in the 2014 Texas Integrated Report on assessment unit 1803_01, which includes the lower 25 miles of the segment. The average nitrate-nitrogen value was assessed at 8.47 mg/L, which was more than four times the General Use nutrient screening level of 1.95 mg/L. The elevated nitrate concentrations were not identified in any of the four other assessment units of the segment, which were all located upstream of the confluence with Coleto Creek. This concern was most likely due to contributions of data from a historical monitoring station (16579). Monitoring at the historical station was discontinued in 2006 because it was found to be located within the mixing zone of an industrial wastewater discharge and therefore not representative of ambient conditions in this portion of the stream. An alternative station has never been monitored in this assessment unit due to site access concerns in this portion of the river. The 2014 Texas Integrated Report of Water Quality also removed a contact recreation concern for bacteria in assessment unit 1803_04, which included the portion of the segment 25 miles downstream of the Sandies Creek confluence. This concern was eliminated because the assessed mean of bacteria concentrations for this AU dropped below the 126 MPN/ 100 mL assessment criteria. The Texas Instream Flow Program (TIFP) was enacted by the legislature under Texas Senate Bill 2. In 2012, preliminary study design began on an in depth scientific study of the flows necessary to support a sound ecosystem on the Lower Guadalupe River. The Eagle Ford Shale Play, located in Dewitt and Gonzales counties, has become one of the richest oil and gas deposits in Texas because of the exploration technology called hydraulic fracturing or “fracking.” Fracking is the process to stimulate wells and recover natural gas and oil by creating fractures that extend from a well bore into formations and allow the product to travel more easily. The fracking solution can be made of a proprietary mixture of organic chemicals, acids and bases. Concerns have been raised about the impacts that these activities will have on groundwater quality, surface water quality, the quantity of water needed in a water-limited area and the potential for spills and loss of containment of chemicals. The GBRA analyzed the water quality data from this stream segment to look for trends over time at all three monitoring stations in the segment.

Station 20470 is the most upstream station in this segment and is located at the crossing of State Highway 183 near the community of Hochheim. This station is located in stream segment 1803_05, which encompasses the portion of the watershed from 25 miles upstream of the Sandies Creek confluence to the confluence with the San Marcos River. This station was initiated by the GBRA in 2008 and is the station with the shortest data set available in the segment. No water quality parameters were found to be significantly changing over time at this station.

Station 12592 represents AU 1803_03 from the confluence with Sandies Creek to a point 25 miles upstream. This station is located at the Farm to Market Road 766 road crossing upstream of the city of Cuero and has been routinely monitored by the GBRA since 1990 and was incorporated into the Clean Rivers Program in 1996. An analysis of the data from this station revealed a significant decrease in stream flow over time (Figure 1). This station also had a significant decrease in dissolved oxygen over time and a significant increase in chlorides over time (Figures 2 & 3). The changes over time in these two parameters were both likely due the effects of several years of drought and the effects of stream flow (Figure 4) on this longer data set.

Station 12590 is the most downstream monitoring station in this segment. This station is located at FM 447 near Nursery, upstream of the city of Victoria and has been monitored by the GBRA since 1999. The station represents AU 1803_04, which includes the portion of the watershed between the confluence with Coleto Creek and the Confluence with Sandies Creek. This AU also includes the three major discharges from the city of Victoria. Victoria has a WWTF located downstream of the city at US highway 59 that is permitted to discharge up to 9.6 million gallons per day (MGD). The city also operates a plant on Willow Street near the center of town that is permitted to discharge up to 2.5 MGD and new plant on Odem Street that is permitted to discharge up to 6.6 MGD. All three wastewater treatment facilities ensure that the effluent that is discharged into the Guadalupe River in this segment has a biochemical oxygen demand (BOD) that does not exceed 20 mg/L, a total suspended solids (TSS) concentration that does not exceed 20 mg/L and a geometric mean of E. coli that does not exceed 126 MPN/100 mL. This monitoring station is significantly decreasing in stream flow over time (Figure 5) similar to the upstream station 12592. This change in stream flow was accompanied by an increase in pH over time and a decrease in total hardness over time (Figures 6 & 7). The change in pH is most likely due to the effects of increased photosynthetic activity from plant and algae growth associated with the lower flow conditions.

Segment 1802 consists of one assessment unit that encompasses its entire length. The Texas Integrated Report assessed a mean concentration of 3.13 mg/L of nitrate-nitrogen for this segment, which exceeded the general use nutrient screening level criteria of 1.95 mg/L. Other assessed nutrient parameters such as total phosphorus, ammonia nitrogen showed no concern and the chlorophyll a. A single routine monitoring station (12578) is sampled monthly by the GBRA upstream of the saltwater barrier on Shultz Road. This station is also the closest station to the confluence with the San Antonio River confluence and any changes in water quality from the San Antonio River are seen at this station. An analysis of the data from this station revealed that stream flow was decreasing over time (Figure 8). The nitrate nitrogen concentrations at this station were significantly increasing over time, while the dissolved oxygen concentrations were significantly decreasing over time. (Figures 9 & 10). These trends are most likely due to a greater influence of wastewater effluent influence during periods of diminished flow, as nitrate nitrogen is a common byproduct of a properly functioning wastewater facility, as it treats ammonia waste.

Segment 1801 is assessed as a single assessment unit, which includes the length of the entire segment. A routine station (12577) has been monitored quarterly at the state highway 35 tidal bridge by TCEQ region 14 staff and TCEQ predecessor agencies since 1970.The 2014 Texas Integrated Report assessed a mean concentration of 2.47 mg/L of nitrate-nitrogen for this segment, which exceeded the general use nutrient screening level criteria of 1.10 mg/L for tidal waterbodies. A total of 18 of the 25 measurements that were analyzed for the assessment exceeded these screening criteria. High nitrate-nitrogen levels may contribute to eutrophic conditions in the waterbody that can lead to low dissolved oxygen concentrations for the aquatic ecosystem. Although nitrate nitrogen levels appeared to be elevated in the last assessment, other nutrients such as ammonia nitrogen, and total phosphorus were not concerns. Chlorophyll-a is a common response indicator for excessive algae and nutrient enrichment, but these concentrations were also below the assessed screening criteria. The TCEQ is currently evaluating possible ways to incorporate numerical nutrient criteria into water quality standards for freshwater and tidal streams. The GBRA found that the pH at station 12577 is significantly increasing over time (Figure 11), which may be an indication of additional photosynthetic activity during periods of low flow.

The Senate Bill 3 stakeholder process has recommended instream flows for the Guadalupe and San Antonio rivers and inflows into the bays and estuaries in the lower basin. TCEQ has since established environmental flow requirements for the Guadalupe and San Antonio rivers using stakeholder recommendations. The ongoing Senate Bill 2 Texas Instream Flow Program (TIFP) will provide additional scientific data to the TCEQ in order to further refine the environmental flow requirements for the future and facilitate adaptive management strategies.

LOWER GUADALUPE RIVER

Table 1

Station 20470 – Guadalupe River at Hochheim 09/2008 – 09/2016					
AU 1803_05 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (°C)	22.9	32.7	9.6	34	33.90
pH	8.1	8.3	7.8	34	6.5 – 9.0
Chloride (mg/L)	30.4	44.2	14.8	34	100.00
Sulfate (mg/L)	31.9	40.0	19.7	34	100.00
Total Dissolved Solids (mg/L)	344	394	258	34	500.00
NH3-N (mg/L)	0.14	0.49	<0.10	34	0.33
Total Phosphorus (mg/L)	0.09	0.37	<0.02	34	0.69
Chlorophyll-a (µg/L)	3.2	12.8	<1.0	34	14.1
Nitrate Nitrogen (mg/L)	0.69	1.40	<0.05	34	1.95
TKN (mg/L)	0.39	0.87	0.20	34	N/A
AU 1803_05 Recreational Use					
E. coli (MPN/100 mL)	72 Geomean	2,000	5	34	126 Geomean
AU 1803_05 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.7	12.8	6.8	34	≥3.0 Minimum & ≥5.0 Average

Table 2

Station 12592 – Guadalupe River at FM 766 12/2002 - 11/2016					
AU 1803_03 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (°C)	22.8	33.4	9.4	163	33.90
pH	8.0	8.4	7.4	163	6.5 – 9.0
Chloride (mg/L)	28.5	46.4	7.2	164	100.00
Sulfate (mg/L)	31.5	45.8	12.6	164	100.00
Total Dissolved Solids (mg/L)	340	449	173	163	500.00
NH3-N (mg/L)	<0.10	0.69	<0.02	84	0.33
Total Phosphorus (mg/L)	0.10	0.91	0.02	163	0.69
Chlorophyll-a (µg/L)	4.36	50.0	<1.0	163	14.1
Nitrate Nitrogen (mg/L)	0.76	1.59	0.05	163	1.95
TKN (mg/L)	0.44	0.69	<0.02	84	N/A
AU 1803_03 Recreational Use					
E. coli (MPN/100 mL)	57 Geomean	>24,000	3	164	126 Geomean
AU 1803_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.1	13.9	5.0	163	≥3.0 Minimum & ≥5.0 Average

Table 3

Station 12590 – Guadalupe River at FM 447 near Nursery 01/2003 - 10/2016					
AU 1803_04 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (°C)	22.3	31.3	11.1	54	33.90
pH	8.0	8.5	7.4	54	6.5 – 9.0
Chloride (mg/L)	31.4	75.5	9.1	54	100.00
Sulfate (mg/L)	30.6	67.8	12.3	54	100.00
Total Dissolved Solids (mg/L)	346	447	196	54	500.00
NH3-N (mg/L)	<0.10	0.58	<0.02	54	0.33
Total Phosphorus (mg/L)	0.12	0.38	<0.04	54	0.69
Chlorophyll-a (µg/L)	4.0	11.9	<1.0	53	14.1
Nitrate Nitrogen (mg/L)	0.12	0.38	<0.02	54	1.95
TKN (mg/L)	1.07	8.13	<0.2	89	N/A
AU 1803_04 Recreational Use					
E. coli (MPN/100 mL)	124 Geomean	9,200	11	54	126 Geomean
AU 1803_04 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.8	11.9	5.9	54	≥3.0 Minimum & ≥5.0 Average

Table 4

Station 12578 – Guadalupe River at Salt Water Barrier 12/2002 - 11/2016					
AU 1802_01 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (°C)	23.0	32.2	9.5	163	33.90
pH	7.9	8.5	7.5	163	6.5 – 9.0
Chloride (mg/L)	64	163	16.7	163	150.00
Sulfate (mg/L)	55	139	17.2	163	100.00
Total Dissolved Solids (mg/L)	471	1008	220	163	700.00
NH3-N (mg/L)	0.13	0.88	<0.02	84	0.33
Total Phosphorus (mg/L)	0.33	0.86	<0.05	163	0.69
Chlorophyll-a (µg/L)	6.8	38.3	<1.0	163	14.1
Nitrate Nitrogen (mg/L)	2.13	6.56	0.22	162	1.95
TKN (mg/L)	0.66	2.98	<0.20	67	N/A
AU 1802_01 Recreational Use					
E. coli (MPN/100 mL)	77 Geomean	3,300	4	163	126 Geomean
AU 1802_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.5	12.7	2.6	163	≥3.0 Minimum & ≥5.0 Average

LOWER GUADALUPE RIVER

Table 5

Station 12577 – Guadalupe River Tidal at SH 35 12/2002 – 03/2017					
AU 1801_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	24.1	31.9	8.9	91	35.00
pH	8.0	9.0	7.5	92	6.5 – 9.0
Chloride (mg/L)	81	908	29	55	100.00
Sulfate (mg/L)	55	191	25	55	100.00
Total Dissolved Solids (mg/L)	456	2308	260	92	500.00
NH3-N (mg/L)	<0.10	0.17	<0.02	52	0.46
Total Phosphorus (mg/L)	0.30	0.55	<0.06	48	0.66
Chlorophyll-a (µg/L)	12.2	48.6	3.0	36	21.00
Nitrate Nitrogen (mg/L)	2.24	5.72	0.06	52	1.10
TKN (mg/L)	0.75	2.13	0.31	49	N/A
AU 1801_01 Recreational Use					
E. coli (MPN/100 mL)	48 Geomean	722	3	21	126 Geomean
AU 1801_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	6.7	12.3	260	92	≥4.0 Minimum & ≥5.0 Average

Figure 1

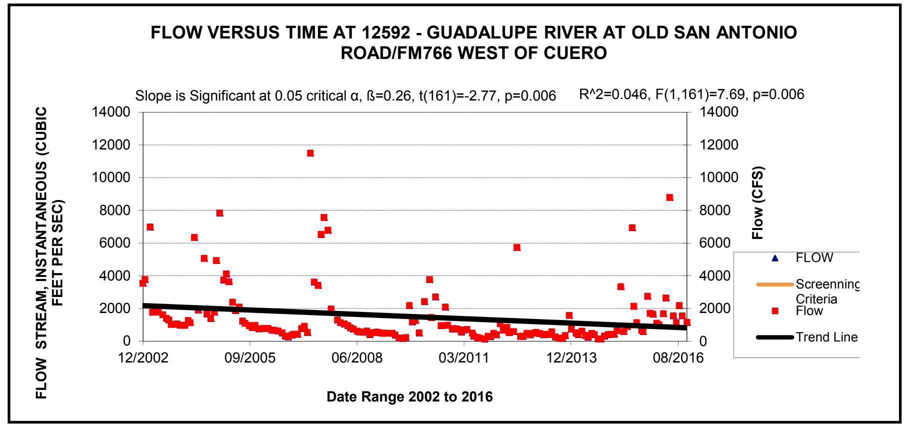


Figure 2

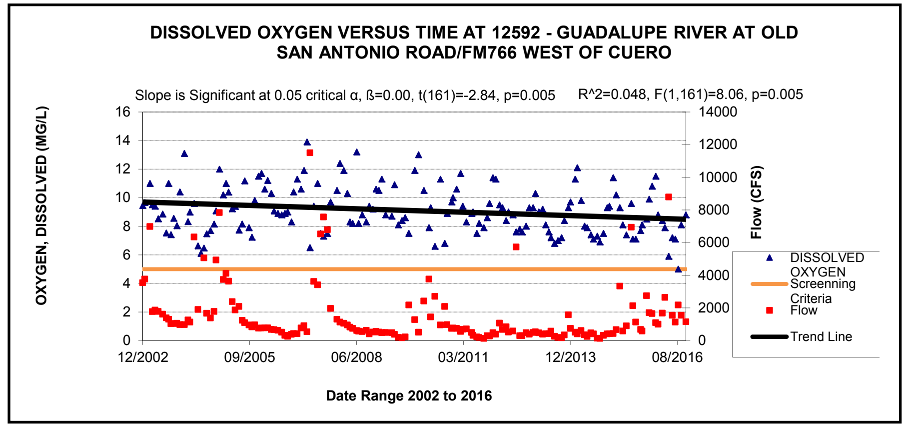
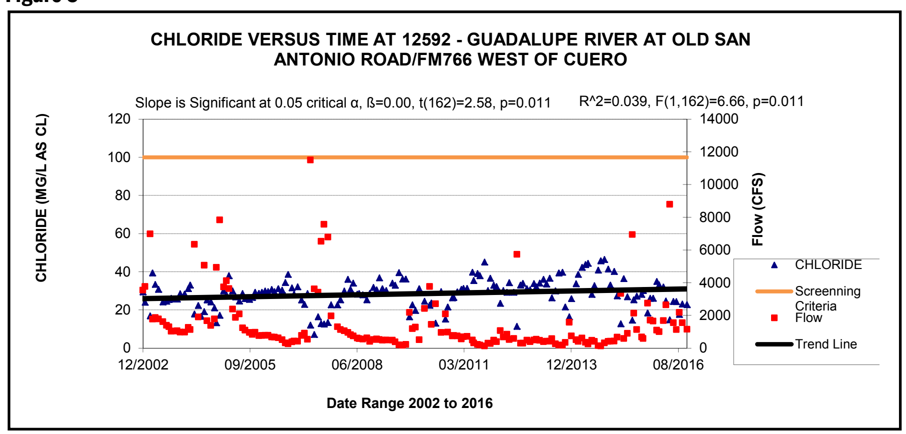
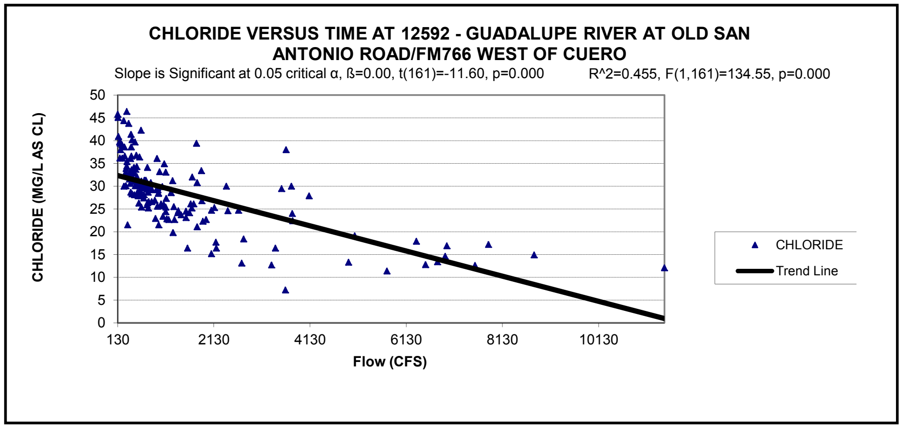


Figure 3



LOWER GUADALUPE RIVER

Figure 4



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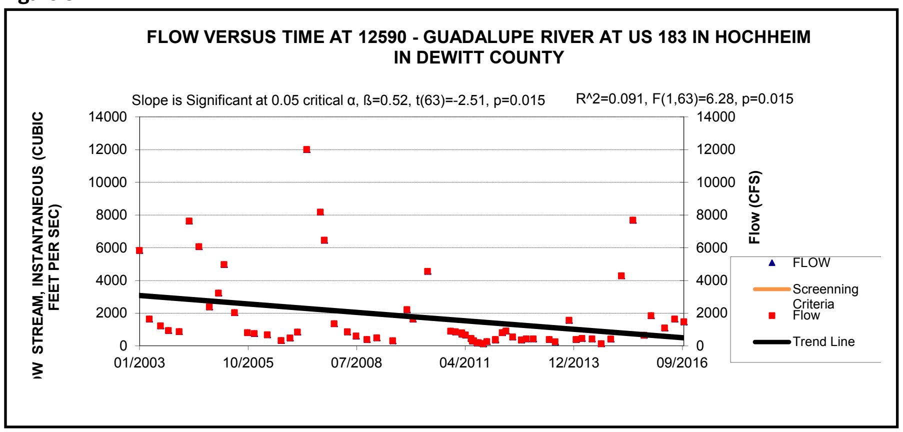

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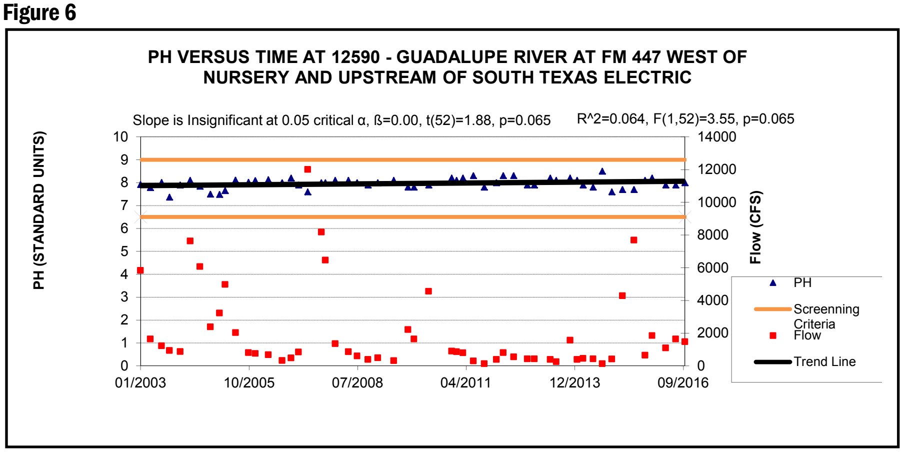

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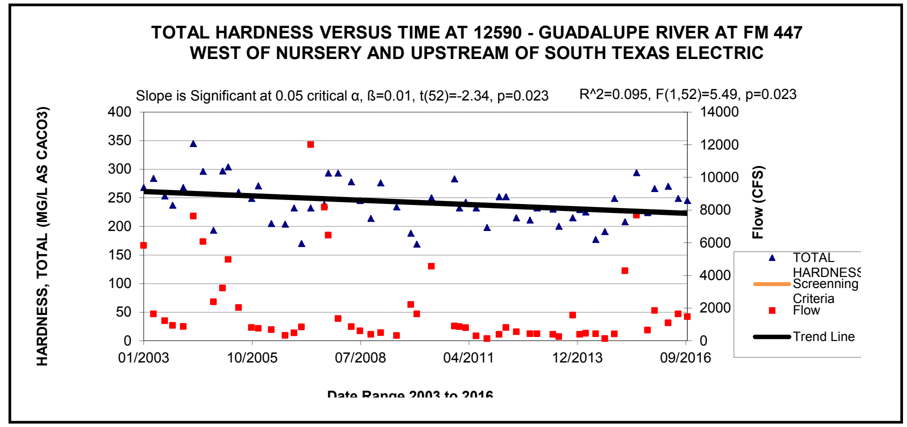


Figure 8

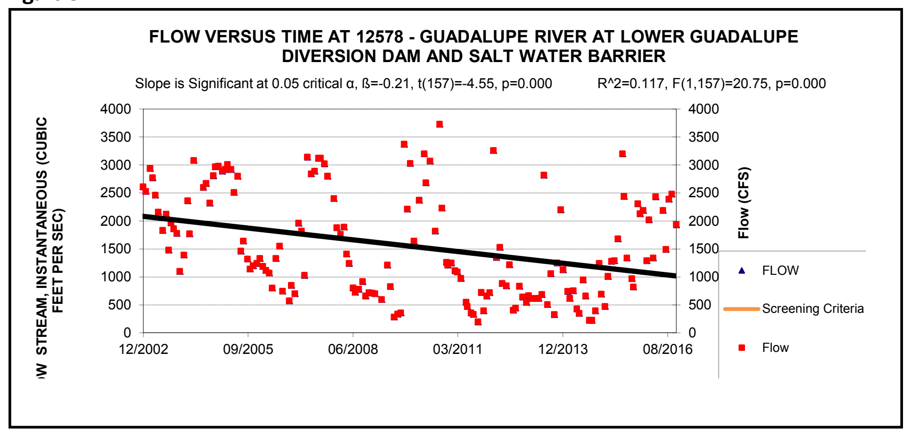
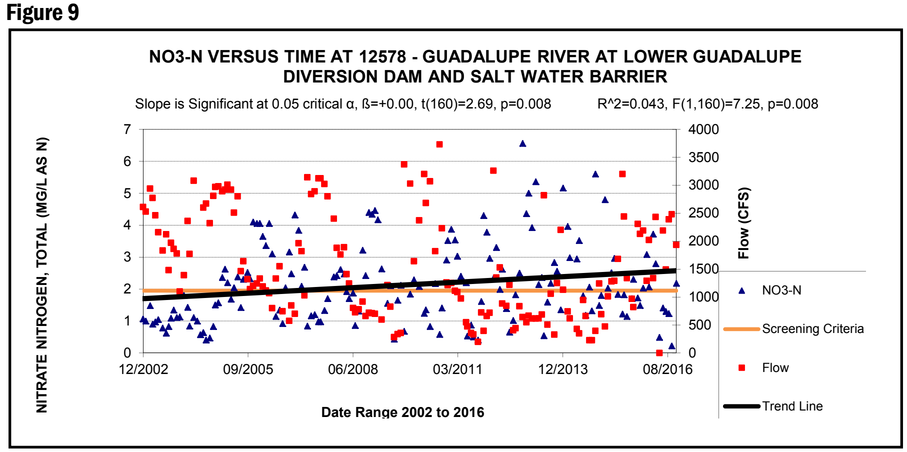


Figure 9



LOWER GUADALUPE RIVER

Figure 10

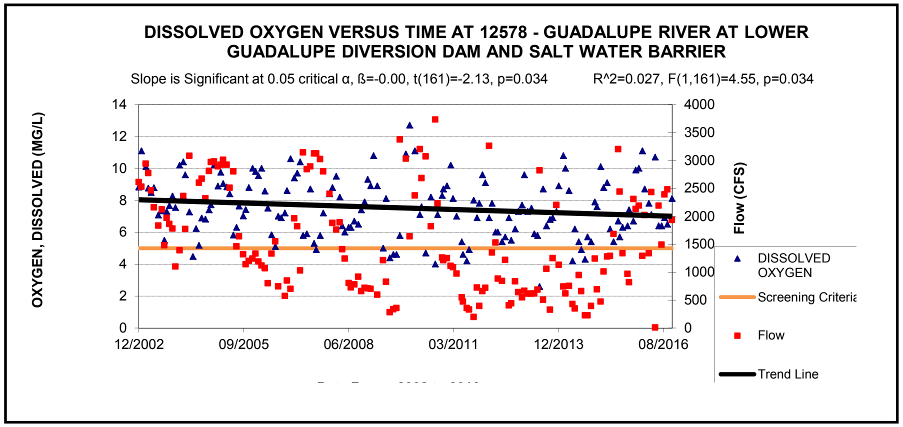
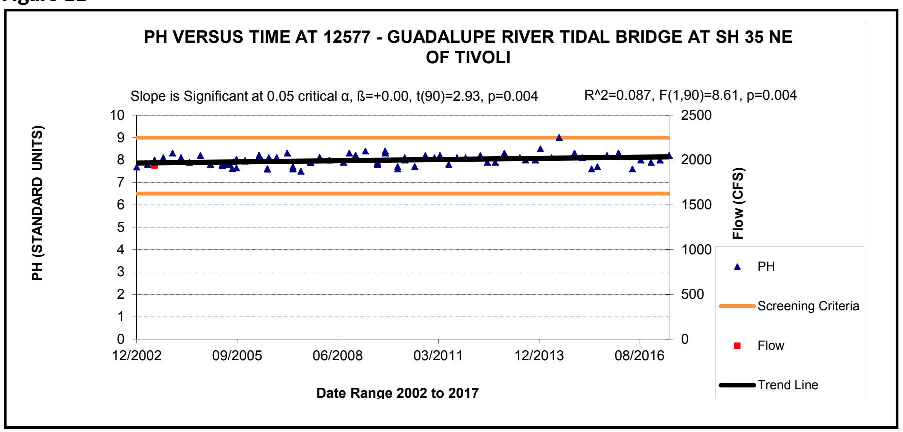
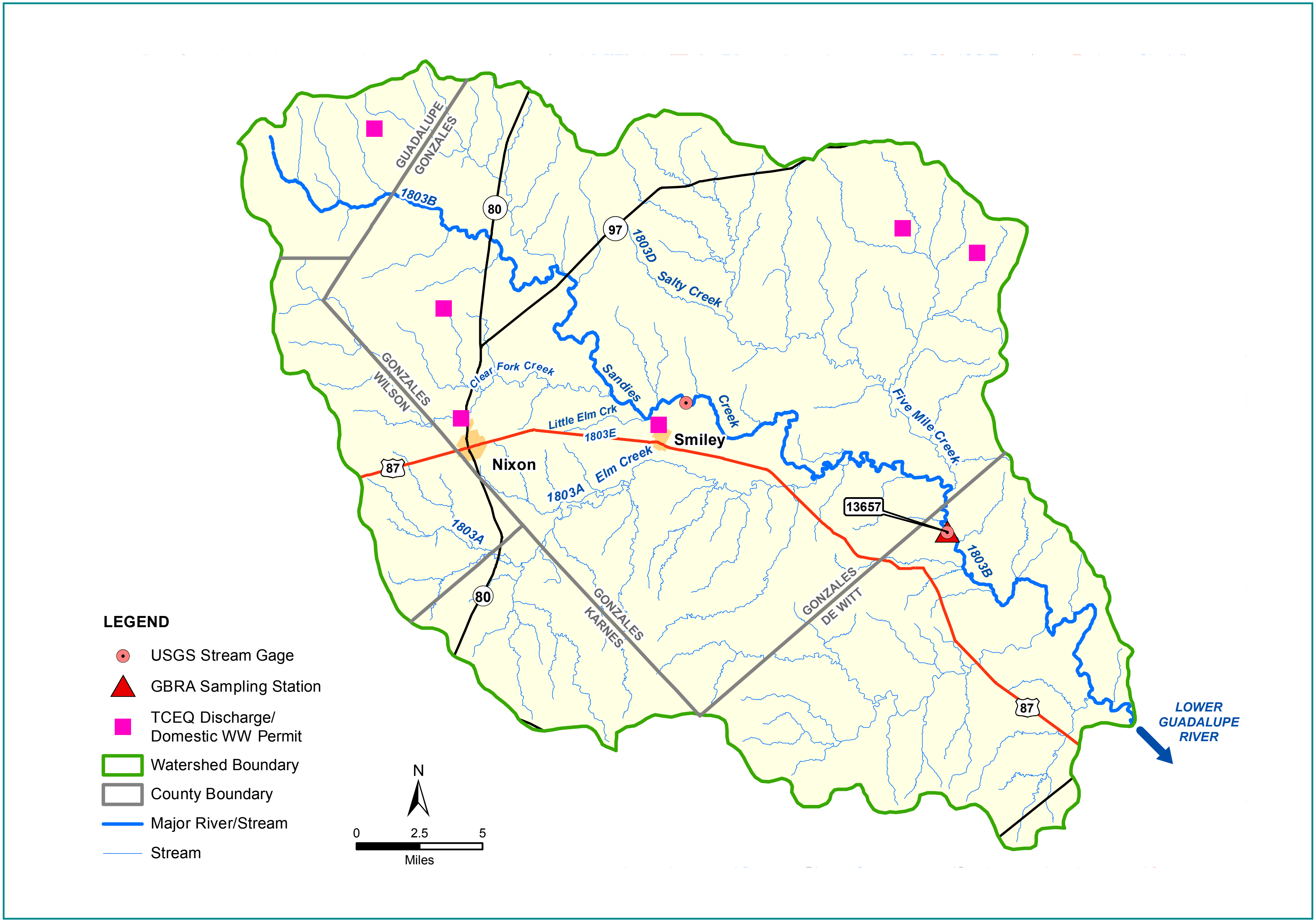


Figure 11



SANDIES CREEK



SANDIES CREEK

Elm Creek *Segment 1803A (unclassified water body) Elm Creek is a fourth order stream that arises west of Nixon, in Wilson County. Elm Creek flows through Karnes and Gonzales Counties for 30.8 miles before it confluences with the Sandies Creek, east of Smiley. The watershed has a total drainage area of 135 square miles and receives water from at least 15 different tributaries. The creek flows past the cities of Pandora, Nixon, Gillett and Smiley. The watershed falls entirely within the Southern Post Oak Savannah ecoregion, which is characterized by sand and sandy loam soils that transition to dense clay pan soils that retain water in low lying areas. The majority of the land use in the watershed is dominated by scrub rangeland, improved pasture for hay production and deciduous post oak forest.*

Sandies Creek *Segment 1803B (unclassified water body) Sandies Creek originates in Guadalupe County northwest of Nixon, although the perennial portion of the creek begins in Gonzales County northwest of Smiley. This fifth order stream travels 79 miles to the confluence of the Guadalupe River west of Cuero, in DeWitt County. The name of this water body is aptly applied, as much of the stream bed consists of sandy substrate. The sandy soil is largely typical of the surrounding Southern Post Oak Savannah ecoregion that surrounds much of the creek before it flows into the Southern Blackland Prairie ecoregion near the confluence with the Guadalupe River. The Blackland Prairie has more clay in the soil than the upland Postoak savannah. Shrub forage and range land remains the dominant land use in both ecoregions, but larger portions of the watershed are used for improved pasture hay and deciduous forest near the mouth of the stream. Sandies Creek has at least 14 named tributaries.*

ELM CREEK (1803A)

Elm Creek is comprised of a single assessment unit (AU) 1803A_01, which includes the length of the entire stream. Elm Creek was listed on the 303(d) list of impaired water bodies in 1999 for impaired aquatic life use due to depressed dissolved oxygen and a concern for chlorophyll-a. The 1999 impairments and concerns remained in the most recent 2014 Texas Integrated Report. Elm Creek was included in a Total Maximum Daily Load (TMDL) study, along with Sandies Creek. The TMDL was never adopted because the TCEQ proposed new water quality standards for this segment. The TCEQ Water Quality Standards division has evaluated recent use attainability analysis studies (UAA) performed in the watershed and has adopted a change in designated aquatic life use for this stream from the previous high level of aquatic life use to an intermediate use in the 2018 water quality standards. This change is currently being reviewed by the EPA. In the 2018 standard, the average 24 hour dissolved oxygen standard will change from the current 5 mg/L to 3 mg/L. The 24 hour minimum dissolved oxygen level standard will also

CONTINUED ON PAGE 116

Sandies Creek
Drainage Area: 711 square miles
Length: 65 miles
Tributaries: Shockley Creek, Mustang Creek, Willow Creek, Racetrack Creek, Wickey Branch, Mound Creek, Panther Branch, Cottonwood Creek, Dykes Creek and Rocky Creek, Cordell Creek, Tidwell Creek, Salt Branch, O'Neal Creek, Yow Branch, Clear Fork Creek, Little Elm Creek (1803E), Elm Creek (1803A), White Oak Branch, Five Mile Creek, Birds Creek, Boggie Creek, Clear Creek, and Deer Creek
Aquifer: Carrizo-Wilcox Aquifer, Gulf Coast
River Segments: 1803A, 1803B
Cities and Communities: Pandora, Gillette, Smiley, Nixon
Counties: Guadalupe, Karnes, Wilson, Gonzales, Dewitt

EcoRegion: Texas Blackland Prairie, Post Oak Savannah
Climate: Average annual rainfall 34.43 inches, Average annual temperature 70.64 ° FVegetation Cover: Evergreen Forest 0.12%, Deciduous Forest 10.73%, Shrubland 46.03%; Grassland 2.04%; Woody
Wetlands: 4.74% Cultivated Crops 2.32% ; Pasture Hay 28.61%
Land Uses: Agriculture, ranching, light industry, and recreational.
Development: Low Intensity 0.42% ; Medium Intensity 0.0.02%; High Intensity 0.01%; Open Space 4.27%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption.
Soils: Dark red sandstone, light tan and gray sandstone
Permitted Wastewater Treatment Facilities: Domestic 4, Land Application 0, Industrial 1

change from a 3 mg/L minimum to a 2 mg/L minimum. Intermediate aquatic life use is the common standard applied to streams with intermittent flows. It is likely that if the EPA approves the proposed reclassification of the aquatic life use standard to this water body, that the current impairments will no longer apply. There is no current water quality station located within this segment. There are also no USGS stream gaging stations in this segment, but the stream has historically gone dry on several occasions and the flow is best described as intermittent during dry weather conditions.

SANDIES CREEK (1803B)

Sandies Creek consists of two assessment units (AUs). 1803B_01 represents the section of Sandies Creek from the Elm Creek confluence down to the confluence with the Guadalupe River. Assessment unit 1803B_02 consists of the section of the creek from the Elm Creek confluence upstream to the headwaters. Station 13657 is monitored monthly by the GBRA at the Cheapside road bridge crossing near the USGS gaging station (08175000). Both assessment units of Sandies Creek have been listed on the 303(d) list of impaired water bodies for aquatic life since 1999 due to depressed dissolved oxygen. In 2002, both assessment units were also listed for impaired contact recreation use because of elevated bacteria concentrations. Additional aquatic life use impairments were assessed on unit 1803_01 in 2010 for impaired fish community and impaired macrobenthic community. These additional aquatic life use impairments were most likely a direct result of the depressed dissolved oxygen levels in the creek. Most recently the 2014 Texas Integrated Report found that assessment unit 1803B_01 had a nutrient screening concern for excessive concentrations of chlorophyll-a. Sandies Creek and Elm Creek were both included in a TMDL study to address the known impairments, but as of 2017, the TMDL has not been adopted because the TCEQ is reviewing the water quality standards for this segment along with Elm Creek. The United States Geological Survey (USGS) has maintained one stream flow gaging station (08175000) two miles northeast of Westhoff, Texas since 1930. This gaging station has recorded a minimum daily average stream flow of 0.00 cfs many times throughout its history including the summers of 2009, 2015 and 2016. The stream gage experienced its historic peak of 92,700 cfs in July of 1936. The current harmonic mean of this gage is 3.9 cfs and the 7Q2 (7 day minimum flow with a 2 year recurrence interval) is 1.2 cfs. The Eagle Ford Shale Play is one of the richest oil and gas deposits in Texas and uses the fracturing process that has raised concerns on potential impacts it may have on groundwater, surface water. Potential stakeholder concerns are future water availability due to the quantity of water used in this water-short area and the potential for spills and loss of

containment of chemicals. The proposed reclassification of the aquatic life use standards will very likely remove the current dissolved oxygen impairments from the next assessment, but the bacteria loading addressed by the TMDL will likely require future management efforts to reduce non-point source pollution in order to meet the contact recreation standard. GBRA analyzed the data from the Station 13657 and noted two trends in water quality. The dissolved oxygen concentrations and the total hardness concentrations at this station are both significantly decreasing over time (Figures 1 & 2). Although no direct correlation with stream flow was discovered, both of these parameters may have been decreasing due to the stagnant conditions resulting from several prolonged years of drought in the watershed.

SANDIES CREEK

Table 1

Station 13657 – Sandies Creek at Cheapside Road 12/2002 - 11/2016					
AU 1803B_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.4	31.0	7.6	184	33.90
pH	7.8	8.9	7.1	184	6.5 – 9.0
Chloride (mg/L)	243	1455	4.65	178	100.00
Sulfate (mg/L)	54	206	3.48	178	100.00
Total Dissolved Solids (mg/L)	964	4167	107	184	500.00
NH3-N (mg/L)	0.20	1.00	<0.02	99	0.33
Total Phosphorus (mg/L)	0.47	1.81	<0.01	180	0.69
Chlorophyll-a (µg/L)	10.0	136.0	<1.0	180	14.1
Nitrate Nitrogen (mg/L)	0.26	1.05	<0.01	182	1.95
TKN (mg/L)	1.26	5.60	0.05	83	N/A
AU 1803B_01 Recreational Use					
E. coli (MPN/100 mL)	223 Geomean	24,000	<1	177	126 Geomean
AU 1803B_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	6.1	13.0	0.8	184	≥3.0 Minimum & ≥5.0 Average

Figure 1

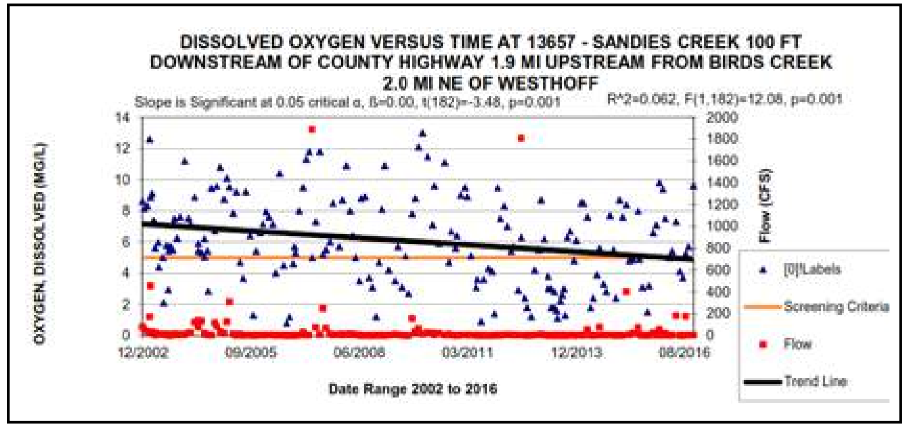
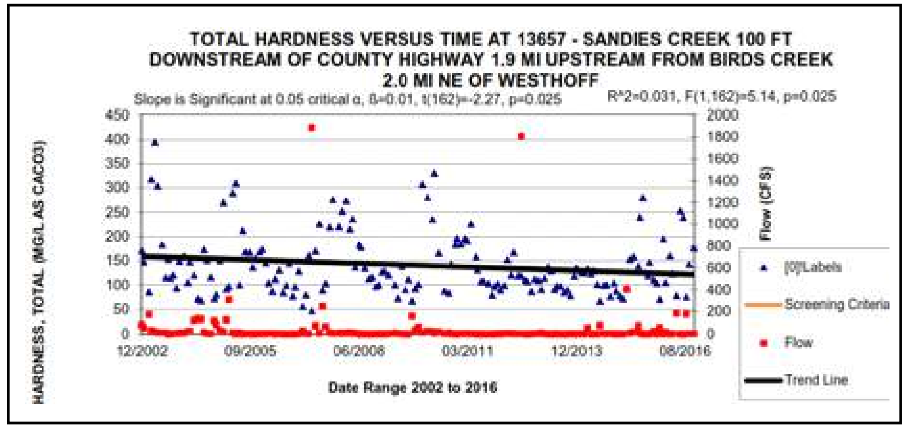
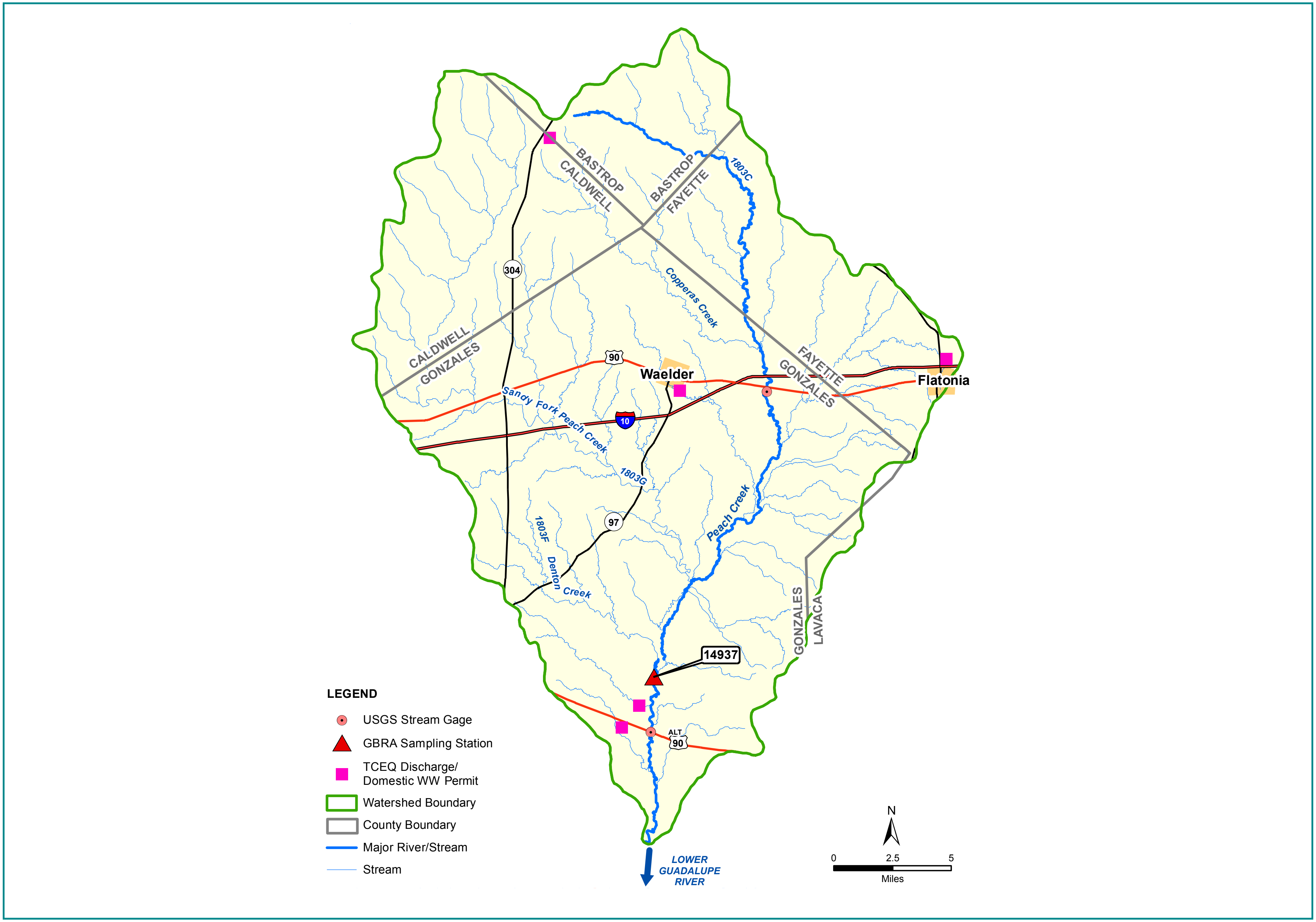


Figure 2



PEACH CREEK



BASTROP
CALDWELL
BASTROP
FAYETTE
1803C
304
Copperas Creek
CALDWELL
GONZALES
90
Waelder
FAYETTE
GONZALES
Flatonia
Sandy Fork Peach Creek
10
1803G
97
1803F
Denton Creek
Peach Creek
GONZALES
LAVACA
14937
ALT 90
LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Discharge/ Domestic WW Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream
LOWER GUADALUPE RIVER
N
0
2.5
5
Miles

PEACH CREEK

Segment 1803C: (Peach Creek, unclassified water body) Peach Creek is a tributary of the Guadalupe River that flows for 64 miles through the gently rolling hills of Bastrop and Fayette counties northeast of Waelder, before reaching the confluence with the Guadalupe River in eastern Gonzales County. The watershed falls entirely within the Post Oak Savannah ecoregion and land use largely consists of undeveloped ranch land. The sandy loam soils of the watershed are dominated by forests of Post Oak, Blackjack Oak, and other hardwoods.

Peach Creek was included on the 303(d) List of Impaired Water Bodies in 2002 because of average bacteria concentrations that exceeded the contact recreation criterion. In 2014, the assessed bacterial concentration mean was 148.61 MPN/100 mL in the assessment unit (AU) 1803C_01 comprising the lower 25 miles of the segment, which was well above the standard criteria of 126 MPN/100 mL. Peach Creek was also found to have impaired dissolved oxygen levels for aquatic life use in 2006. In the latest 2014 assessment, the minimum dissolved oxygen concentration in the creek was found to be below the acceptable criteria on 3 occasions. Peach Creek was also found to have a general use nutrient screening level concern for chlorophyll-a in 2010 in the assessment unit 1803C_03 that included the stream reach from 1.2 miles downstream of farm to market road 1680 in Gonzales County up to the confluence with Elm Creek in Fayette County. In the 2014 Texas Integrated Report, concerns were also identified for total phosphorus concentrations and impaired fish community in this AU. A Total Maximum Daily Load (TMDL) has been adopted for Peach Creek, but to date no implementation of best management practices (BMPs) have been initiated to help remove the pollutant loads that were identified in the TMDL. The TMDL determined that bacterial loading was most likely due to non-point source pollution sources such as failing septic tanks, livestock and wildlife. The TMDL recommended a 47 to 100 percent reduction in loading of bacterial sources. Bacteria limits were also included in the permits for the five wastewater treatment plant discharges into Peach

CONTINUED ON PAGE 120

Peach Creek
Drainage Area: 480 square miles
Length: 64 miles
Tributaries: Rocky Creek, Elm Creek, Pin Oak Creek, Copperas Creek, Big Fivemile Creek, Obar Creek, Sulphur Branch, Baldridge Creek, Valley Branch, Sandy Fork (1803G), Vanham Creek, Denton Creek (1803F), Live Oak Branch, Mitchell Creek, Elm Slough and Gelhorn Creek.
Aquifer: Carrizo-Wilcox Aquifer
River Segments: 1810, 1810A
Cities and Communities: Waelder, Flatonia
Counties: Gonzales, Bastrop, Fayette
EcoRegion: Post Oak Savannah
Climate: Average annual rainfall 32.27 inches, Average annual temperature 70.64°F

Vegetation Cover: Evergreen Forest 3.13%, Deciduous Forest 14.07%, Shrubland 25.20%; Grassland 2.17%; Woody Wetlands: 6.79% Cultivated Crops 2.15% ; Pasture Hay 33.05%
Land Uses: agricultural, ranching, light industry, and recreational.
Development: Low Intensity 0.35% ; Medium Intensity 0.08%; High Intensity 0.01%; Open Space 5.02%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils: Dark red sandstone and tan and grey sandstone
Permitted Wastewater Treatment Facilities: Domestic 2, Land Application 0, Industrial 3

PEACH CREEK

Creek, prior to the TMDL adoption in 2008. Additional monitoring conducted under the TMDL study also found that the Denton Creek (1803F) and Sandy Fork (1803G) tributaries of Peach Creek had bacteria concentrations that exceeded the contact recreation standard. These tributaries were added to the 303(d) list of impaired water bodies in 2010 using data collected during the TMDL study. The tributaries were subsequently removed from the list in 2012, because TCEQ staff discovered that the data used to determine the listing was collected during storm conditions and was not representative of ambient conditions in these water bodies. It is unlikely that the recommended best management practices will be put into place in the near future without further investment in the watershed.

The GBRA collects monthly at a single routine monitoring station (14937) at the CR 353 bridge crossing in AU 1803C_01. The stream has a USGS gage located downstream of Alternate Highway 90 (8174600) with a harmonic mean of 3.2 cfs and a 7Q2 (7 day minimum flow with a 2 year recurrence interval) of 1 cfs. The City of Waelder discharges wastewater effluent to the Baldridge Creek tributary of Peach Creek. This WWTF has a permitted discharge of 0.3 million gallons per day (MGD). This plant treats the wastewater to ensure that the biochemical oxygen demand (BOD) does not exceed 30 mg/L, the total suspended solids (TSS) do not exceed 90 mg/L and the E. coli geometric mean does not exceed 126 MPN/100 mL. The GBRA analyzed data from Station 14937 to look for trends in water quality. Two water quality trends were found at this station. The nitrate nitrogen was significantly decreasing with time and the total kjeldahl nitrogen (TKN) concentrations were increasing over time (Figures 1 & 2). The combination of nitrate nitrogen and TKN represent all of the total nitrogen (TN) in the water column. Nitrate nitrogen is the nutrient form most easily used by biological life and may be decreasing as it used by plants and algae. The increase in the total kjehldahl nitrogen of this system may be an indication of excessive nutrient loading from fertilizer runoff or some other source as the watershed recovers from previous drought conditions.

PEACH CREEK

Table 1

Station 14937 – Peach Creek at CR 353 12/2002 - 11/2016					
AU 1803C_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.4	28.8	5.4	192	32.2
pH	7.8	8.4	5.0	190	6.5 – 9.0
Chloride (mg/L)	61	170	5.7	163	350.00
Sulfate (mg/L)	64	327	6.7	163	150.00
Total Dissolved Solids (mg/L)	307	1424	136	191	1120.00
NH3-N (mg/L)	<0.10	0.44	<0.02	84	0.33
Total Phosphorus (mg/L)	0.24	0.69	<0.05	163	0.69
Chlorophyll-a (µg/L)	2.2	20.8	<1.0	161	14.1
Nitrate Nitrogen (mg/L)	1.83	7.96	<0.05	174	1.95
TKN (mg/L)	0.76	1.97	0.2	66	N/A
AU 1810_01 Recreational Use					
E. coli (MPN/100 mL)	206 Geomean	24,000	10	183	126 Geomean
AU 1810_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.2	13.5	2.1	190	≥3.0 Minimum & ≥5.0 Average

Figure 1

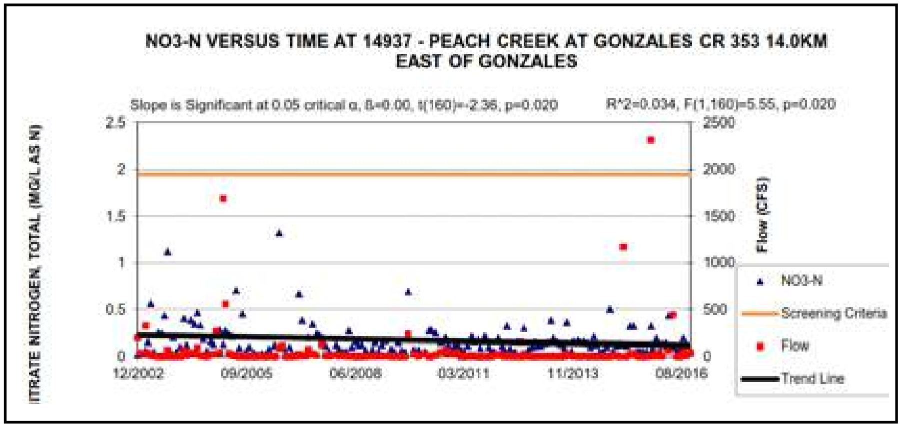
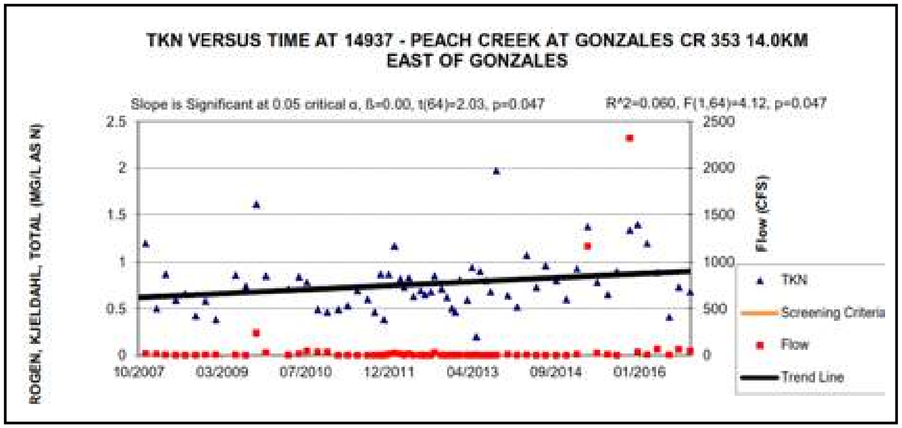
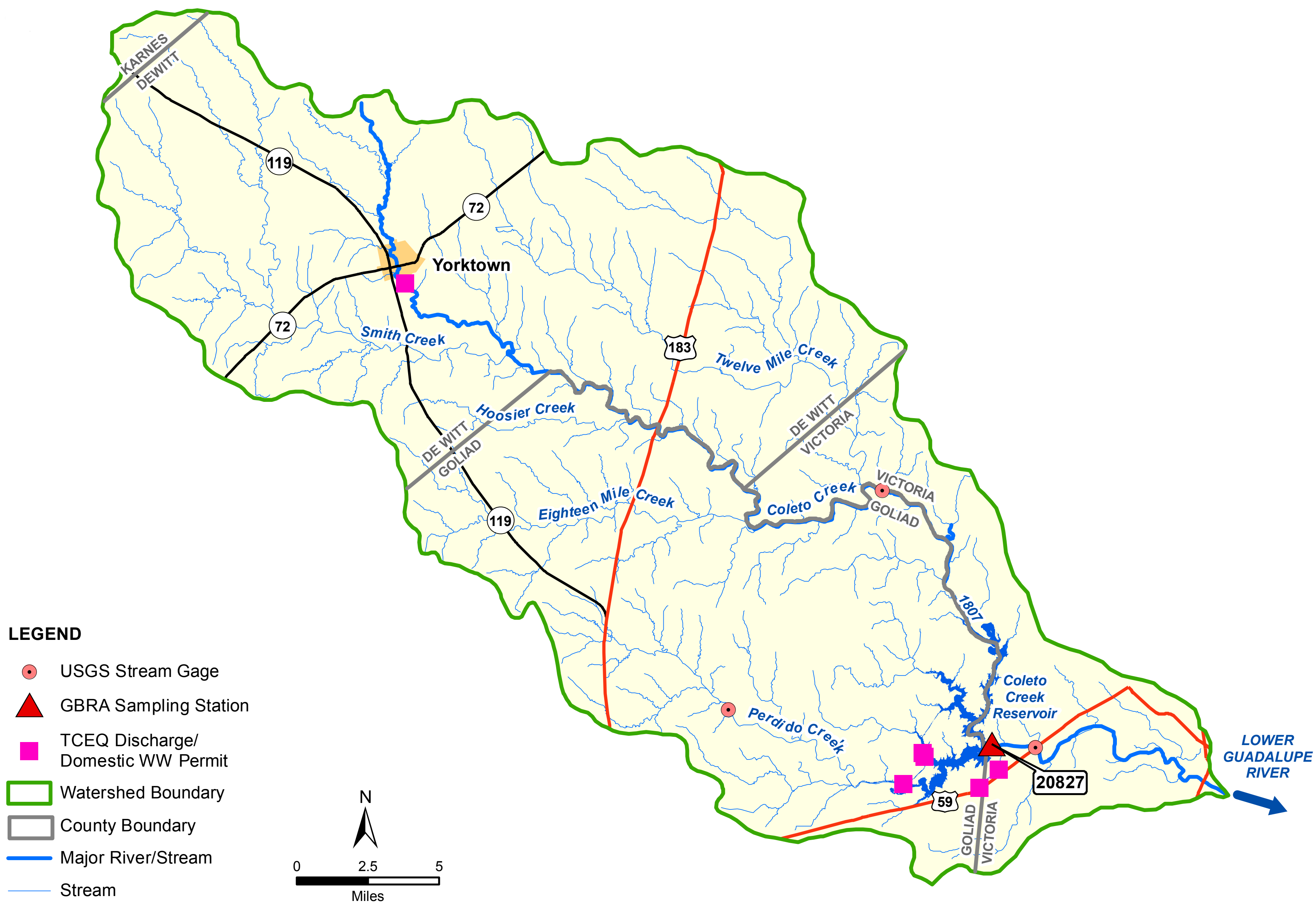


Figure 2



COLETO CREEK



COLETO CREEK

Segment 1807: (Coleto Creek) Coleto Creek extends 27 miles beginning in Dewitt County, through Goliad and Victoria Counties, to the confluence with the Guadalupe River in Victoria County. This segment includes the 3100-acre Coleto Creek Reservoir. The size of Coleto Creek's drainage basin can turn this normally slow moving creek into a fast flowing river during a typical South Texas rainstorm. Much of the creek bottom is sandy, with typical vegetation ranging from brush trees such as mesquite and huisache to large live oaks and anacua trees. The rural setting and limited development of this watershed supports a wide range of Texas wildlife along its shores ranging from turkey and deer, to red fox and bobcats. The completion of the Coleto Creek Reservoir provided habitat to support over 100 different species of birds, such as the Southern Bald Eagle, Osprey, and Roseate Spoonbills.

This segment has one routine station (20827), monitored monthly by GBRA at the midpoint of the dam on the Coleto Creek Reservoir. The water at this monitoring station is over 10 meters deep and depth profiles at the station have shown that the Coleto Reservoir undergoes typical large lake seasonal stratification patterns for temperature and dissolved oxygen. Stratification occurs during the summer months as waters near the surface become less dense due warmer temperatures while the water near the bottom remain more dense and cool. Mixing occurs during the fall as the cooler temperatures of the waters at the surface begin to match the temperatures of the waters at the bottom. The 2014 Texas Integrated Report of Water Quality did not identify any impairments or concerns in either of the assessment units that are evaluated for this segment. Coleto Creek Reservoir is used as cooling water by a coal-fired power plant. The Power Plant contributes to increased ambient temperatures in the reservoir, which influences recreational fishing opportunities throughout the year. . Stakeholders remain concerned about the possible impacts of in-situ groundwater uranium mining activities located in the northwest portion of Goliad County. The area of concern is located in the recharge zone of the Evangeline component of the Gulf Coast Aquifer. Residents fear that the recent issuance of an EPA mining permit to Uranium Energy Corp. (UEC) will lead to contamination of surface water and underground drinking water supplies in the area. Other activities that have the potential to impact water quality in the

CONTINUED ON PAGE 124

Coleto Creek
Drainage Area: 558 square miles
Length: 27 miles
Tributaries: Turkey Creek, Sulphur Creek, and Perdido Creek (1807A)
Aquifer: Gulf Coast
River Segments: 1807
Cities and Communities: Yorktown
Counties: Dewitt, Goliad, Victoria
EcoRegion: Texas Blackland Prairies, Gulf Coastal Plains
Climate: Average annual rainfall 36.77 inches, Average annual temperature 70.15°F

Vegetation Cover: Evergreen Forest 2.66%, Deciduous Forest 16.04%,Shrubland 23.70%; Grassland 3.36%; Woody Wetlands: 2.84% Cultivated Crops 3.00% ; Pasture Hay 41.85%
Land Uses: Agricultural, ranching, hogs, poultry, oil and gas production
Development: Low Intensity 0.26% ; Medium Intensity 0.04%; High Intensity 0.01%; Open Space 4.53%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and power plant cooling.
Soils: Sandy, sandy loam, and clay loam
Permitted Wastewater Treatment Facilities: Domestic 2, Land Application 0, Industrial 1

area include increased oil field mining, new subdivision development and the introduction of invasive aquatic plants. An analysis of the water quality data at monitoring station 20827 revealed several trends over time. The chlorophyll A concentrations (Figure 1) at this station are significantly increasing over time. The TKN concentrations are also significantly increasing over time (Figure 2). These two water quality trends may be linked in that the increase in TKN may indicate that more nitrogen is entering the lake system to provide for the growth of green algae that contain chlorophyll A pigment. The source of additional nutrient loading in the Coleto Creek reservoir remain unclear, but are most likely associated with runoff from agricultural fertilizers in the watershed. The relatively short length of monitoring data available at this station may have caused these trends to be particularly pronounced due to increases in runoff following the drought years at the beginning of the data set.

COLETO CREEK

Table 1

Station 20827 – Coleto Creek Reservoir at Center of Dam 09/2010 - 11/2016					
AU 1807_02 General Use					
Parameter	**Mean**	**Maximum**	**Minimum**	**# of Measurements**	**Screening Criteria**
Temperature (°C) at 0.3 meters	23.6	34.9	12.6	106	33.90
Temperature (°C) at all depths	23.8	34.9	12.4	352	33.90
pH at 0.3 meters	8.2	8.8	7.2	106	6.5 – 9.0
pH at all depths	8.0	8.8	6.8	352	6.5 – 9.0
Chloride (mg/L)	55	93	8.3	75	250.00
Sulfate (mg/L)	26	50	5.2	75	100.00
Total Dissolved Solids (mg/L) at 0.3 meters	451	708	191	106	500.00
Total Dissolved Solids (mg/L) at all depths	477	708	191	352	500.00
NH3-N (mg/L)	0.18	0.76	<0.10	39	0.33
Total Phosphorus (mg/L)	0.60	2.69	<0.05	176	0.69
Chlorophyll-a (µg/L)	8.7	28.8	<1.0	74	14.1
Nitrate Nitrogen (mg/L)	0.06	0.24	<0.05	74	1.95
TKN (mg/L)	0.79	1.36	0.20	51	N/A
AU 1807_02 Recreational Use					
E. coli (MPN/100 mL)	4 Geomean	380	<1	74	126 Geomean
AU 1807_02 Aquatic Life Use					
Dissolved Oxygen (mg/L) at 0.3 meters	8.0	11.2	2.5	106	≥3.0 Minimum & ≥5.0 Average
Dissolved Oxygen (mg/L) at all depths	6.0	11.2	0.1	352	≥3.0 Minimum & ≥5.0 Average

Figure 1

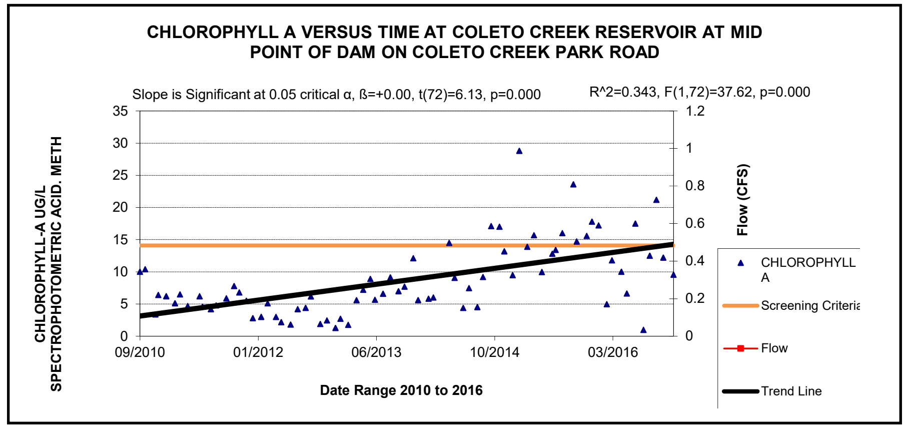
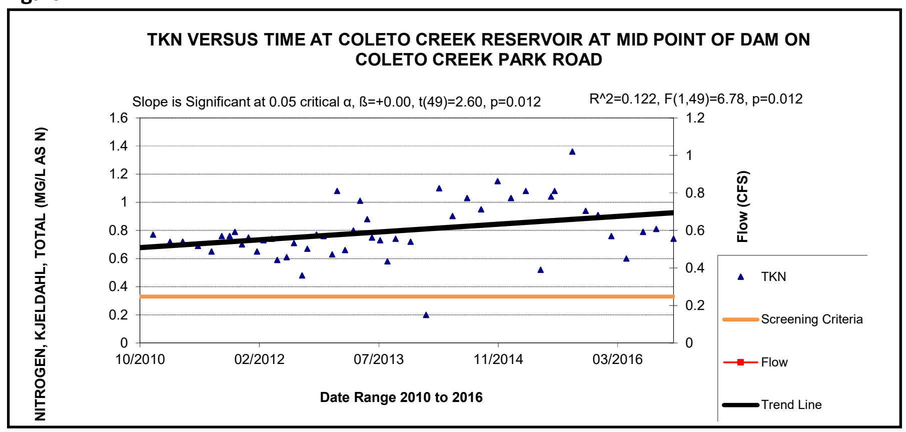
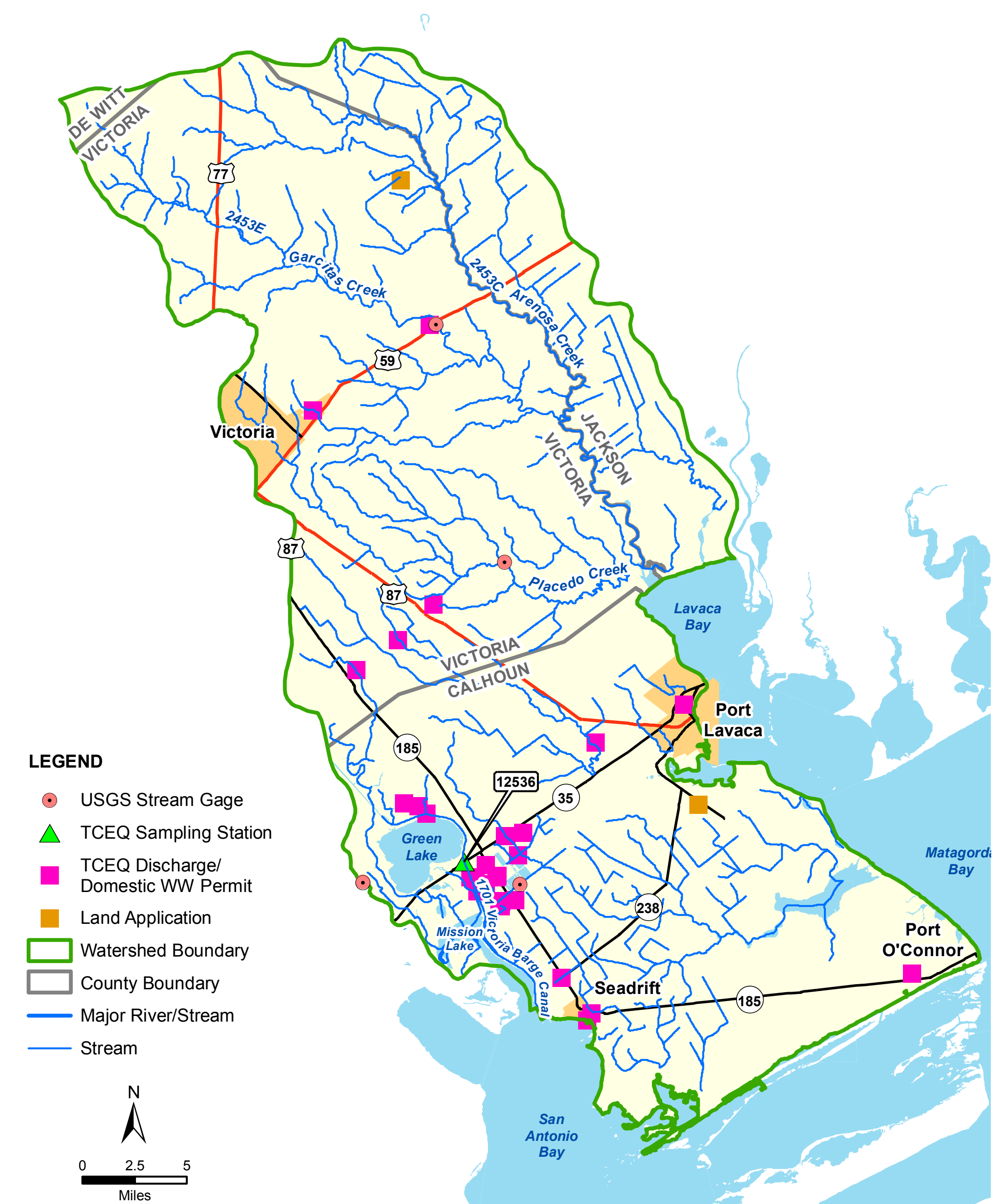


Figure 2



LAVACA-GUADALUPE COASTAL BASIN



LAVACA-GUADALUPE COASTAL BASIN

Segment 1701 (Victoria Barge Canal) represents the Victoria Barge Canal, which is a 35 mile long man made stream segment that was completed in 1968. The barge canal was constructed to provide a navigable waterway from the Victoria Turning Basin in Victoria County to the Gulf Intracoastal Waterway (GIWW) located at the confluence with the San Antonio Bay in Calhoun County. This waterway provides a route for barge traffic to reach the Port of Victoria without the need to deal with the frequent log jams and course changes in the Lower Guadalupe River. The canal was originally constructed 9 feet in depth and 100 feet in width, but was expanded from 1995 to 2002 to a depth of 12 feet and a width of 125 feet. The canal sees large amounts of shipping traffic to accommodate the needs of several industrial manufacturing plants located along its length.

TCEQ Region 14 staff and TCEQ predecessor agencies have monitored station 12536 quarterly at the State Highway 35 bridge crossing since 1969. The average depth to the bottom at this location is 1.9 meters. The 2014 Texas Integrated Report identified general use concerns for chlorophyll-a and nitrate-nitrogen. Chlorophyll-a concentrations were assessed at a mean value of 39.34 mg/L, which exceeded the nutrient screening criteria of 11.60 mg/L by more than three times. Elevated chlorophyll-a values are usually linked to excessive algal growth in the water body. Algae biomass is dependent upon available nutrients and may be affected by the nitrate-nitrogen concern for this segment. The average nitrate-nitrogen concentration was assessed at 0.72 mg/L, which was four times greater than the nutrient screening criteria of 0.17 mg/L. Nutrient screening levels are more restrictive on the tidally influenced barge canal than in most freshwater waterways. This waterway is unique among tidally influenced segments in that it does not receive any direct freshwater influences from any perennial rivers or streams. Most of the water in the canal originates in the San Antonio Bay system, although it does receive some freshwater from industrial wastewater effluent and storm runoff. The data from this segment was analyzed by GBRA for trends over time. The specific conductance, chloride and sulfate concentration are all significantly increasing over time (Figures 1, 2, & 3). The increase in all three of these parameters is an indication that this water body is becoming more saline. This change is most likely due to several years of prolonged drought and the resulting reduction in freshwater runoff into the system.

Lavaca-Guadalupe Coastal Basin
Drainage Area: 998 square miles
Length: 27 miles
Aquifer: Gulf Coast
River Segments: 1803, 1802, 1801, 1701
Cities and Communities: Victoria, Seadrift, Bloomington, Inez, Port O'Conner, Port Lavaca
Counties: Calhoun, Victoria, Jackson
EcoRegion: Texas Blackland Prairie, Post Oak Savannah, Gulf Coastal Plains, East Central Texas Plains
Climate: Average annual rainfall 34.76 inches, Average annual temperature 72.5°F

Vegetation Cover: Evergreen Forest 0.21%, Deciduous Forest 8.4%, Shrubland 16.9%; Grassland 13.7%; Woody Wetlands: 17.2% Cultivated Crops 21.4% ; Pasture Hay 15.1%
Land Uses: urban, heavy industry, agriculture, ranching and recreational.
Development: Low Intensity 1.33% ; Medium Intensity 0.18%; High Intensity 0.03%; Open Space 3.41%
Water Body Uses: aquatic life, non-contact recreation, general use, fish consumption, and industrial cooling.
Soils: Clay subsoil, deep black soil, sandy clay, dark clay loam, clay
Permitted Wastewater Treatment Facilities: Domestic 11, Land Application 1, Industrial 7

Table 1

Station 12636 – Victoria Barge Canal at SH 35 12/2002 – 06/2017					
AU 1701_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C) at 0.3 meters	24.6	31.9	9.9	59	35.00
Temperature (°C) at all depths	24.8	31.9	9.9	131	35.00
pH at 0.3 meters	8.1	9.2	7.5	58	6.5 – 9.0
pH at all depths	8.1	9.2	7.4	130	6.5 – 9.0
Chloride (mg/L)	4,530	15,200	234	55	N/A
Sulfate (mg/L)	666	2,300	35	57	N/A
Total Dissolved Solids (mg/L)	12,600	38,500	1,020	59	N/A
Total Dissolved Solids (mg/L)	7,810	25,090	663	131	N/A
NH3-N (mg/L)	<0.10	0.33	<0.05	53	0.10
Total Phosphorus (mg/L)	0.16	0.30	<0.05	51	0.21
Chlorophyll-a (µg/L)	21.3	246	4.5	54	11.6
Nitrate Nitrogen (mg/L)	0.31	1.40	<0.04	55	0.17
TKN (mg/L)	0.97	2.57	0.44	52	N/A
AU 1701_01 Recreational Use					
Enteroccus (MPN/100 mL)	17 Geomean	1,250	<1.0	44	35 Geomean
AU 1701_01 Aquatic Life Use					
Dissolved Oxygen (mg/L) at 0.3 meters	8.0	17.6	4.9	59	≥3.0 Minimum & ≥4.0 Average
Dissolved Oxygen (mg/L) at all depths	7.8	17.6	4.5	131	≥3.0 Minimum & ≥4.0 Average

Figure 1

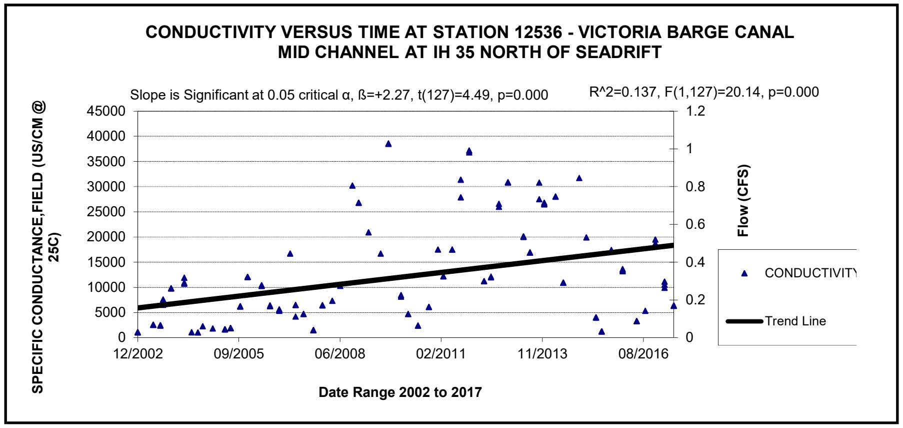


Figure 2

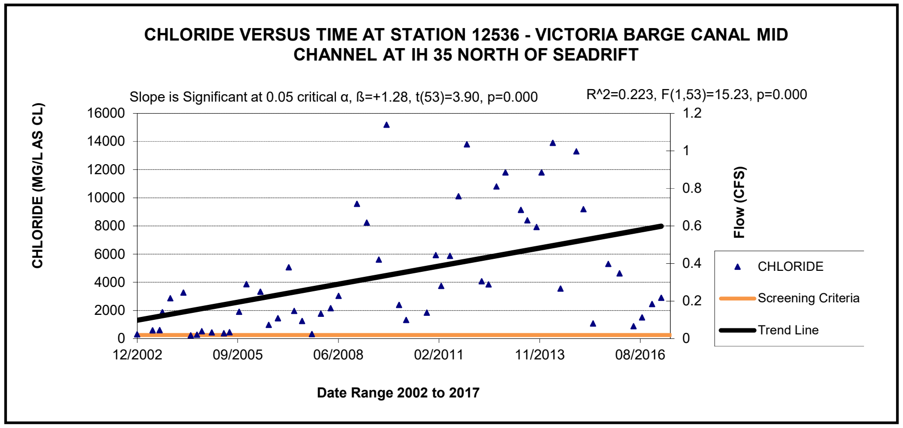
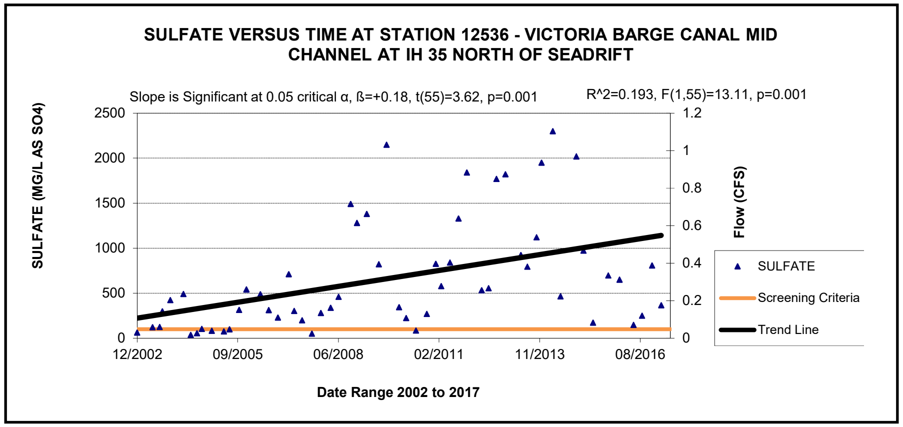


Figure 3



CONCLUSION TO GUADALUPE / LAVACA CLEAN RIVERS PROGRAM

CONCLUSION

The residents of the Guadalupe River and Lavaca-Guadalupe Coastal Basins have greatly benefited by the monitoring and educational outreach provided by the Clean Rivers Program. The Guadalupe-Blanco River Authority, Upper Guadalupe River Authority, and Wimberley Valley Watershed Association partner relationship under the Texas Clean Rivers Program has generated a tremendous amount of quality assured data that is made available to the public and state regulators. The data generated by the CRP has been used by invested stakeholders to develop watershed protection plans to improve water quality in the Plum Creek watershed, Geronimo & Alligator Creek watershed, Cypress Creek watershed, the Comal River & Dry Comal Creek watershed and the Upper San Marcos River watershed. The CRP data has also been used by state regulators to identify water quality impairments and target Total Maximum Daily Load Studies on the Guadalupe River above Canyon Lake, Sandies Creek, Elm Creek, and Peach Creek. These regulatory activities include several success stories, such as Camp Meeting Creek in Kerr County and the Guadalupe River in Kendall County, where water quality improvements have resulted in the attainment of designated stream uses. The public outreach opportunities provided by the Clean Rivers Program have increased public knowledge and involvement with the waters of the river basin through public outreach, volunteer monitoring training, and school programs.

WATER QUALITY CONCERNS IN THE GUADALUPE RIVER BASIN

The Guadalupe River Basin has seen tremendous population growth since the last Basin Summary Report was completed in 2013. Three of the counties in the Guadalupe River basin were ranked in the top 10 counties for growth in the United States. According to US Census Bureau estimates between 2016 and 2017, Comal County is ranked second in the nation with growth rate of 5.1%, Hays County is ranked fourth with a rate of 5%, and Kendall County is ranked fifth with a rate of 4.9%. The large number of new residents to the watershed present a number of potential concerns. New residential growth often includes additional impermeable cover in the watershed due to construction. Impermeable cover may cause more water and pollutants to run off into streams, because there is less open land available to soak up precipitation. New residents may also not be aware of water conservation and pollution prevention activities already in place in the watershed.

Prolonged drought conditions throughout the watershed have occurred multiple times during the data collection efforts of the Clean Rivers Program. A significant drought occurred in Central Texas from 2010 to 2015. This included a period between October of 2010 and September of 2011, which was the lowest precipitation period recorded in Texas. These conditions caused the majority of the watershed to experience increased concentrations of Total Dissolved Solids, Chlorides and Sulfates as these dissolved constituents became more concentrated during diminished flow conditions. The drought may also have affected bacteria levels throughout the watershed, as diminished alternative water sources drove wildlife to the Guadalupe River and its tributaries. Elevated bacteria concentrations are the most common impairment identified in the Guadalupe River Basin and efforts to reduce these concentrations through best management practices identified by WPPs and TMDLs are often targeted at non-point source pollution, such as wildlife.

The Canyon Reservoir has been identified as infested with Zebra Mussels by the Texas Parks and Wildlife Department. This designation indicates that this water body has a breeding population of the invasive mussels. These mussels can cause massive infrastructure costs as they colonize and hard surfaces below the waterline such as boat motors and water pipelines. Stakeholders remain concerned that these mussels will continue to spread throughout Canyon Reservoir and downstream to the other hydrological impoundments of the Guadalupe River. The GBRA & TPWD are performing early detection monitoring on these downstream lakes.

Many invasive nuisance plant species continue to persist in the Guadalupe River watershed, including Water Hyacinth and Hydrilla. These species can inhibit recreational boating uses as they clog water ways and become entangled in boat propellers. The GBRA has partnered with the TPWD to perform strategic spraying of nuisance plants in an effort to prevent the spread of these species.

RECOMMENDATIONS FOR THE FUTURE

- Coordinated water quality data collection efforts must continue in order to track and identify ongoing and future impairments and concerns in the basin.
- Additional biological monitoring should be increased in the basin in order to measure and track the impacts of water quality conditions on aquatic life.
- Stakeholder driven watershed protection plans should continue to expand in order to make the most of in-kind labor contributions from current monitoring efforts to improve water quality.
- Public education and outreach efforts must continue in order to educate the public about water quality as the population of the basin continues to expand at a record pace.
- Invasive species prevention, monitoring and treatment activities should continue to reduce the impact of nuisance species.

This report was sent to stakeholders, requesting input. No additional recommendations were provided.

WATER QUALITY PARAMETERS

Field Parameters are water quality constituents that can be obtained on-site and generally include: dissolved oxygen (DO), conductivity, pH, temperature, stream flow (not in reservoirs), and secchi disc depth (reservoirs only).

Dissolved Oxygen indicates the amount of oxygen available in the stream to to support aquatic life. DO can be reduced by the decomposition of organic matter.

Conductivity is a measure of the water body's ability to conduct electricity and indicates the approximate levels of dissolved salts, such as chloride, sulfate and sodium. Elevated concentrations of dissolved salts can impact water as a drinking water source and aquatic habitat.

pH is a measure of the hydrogen ion concentration in an aqueous solution. It is a measure of the acidity or basic property of the water. Chemical and biological processes can be affected by the pH. The pH can be influenced by dissolved constituents, such as carbon dioxide and by point and nonpoint source contributions to the stream.

Temperature of the water affects the ability of the water to hold dissolved oxygen. It also has an impact on the biological functions of aquatic organisms.

Stream Flow is an important parameter affecting water quality. Low flow conditions common in the warm summer months create critical conditions for aquatic organisms. Under these conditions, the stream has a lower assimilative capacity for waste inputs from point and nonpoint sources.

Secchi Disc transparency is a measure of the depth to which light is transmitted through the water column, and thus the depth at which aquatic plants can grow.

Conventional Parameters are typical water quality constituents that require laboratory analysis and generally include: nutrients, chlorophyll *a*, total suspended solids, turbidity, hardness, chloride, and sulfate.

Nutrients include the various forms of nitrogen and phosphorus. Elevated nutrient concentrations may result in excessive aquatic plant growth and can make a water body unfit for its intended use(s).

Chlorophyll *a* is a plant pigment whose concentration is an indicator of the amount of algal biomass and growth in the water.

Turbidity is a measure of water clarity or light transmitting properties. Increases in turbidity are caused by suspended and colloidal matter such as clay, silt, fine organic and inorganic matter, plankton and other microscopic organisms.

Total Suspended Solids indicate the amount of particulate matter suspended in the water column.

Hardness is a composite measure of certain ions in water, primarily calcium and magnesium. The hardness of the water is critical due to its effect on the toxicity of certain metals. Typically, higher hardness concentrations in the receiving stream can result in reduced toxicity of heavy metals.

Chloride and Sulfate are major inorganic anions in water and wastewater. Numeric stream standards for chloride and sulfate have been set on all of the classified stream segments in the basin. Both of these inorganic constituents can impact the designated uses and can come from point and nonpoint sources, such as wastewater discharges, oil field activities, and abandoned flowing wells from ground-water with elevated concentrations of dissolved solids.

Other Parameters

Bacteria, specifically *E. coli*, is used as an indicator of the possible presence of disease-causing organisms.

Biological and Habitat assessment includes collection of fish community data, benthic macroinvertebrate (insects) data, and measurement of physical habitat parameters. This information is used to determine whether the stream adequately supports a diverse and desirable biological community. The physical, chemical and biological data are used together to provide an integrated assessment of aquatic life support.

24-Hour DO studies perform measurements of DO in frequent intervals (e.g., one hour) in a 24-hour period. The average and minimum concentrations in the 24-hour period are compared to corresponding criteria. This type of monitoring takes into account the diurnal variation of DO and avoids the bias in samples taken only at certain times of the day.

Metals in Water, such as mercury or lead, typically exist in low concentrations, but can be toxic to aquatic life or human health when certain levels are exceeded. To obtain accurate data at low concentrations, the GBRA uses special clean methods that minimize the chance for sample contamination and provide high quality data.

Organics and Metals in Sediment could be a source of toxicants for the overlying water, though currently there are no numeric sediment standards.

Organics in Water, such as pesticides or fuels, can be toxic to aquatic life or human health when certain levels are exceeded.

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933 East Court Street, Seguin, Texas 78155
830-379-5822
www.gbra.org

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