Brazos River Basin Summary Report

2012

ACKNOWLEDGEMENTS

The Authority wishes to thank the people listed on the following pages for their hard work and significant contributions to the Clean Rivers Program. Thanks also go out to the hundreds of individuals and organizations that are not named on these lists who have attended public meetings and other outreach events sponsored by the Authority and the Clean Rivers Program. Their input is the foundation of the watershed management process.

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The Brazos River Authority was created by the Texas Legislature in 1929 as the first state agency in our nation specifically created for the purpose of developing and managing the water resources of an entire river basin.

Today, the Authority's staff of around 250 develops and distributes water supplies, provides water and wastewater treatment, monitors water quality and pursues water conservation through public education programs.

This report was funded by the Texas Commission on Environmental Quality's Clean Rivers Program.

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1.0 INTRODUCTION

The principal aim of the Texas Clean Rivers Program (CRP) is to ensure safe, clean water supplies for the future of Texans' drinking water needs, industry, agriculture, healthy ecosystems, and recreation and for all other uses of this valuable state resource.

According to the Mission Statement contained in the Clean Rivers Program Long Term Action Plan, 2006: The goal of the CRP is to maintain and improve the quality of water resources within each river basin in Texas through an ongoing partnership involving the Texas Commission on Environmental Quality (TCEQ), other agencies, river authorities, regional entities, local governments, industry and citizens. The program's watershed management approach will identify and evaluate water quality issues, establish priorities for corrective action, work to implement those actions, and adapt to changing priorities.

Meeting the above goal requires addressing water quality problems through a watershed-based approach. A watershed-based approach provides a means to resolve and/or prevent water quality problems and considers all potentially harmful activities, from industrial activities to every-day household activities in the watershed.

This comprehensive approach is increasingly important as the United States moves beyond its 40-year campaign to bring point sources, such as industrial discharges, under control and begins to focus more on the difficult nonpoint pollution issues like stormwater runoff. A watershed approach is critical since government responds to most problems within various jurisdictional lines while environmental problems occur within natural settings unrelated to political boundaries. The CRP and its participants have become leaders of watershed management in Texas. Watershed management includes such initiatives as developing basin-wide water quality monitoring strategies, simultaneous expiration of wastewater permits within watersheds to allow for more informed permitting, and working with local stakeholders to identify and implement best management practices. This watershed management approach puts the state in a favorable position as Congress works toward a revised Clean Water Act that emphasizes a watershed-based approach to water quality protection and enhancement.

In order to meet its goals, the CRP has focused on consensus building in each major river basin. To aid in achieving consensus within river basins, the TCEQ contracts with local agencies to administer the program within their respective river basins. These agencies, primarily river authorities, are called "CRP Planning Agencies." It is their task to conduct the CRP requirements within each basin. The Planning Agencies work closely with local municipalities and other agencies to document and improve water quality across the state. The Brazos River Authority (or Authority or BRA) is the Planning

Agency in the Brazos River Basin. To help guide the planning agencies in this effort, each basin has a Steering Committee composed of interested individuals and stakeholders. Within the Brazos basin, this Steering Committee meets annually and is relied upon to provide input regarding issues of priority that deserve special attention. With the size of the Brazos River Basin, the Steering Committee allows the Authority and the CRP to hear from the varied local interests across the basin. By having stakeholders that represent specific parts of the basin the CRP is able to gather vital local knowledge of water issues that the Authority would not have otherwise.

The results of the Steering Committee process help the Authority set the agenda for the CRP in the Brazos River Basin and provide the baseline data needed by TCEQ for a variety of processes, including: monitoring, standards development, permitting, enforcement, public outreach, field investigations and research. At the same time, these programs must take advantage of the basin assessment process to see that TCEQ's information needs are addressed and in line with local priorities. In the end, the underlying goal of the entire Clean Rivers process is to make the most effective use possible of the valuable public funds already directed toward water quality protection.

1.1 Texas Clean Rivers Act

In 1991, the Texas Legislature passed the Texas Clean Rivers Act (Act) (Texas Water Code, Section 26.0135) which has subsequently been reauthorized in 1997. The Act was intended to move Texas toward comprehensive water resources planning and management to ensure the integrity of the state's water supply for the future.

The water needs of approximately 25.4 million Texans are currently being met, however; some forecasts estimate that the state's population will grow by 82 percent to over 46 million Texans in the next 50 years. Texas' water supplies are projected to decrease about 10 percent, from about 17.0 million acre-feet in 2010 to about 15.3 million acre-feet by 2060. In fact, in the event of severe drought conditions, the state faces an immediate need for additional water supplies of 3.6 million acre-feet per year. Water is a precious commodity in Texas, and the quality of that water must also be protected. Various water pollution concerns remain to be addressed across the state even after several decades of substantial progress in restoring the quality of Texas waters.

The Clean Rivers Act requires an ongoing assessment of water quality issues and development of management strategies statewide to guide Texas water resources policy in the future. The Act established the Texas Clean Rivers Program under the Texas Water Commission (now the TCEQ). The program is funded by fees assessed on wastewater discharge permittees and water rights holders.

1.2 Objectives of the Clean Rivers Program

- Provide quality-assured data to TCEQ for use in water quality decision making
- Identify and evaluate water quality issues
- Promote cooperative watershed planning
- Inform and engage stakeholders
- Maintain efficient use of public funds by leveraging program funds to maximize the effectiveness of watershed activities
- Adapt programs to emerging water quality issues

1.3 Brazos River Authority's Involvement in the Clean Rivers Program

The Authority was designated by the Texas Legislature through the Clean Rivers Act as the lead agency responsible for conducting the regional water quality assessment for the Brazos River Basin. As the first river authority in the state, the Authority has over 83 years of water resource planning and public outreach experience. Importantly, the Authority also has a continuously updated Geographic Information System and surface water quality database for the basin, which are valuable data management, analysis and mapping tools for the basin assessment process. As the lead agency for the Brazos River Basin, the Authority oversees all aspects of the Clean Rivers process in the basin. This includes: serving as liaison between TCEQ and the stakeholders, participating in state-wide CRP task forces; performing all administrative and project tasks; supporting the Brazos River Basin CRP Steering Committee and Technical Advisory Committee; and maintaining regular contacts with other Planning Agencies.

1.4 Purpose of the Basin Summary Report

This report presents the results of the Authority's assessment work for the Brazos River basin and its 14 major watersheds. This includes specific findings and recommendations from the basin assessment process, stakeholder input and public outreach activities.

The Brazos River Authority (BRA) carries out the water quality management efforts in the basin under contract with TCEQ. The activities described in this report include water quality monitoring results, a review of the 2010 Integrated Report (IR), a status update of proposed changes to surface water quality standards, a summary of significant events affecting water quality and a summary of other water quality studies being conducted in the Brazos River Basin.

The digital version of this report is imbedded with hyperlinks so that you can easily access more detailed information on projects in the Brazos River Basin. So wherever you see a word that looks like this, just click and see where it takes you. You can also click the Table of Contents to navigate to your desired section. After having been directed to another page in

the document or to an internet page, either close the web page or press Alt+◄— and you will return to where you were in the document.

The Clean Rivers Act requires that planning agencies prepare written reports every five years for the governor, TCEQ, the Texas State Soil and Water Conservation Board and the Texas Parks and Wildlife Department. This reporting process began in 1997 and is ongoing. The purpose of the Basin Summary Report (BSR) is to outline water quality issues confronting the entire basin as well as individual streams and lakes. These issues are complied based on public and stakeholder committee input as well as technical analysis of historical and current trends in water quality. This work is performed in accordance with TCEQ guidance, which specifies a range of parameters to be examined to achieve a comprehensive assessment.

The BSR also complements the TCEQ's 305(b) Texas Water Quality Inventory Report and 303(d) List of Impaired Waterbodies. The State's Integrated Report (IR) provides an assessment of waters throughout the state and is conducted on even numbered years. However, not all streams and lakes are assessed in every report. The assessment is conducted to evaluate stream and lake compliance with their respective designated water quality standards and uses. Streams that are not in compliance with their designated standards or uses are placed on the 303(d) List.

1.5 Brazos River Basin Clean Rivers Program Priorities

- Identify water quality issues
- Inventory basin features to verify where activities could impact water quality
- Analyze trend data to identify potential water quality concerns and determine where more information is needed
- Participate in state-wide task forces which establish the direction of the Clean River Program
- Participate in the Watershed Action Planning Process
- Monitor other key programs and special interest groups with similar missions
- Pursue special studies and other recommended actions resulting from the basin assessment process

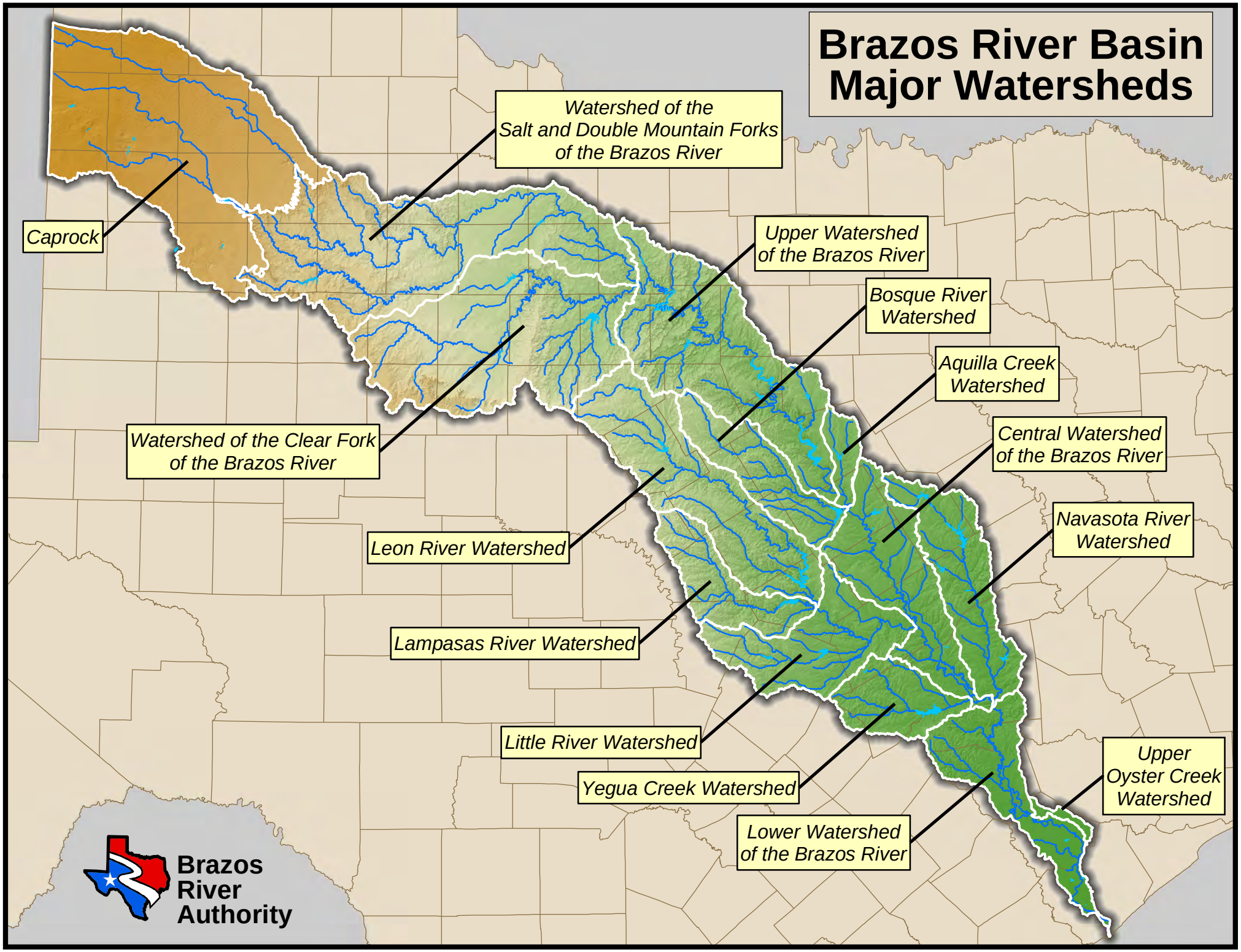
1.6 Brazos River Basin Characteristics

The Brazos River Basin can be divided into 14 major watersheds that fall within the 42,000 square miles and portions of 70 counties that make up the basin. The 14 major watersheds include:

- the Caprock watershed;
- the Double Mountain Fork/Salt Fork of the Brazos watershed;
- the Clear Fork of the Brazos watershed;

- the Upper Brazos River watershed;
- the Lampasas River watershed;
- the Leon River watershed;
- the Bosque River watershed;
- the Aquilla Creek watershed;
- the Little River watershed;
- the Central Brazos River watershed;
- the Navasota River watershed;
- the Yegua Creek watershed;
- the Lower Brazos River watershed; and
- the Oyster Creek watershed.

The Caprock watershed is a non-contributing watershed to the Brazos River Basin due to lack of rainfall and high evaporative rates in northwest Texas. Precipitation in this area is either absorbed by area soils or is contained in the hundreds of playa lakes in this part of the state. Playa lakes are shallow, round depressions that fill after storms then rapidly dry due to evaporation. These temporary lakes provide water for wildlife and flood control for municipalities. However, due to their ephemeral natures, these lakes are not monitored or assessed as part of the CRP.


Brazos River Basin
Major Watersheds
Caprock
Watershed of the
Salt and Double Mountain Forks
of the Brazos River
Upper Watershed
of the Brazos River
Bosque River
Watershed
Aquilla Creek
Watershed
Central Watershed
of the Brazos River
Navasota River
Watershed
Watershed of the Clear Fork
of the Brazos River
Leon River Watershed
Lampasas River Watershed
Little River Watershed
Yegua Creek Watershed
Lower Watershed
of the Brazos River
Upper
Oyster Creek
Watershed
Brazos
River
Authority

Regional Geography

The Brazos River marks its headwaters at the foot of the south plains near the Texas-New Mexico border. While providing boating, swimming and fishing for more than 840 river miles, the Brazos River also serves as a water source for cities, agriculture, industry and mining. The Brazos River serves more than 3.9 million Texans living within its basin. The more than 42,000 square miles that make up the Brazos River basin are divided into 14 major watersheds each with distinctive climate, topography, land uses, and water needs. The Brazos River basin is one of the most diverse river basins in the state spanning eight distinct ecoregions each with unique soils, vegetation, mineral resources, climate and geology. The basin spans three climatological zones: the Continental Steppe characterized by large variations in daily temperatures, low humidity and irregularly-spaced rainfall of moderate amounts; the Subtropical Subhumid zone characterized by hot summers and dry winters; and the Subtropical Humid zone characterized by warm summers and high humidity. Average annual precipitation in the basin varies from 15 to 25 inches per year in the northern part of the basin, 35 to 40 inches per year in the central part of the basin and 45 to 50 inches per year in the southern part of the basin. Topography ranges from just over 4,385 feet in the northern portion of the basin to near sea level at the confluence with the Gulf of Mexico with rugged, uneven terrain in the northwestern part of the basin to flat, forested areas with rich soils and the Gulf Prairies in the southern portion of the basin

Land Cover and Ecosystems

In addition to the diverse natural setting, the region contains a variety of land cover and land use types and a wide range of ecosystems. Land uses range from extreme rural areas with little to no development to areas of scattered development to areas with dense industrial, commercial and residential development. This range of land use types creates a challenging array of issues for water quality management. Most areas of the Brazos River basin are undeveloped and land is used primarily for grazing and other agricultural activities. Lubbock, Taylor, Hood, Johnson, McLennan, Bell, Williamson, Brazos and Fort Bend Counties all have areas of dense development around the major population centers of the basin.

Rural and Undeveloped Areas

The watersheds of the Brazos River basin are primarily undeveloped areas with scattered small towns and communities. Land uses are generally a mix of residential and commercial, with large acreages used for grazing and wildlife.

Urban

The major urban areas of the basin include the following cities and associated suburban communities: Lubbock, Abilene, Cleburne, Granbury, Waco, Temple/Belton, Georgetown/Round Rock, Bryan/College Station, and Sugar Land. These

areas contain a wide mix of land uses ranging from residential to commercial to industrial. Williamson and Fort Bend Counties are ranked in the top five counties in the state for population growth.

Industrial

Industrial use in the basin consists of water used for manufacturing, steamelectric cooling during power generation, nuclear power generation, hydropower generation and for mining operations. Industrial activities are scattered throughout the basin but are typically close to the major population centers. The exception to this is the power generation facilities which are more closely associated with lakes rather than major population centers. Lakes in the Brazos River basin associated with power generation facilities include: Millers Creek Reservoir, Lake Palo Pinto, Lake Granbury, Squaw Creek Reservoir, Lake Whitney, Tradinghouse Creek Reservoir, Lake Limestone, Twin Oaks Reservoir, Gibbons Creek Reservoir, and Alcoa Lake. Industrial activities in the lowest two counties, Fort Bend and Brazoria Counties, are dominated by the petrochemical industry. Natural gas exploration including the process of hydraulic fracturing is rapidly increasing basinwide. With these efforts comes an increased need for water to support these operations.

Agriculture

Agriculture is the mainstay of the Brazos Basin's rural economy. In the upper region, the major dryland products are extensive row-crops, such as cotton and wheat. Hay and silage are also produced in the upper region: however, due to low rainfall, their acreage is much less than other regions of the basin. There is a slow migration of dairy related confined animal feeding operations (CAFOs) from the central to the northern areas of the basin. Dairy operators have found the arid climate and reduced rainfall amounts in the northern area conducive to production. Moreover, the reduced stormwater runoff in this area allows the permitting process to run smoothly. As dairy operations move north, the central and lower portions of the basin are experiencing growth in the poultry industry ranging from producers to major processing facilities. The central region of the Brazos River Basin is noted for its dryland production of a variety of crops. The major crops produced in the central region include: hay, silage, peanuts, pecans, vegetables, corn, wheat and cotton. Comanche, Eastland, Erath, and Somervell Counties combined lead the state in dairy production. This is due to several factors such as available groundwater, soils suitable for forage production, topography and existing infrastructure. The lower region of the Brazos River Basin has limited row-crop agriculture due to lack of suitable topography and soils. Hay and silage are the major agricultural products. The Brazos River Bottoms counties (Brazos, Burleson and Robertson) produce most of the crops in the region, including corn, sorghum and cotton. The fertile soils of the Gulf Prairies in Fort Bend and Brazoria Counties support the production of rice.

Water Quality Management

From the dry, arid north to the Gulf Prairie in the far south, the setting for the Brazos River Basin is quite diverse. This creates a multitude of challenges for water quality assessment and planning. While some of the land cover types, such as wetlands, contain properties that provide self-purification and buffering capabilities, many of the waterways are affected by man-made impacts. The Authority collects water quality monitoring data from across the basin in an effort to assess the quality of the watersheds and determine sources of impairment for those waterbodies that exhibit compromised water quality. Through the CRP, the Authority has committed to the goal of maintaining or improving water quality. After reviewing available data throughout the basin, the Authority has compiled a list of findings and recommendations for the entire basin as well as findings for each individual major watershed of the Brazos Basin. These can be found in Section 5.0, Conclusions and Recommendations.

Water Resource Issues

Through its assessment activities, Steering Committee and public input, the Authority continues to maintain an inventory of issues facing the basin's water quality management agencies and residents. The overriding, long-term challenge for basin water quality management will be to maintain and, where possible, improve water quality of basin waterways despite the cumulative impacts that will come with projected population growth and ongoing urban development and agricultural activities. Among the challenges are:

- Increased wastewater generation that impacts already stressed wastewater systems that are at or near capacity along with the continued proliferation of on-site sewage disposal systems,
- Protection of source water for increased water supply needs from the lakes of the Brazos River Basin,
- Increased demand on waters for contact recreational uses such as swimming, boating and fishing,
- Increased land disturbance and more impervious surfaces associated with ongoing development, that generate more nonpoint source pollution from a wider geographic area, and
- altered drainage patterns resulting from land development activities and encroachment into the floodplain.

1.7 Water Quality Management Issues Facing the Brazos River Basin

Exceedance of State Standards

- Concerns for recreation due to elevated bacteria levels are pervasive throughout the Brazos River Basin.
- Dissolved oxygen depletion which may negatively impact aquatic life.
- Natural salt which impacts the usability of water for human consumption in the Brazos River.
- Evaluate stream standards to ensure that they are appropriate before listing segments for water quality violations.

Data Needs

- Respond to the listing (support or refute) of stream segments on the 303(d) List and in the 305(b) Report.
- Data elements such as rainfall, flow, and other climatic and geographic conditions to determine if a listed or suspected impairment is naturally occurring, especially in relatively undeveloped watersheds.
- Collection of accurate flow information to correlate with regional water quality data to better understand that data.

Nonpoint Source Pollution, Stormwater Discharge and Runoff

- Work to determine the actual role stormwater conveyances play in the cause of elevated bacteria levels.
- Accumulation of pesticides, fertilizers and animal waste from residential properties and agricultural practices.
- Sedimentation and turbidity from soil and bank erosion, quarrying and construction activities, along with the transport of other pollutants with sediment.
- Accumulation of trash and other debris from littering and illegal dumping.

Wastewater

- Maintaining the progress made in the quality of municipal and industrial point source discharges.
- Closer oversight and technical assistance to the numerous small wastewater dischargers in the basin.
- Regionalize wastewater treatment facilities whenever possible to reduce the problems caused by inadequately-operated smaller plants that are dispersed across the basin and the problems caused by the high concentration of aging, poorly functioning on-site sewage disposal systems in population growth centers.
- Burden on local governments to finance and accomplish major capital improvements, especially in response to state and federal mandates, budget cuts, and the problems caused by aging infrastructure.

Watershed Management

- Watershed-based management strategies built on stakeholder involvement.
- Coordinating and integrating concurrent assessment and management programs whenever possible.
- Narrow the focus to microwatershed with concerns for nonpoint source runoff, point source discharges and accidental spills and illegal dumping.
- Determine continuous sources of contamination.

Ecosystems

- Inadequate management of shoreline and riparian areas adjacent to waterways.

- Physical alteration and disruption of waterways and their associated natural drainage systems, wetlands, floodplains, and riparian areas:
    - erosion and sedimentation
    - loss of stabilizing, filtering, and shading vegetation
    - stream diversions
    - man-made, dead-end canals and channels
    - impacts on boating traffic
    - Impacts of degraded water quality on aquatic life and on species abundance and diversity.

Funding

- Stable, adequately-funded, long-term water quality monitoring programs.
- Implementation funds to address problems in areas where small communities or low-income residents do not have the resources.
- Funds to help communities improve aging infrastructure.

Public Education

- Public education on the role that individual citizens play in pollution prevention and the cumulative effects of individual actions.
- Public resistance to land use regulation and other measures that would impact individuals and private property.
- Effectiveness of voluntary water quality protection efforts on private lands, particularly for agricultural lands and residential properties.
- Importance of basic water aesthetics to the general public.

Enforcement

- Difficulty of illegal dumping prevention and enforcement of ordinances already in place.
- Difficulty of identifying illegal dischargers and enforcement of regulations already in place.
- Prevention of the proliferation of non-native, invasive species and enforcement on those trading in these species.
- Education of rural law enforcement and judicial personnel regarding environmental laws and prosecution of environmental crimes.

Natural Salt

- Brine springs in the upper region of the basin impact the Brazos River with elevated chloride levels affecting water use and availability.

- Burden on local governments and industry to finance advanced treatment technologies to produce potable water from the Brazos River.
- Difficulty of disposal of highly concentrated brine from the advanced treatment process.

2.0 PUBLIC INVOLVEMENT

2.1 Brazos River Basin Clean Rivers Program Steering Committee

The size and diversity of issues across the Brazos River basin presents a challenge for the large group of stakeholders in our basin. The Brazos River Clean Rivers Program (CRP) Steering Committee participants represent diverse interests that are represented by government agencies, municipalities, industry, agriculture, organized local stakeholder groups, individuals, and environmental groups.

The BRA holds an annual meeting that provides the Steering Committee with an opportunity to hear results of water quality monitoring and CRP special studies and gives them a forum where they may voice opinions, make recommendations and interact with other stakeholder participants and BRA staff. Steering Committee members also participate by providing input into planning water quality monitoring activities, prioritizing problems within the basin for prospective CRP special studies, identifying problem areas, developing actions to address potential problem areas in the basin and commenting on the current year's draft Basin Highlights Report.

How to get involved with the Brazos Basin CRP?

BRA promotes communication and participation from the general public. If you are interested in serving on the Brazos River Basin CRP Steering Committee, send an email to jbarrett@brazos.org. Please indicate what topics you are interested in and provide an email address so that you can receive electronic notices of meetings and reports. In addition, the information you provide will help us to develop more effective meetings and provide direction to the program. We highly encourage participation in our meetings and input on water quality issues in the basin.

2.2 Brazos Basin CRP Website

The BRA maintains both a river authority website and a CRP website as a mechanism to keep the public informed via the internet. These websites provide information on topics of interest in the basin. The websites provide links to a range of information, including:

Water quality data

Water quality data generated by the BRA is available in a searchable format and can be easily downloaded to an Excel file. This site is updated weekly. A link to the TCEQ data website is also provided.

Special Studies Reports

Available for download in .pdf format.

Quality Assurance Information

The Quality Assurance Project Plan for CRP and Data Management Plan are available for download in .pdf format.

Schedule of Monitoring Activities

A link is provided to the coordinated monitoring website, which contains a list of the water quality monitoring locations in the state.

Information on Non-CRP Water Quality Projects

Information is provided on a variety of water quality related projects sponsored by the BRA that are not conducted as part of the CRP.

Recreational Information

Information is provided on boating, fishing and other river and lake activities including canoeing maps below Possum Kingdom Lake and Lake Granbury.

River and Reservoir Levels

An interactive map provides information on USGS Stations in the basin, flood stage at each station and current flow at each station.

Current Drought Status

An updated Palmer Drought Index map is provided along with copies of the BRA's Drought Contingency Plan and Water Conservation Plan.

Water Supply Data

Information is provided on reservoir locations, elevations, and capacities and surface area.

Technical Assistance Program

Information is provided on services offered by the BRA to municipalities and utility districts in the basin, including: Industrial Pretreatment Programs, Regulatory Reviews, and Operations Assistance.

3.0 WATER QUALITY REVIEW

3.1 Descriptions of Water Quality Parameters and Terminology

Following are typical terms that are used when discussing water quality with descriptions of several water quality parameters and how they relate to achieving water quality standards. There are two groups of parameters:

Field parameters are those water quality constituents that can be obtained on-site and generally include:

PARAMETER	POTENTIAL IMPACTS WHEN STATE STANDARDS ARE NOT MET	POTENTIAL CAUSES OF STATE STANDARDS NOT BEING MET
Temperature	Water temperature affects the oxygen content of the water, with warmer water unable to hold as much oxygen. When water temperature is too cold, cold-blooded organisms may either die or become weaker and more susceptible to other stresses, such as disease or parasites.	Colder water can be caused by reservoir releases. Warmer water can be caused by removing trees from the riparian zone, soil erosion, or use of water to cool manufacturing equipment.
Specific Conductance	Specific conductance is a measure of the waterbody's ability to conduct electricity and indicates the approximate levels of dissolved salts, such as chloride, sulfate and sodium in the stream.	Elevated concentrations of dissolved salts can impact the water as a drinking water source and as suitable aquatic habitat.
pH	Most aquatic life is adapted to live within a narrow pH range. Different organisms can live at and adjust to differing pH ranges, but all fish die if pH is below four (the acidity of orange juice) or above 12 (the pH of ammonia).	Algal blooms produce diel swings in dissolved oxygen causing super-saturation during the day while respiration can cause night-time oxygen levels to crash. Chemical byproducts of this photosynthesis/respiration process cause swings also in pH, with lower levels (acidic conditions) during the day and higher levels (alkaline

PARAMETER	POTENTIAL IMPACTS WHEN STATE STANDARDS ARE NOT MET	POTENTIAL CAUSES OF STATE STANDARDS NOT BEING MET
		conditions) at night. Industrial and wastewater discharge, runoff from quarry operations and accidental spills can also be a cause.
Dissolved Oxygen (DO)	Organisms that live in the water need oxygen to live. In stream segments where DO is low, organisms may not have sufficient oxygen to survive.	DO levels may be low due to no primary productivity, stagnant, pooled or low-flow conditions. Modifications to the riparian zone, human activity that causes water temperatures to increase, increases in organic matter, bacteria and over abundant algae may also cause DO levels to decrease. Algal blooms produce diel swings in dissolved oxygen causing super-saturation during the day while respiration can cause night-time oxygen levels to crash.
Stream Flow	Flow is an important parameter affecting water quality. Low flow conditions common in the warm summer months create critical conditions for aquatic organisms.	At low flows, the stream has a lower assimilative capacity for waste inputs from point and nonpoint sources. DO concentrations can also decrease as flow decreases.
Transparency and Secchi Disk Depth	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.	Low transparency or secchi disc depth is an estimate of turbidity.

Conventional Parameters are typical water quality constituents that require laboratory analysis and generally include:

PARAMETER	POTENTIAL IMPACTS WHEN STATE STANDARDS ARE NOT MET	POTENTIAL CAUSES OF STATE STANDARDS NOT BEING MET
Turbidity	Turbidity is a measure of the water clarity or light transmitting properties.	Increases in turbidity are caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms.
Hardness	Hardness is a composite measure of certain ions in the water, primarily calcium and magnesium. The hardness of the water is critical due to its effect on the toxicity of certain metals	Higher hardness concentrations in the receiving stream can result in reduced toxicity of heavy metals.

PARAMETER	POTENTIAL IMPACTS WHEN STATE STANDARDS ARE NOT MET	POTENTIAL CAUSES OF STATE STANDARDS NOT BEING MET
Chloride	Chloride is an essential element for maintaining normal physiological functions in all organisms. Elevated chloride concentrations can disrupt osmotic pressure, water balance and acid/base balances in aquatic organisms which can adversely affect survival, growth and/or reproduction.	Natural weathering and leaching of sedimentary rocks, soils and salt deposits can release chloride into the environment. Other sources can be attributed to oil exploration and storage, sewage and industrial discharges, run off from dumps and landfills and saltwater intrusion.
Sulfate	Effects of high sulfate levels in the environment have not been fully documented. However, sulfate contamination may contribute to the decline of native plants by altering chemical conditions in the sediment.	Due to abundance of elemental and organic sulfur and sulfide mineral, soluble sulfate occurs in almost all natural water. Other sources are the burning of sulfur containing fossil fuels, steel mills and fertilizers.
Total Dissolved Solids	High total dissolved solids may affect the aesthetic quality of the water, interfere with washing clothes and corrode plumbing fixtures. High total dissolved solids in the environment can also affect the permeability of ions in aquatic organisms.	Mineral springs, carbonate deposits, salt deposits and sea water intrusion are sources for natural occurring high concentration TDS levels. Other sources can be attributed to oil exploration, drinking water treatment chemicals, storm water and agricultural runoff and point/nonpoint wastewater discharges.
Bacteria • ***Escherichia coli* (*E. coli*)** • **Enterococcus**	Although certain species of bacteria may not themselves be harmful to human beings, their presence is an indicator of recent fecal matter contamination and that other pathogens dangerous to human beings may be present.	Present naturally in the digestive system of all warm blooded animals, these bacteria are in all surface waters. Poorly maintained or ineffective septic systems, overflow of domestic sewage or nonpoint sources and runoff from animal feedlots can elevate bacteria levels.
Ammonia Nitrogen	Elevated levels of ammonia in the environment can adversely affect fish and invertebrate reproductive capacity and reduce the growth of young.	Ammonia is excreted by animals and is produced during the decomposition of plants and animals. Ammonia is an ingredient in many fertilizers and is also present in sewage, storm water runoff, certain industrial wastewaters and runoff from animal feedlots.

PARAMETER	POTENTIAL IMPACTS WHEN STATE STANDARDS ARE NOT MET	POTENTIAL CAUSES OF STATE STANDARDS NOT BEING MET
Total Suspended Solids (TSS)	Suspended solids increase turbidity which reduces light penetration and decreases the production of oxygen by plants. They can also clog fish gills. Eventually, the suspended solids settle to the bottom of the stream or lake, creating sediment. Excessive sediment in the water column can also reduce growth of algae and can transport other contaminants such as nutrients and bacteria. Habitat for aquatic organisms can also be reduced.	Excessive TSS is the result of accelerated erosion and is often associated with high flows where river banks are cut or sediment is resuspended. It can also be the result of sheet erosion, where over land flow of water causes a thin layer of soil to be carried by the water to the stream. Disturbing vegetation without a proper barrier to slow down overland flow (such as construction sites or row cropping) increases TSS.
Nutrients • **Nitrogen** • **Nitrate** • **Total Phosphorus** • **Ortho-phosphate phosphorus**	Nutrients increase plant and algae growth. When plants and algae die, the bacteria that decompose them use oxygen. This reduces the dissolved oxygen in the water. High levels of nitrates and nitrites can produce nitrite toxicity, or "brown blood disease," in fish. This disease reduces the ability of blood to transport oxygen throughout the body.	Nutrients are found in effluent released from wastewater treatment plants (WWTPs), fertilizers and agricultural runoff carrying animal waste from farms and ranches. Soil erosion and runoff from farms, lawns and gardens can add nutrients to the water.
Chlorophyll *a*	High levels of nutrients in relatively stable waters can cause algae blooms, decrease water clarity and cause swings in dissolved oxygen and pH due to photosynthesis. This is most commonly measured using chlorophyll *a* concentrations.	Algal blooms can result in elevated chlorophyll *a* concentrations indicating an increase in nutrients that increase growth and reproduction in algal species.

Biological and Habitat Assessment The three components evaluated during a biological assessment include: measurement of physical habitat parameters, collection of fish community and the benthic macroinvertebrate community data. Each component, depending on the nature of a particular waterbody and its biota, is classified as having limited, intermediate, high, or exceptional aquatic life. Assessments are conducted to provide baseline data on environmental conditions or to determine if the designated aquatic life use for the stream is being attained. Data collected as part of a biological assessment are used for the IR.

24-hr Dissolved Oxygen studies perform measurements of DO in frequent intervals in a 24-hr period. This type of monitoring is conducted to measure the diurnal variation of DO and its impacts on the biological community. This monitoring is frequently paired with biological and habitat assessments.

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.

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

3.2 Data Review Methodology

All data discussed in this report has been collected under TCEQ approved Quality Assurance Project Plans.

Water quality information in this report was derived from two assessment methods:

- The 2010 Integrated Report (IR) – a comparison of a seven-year data set to the State Water Quality Standards
- A trend analysis using the entire historical data set with a 10-year minimum to detect changes in water quality over time.

2010 Integrated Report

The TCEQ assesses the condition of the state's waterbodies on a periodic basis under the Clean Water Act (CWA) Section 305(b). The results of the assessment are contained within the Texas Water Quality Inventory and 303(d) List and are comprised of a complete listing of all water quality concerns in the state. This report is referred to as the Integrated Report. As required by the CWA, the IR is updated every two years and includes the review of the past seven years of data (with a lag-time of two years) collected by many organizations statewide, including the BRA. The IR remains a draft document until approval by EPA. Specific assessment methodologies are described in the 2010 Guidance for Assessing and Reporting Surface Water Quality in Texas. The 2010 IR, on which the following information is based, provides an assessment of water quality results using data acquired from December 1, 2001 through November 30, 2008. Please click here for more information and to review the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d). In November 2011, the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) was approved by the USEPA.

The 2010 IR provides an overview of surface water quality throughout the state, including issues relating to public health, fitness for use by aquatic species and other wildlife, specific pollutants and their possible sources. These water quality

issues are identified by comparing concentrations in the water to numerical criteria that represent the state's water quality standards or screening levels to determine if the waterbody supports its designated uses, such as suitability for aquatic life, for contact recreation, or for public water supply. The report determines if fish and aquatic insects have adequate oxygen, if people swimming in the water are exposed to pathogens that may cause illness. Waterbodies that do not meet established water quality standards are placed on the 303(d) List and are referred to as "impaired," "not supporting," or "NS." Once placed on the list the waterbody is targeted for special study and/or corrective action.

Water quality standard numerical criteria are used by TCEQ as the maximum or minimum instream concentration that may result from permitted discharges and/or nonpoint sources and still meet designated uses. To resolve the issues of regional and geological diversity of the state, standards are developed for classified segments. Classified segments are defined segments of waterways that are unique from other segments. Each classified segment has been designated a four-digit code. The Brazos River Basin is designated by the number 12. Each classified segment is distinguished by the next two numbers, for example, the Brazos River Tidal Segment: 1201. Appropriate water uses such as contact recreation, public water supply, and aquatic life are then applied to the segments. Site-specific water quality criteria have been developed for water temperature, dissolved oxygen, pH, bacteria, chloride, sulfate and total dissolved solids for classified segments. Use support is reported at both the segment and sub-areas levels. Each assessment sub-area is known as an assessment unit (AU) which is defined as the smallest geographic area of use support reported in the assessment. Support of criteria and uses are examined for each AU. To address water quality regulatory activity such as permitting, standards development, and remediation, use support information applies to the AU level. The 303(d) list is reported at the level of the AU for each waterbody. Each AU within a waterbody segment is given a number following an underscore after the segment designation, such as 1201_01. A segment may consist of one or more AUs.

There are also many streams that are not classified segments that are also are assessed throughout the state. These are referred to as unclassified segments and are coded with the four-digit designation followed by a letter, such as 1201A. These unclassified segments do not have specific water quality standards developed for them. For assessment purposes, unclassified streams are assessed using the numeric criteria developed for the classified segment into which the stream flows.

The TCEQ identifies segments where the data conditions are such that the waterbody is close to violating water quality standards as having a "concern for near non-attainment of standards" or "CN." These CN segments are then targeted for increased monitoring to better understand the conditions in the stream.

Numeric quality standards have not been developed for nutrients and chlorophyll *a* (although chlorophyll *a* criteria has been developed for certain reservoirs). Instead, the water quality standards for nutrients and chlorophyll *a* are expressed as narrative criteria. In the absence of segment-specific numeric water quality criteria, the state has developed screening levels for these parameters in order to identify areas where elevated concentrations may cause water quality concerns. These screening levels are applied to waterbodies statewide, and are based on the 85th percentile of nutrient values in the statewide water quality database. Waterbodies that exhibit frequent (>25% of the time) elevated concentrations of nutrients or chlorophyll *a* are referred to as having a "concern for screening level violations" or "CS" and are often targeted for continued and increased monitoring to better understand the effects of the elevated concentrations.

Impairments and selected concerns are illustrated in the Watershed Summaries chapter of this report for each watershed in maps entitled "**FY12 Water Quality Monitoring and 2010 IR Status**". There is also a table for each watershed entitled "**Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends.**" This table lists each classified and unclassified segment in the respective watershed with its descriptive name, type and attainability of its use, surface water quality standard, and nutrient screening criteria. The table is color-coded: indicates that a segment or portion of segment (AU) is impaired for that standard, indicates that a segment or portion of segment (AU) has a concern for the standard or the screening level. This table also offers one more piece of information, trend information. ↑indicates a statistically significant increasing trend, while ↓indicates a statistically significant decreasing trend.

Trend Analysis

The Authority used linear regression to detect trends and ANOVA to determine if the trend was statistically significant. A trend was considered statistically significant at $p \leq 0.05$. Trends described in this report are based on analysis of all data collected from the 1970s through 2011 with a minimum 10-year data set. Long-term data sets are more useful for estimating trends due to the drought effects of the last few years. Correlation of one parameter to another was determined using Pearson Correlation, significant at $p \leq 0.05$. Data used for trending was provided by TCEQ. The statistical analysis was performed with SPSS Version 19.0. The detection of trends is important for many environmental studies and monitoring programs.

Trends were examined for the following water quality parameters:

- Temperature
- Dissloved Oxygen (DO)
- pH
- Total Suspended Solids (TSS)

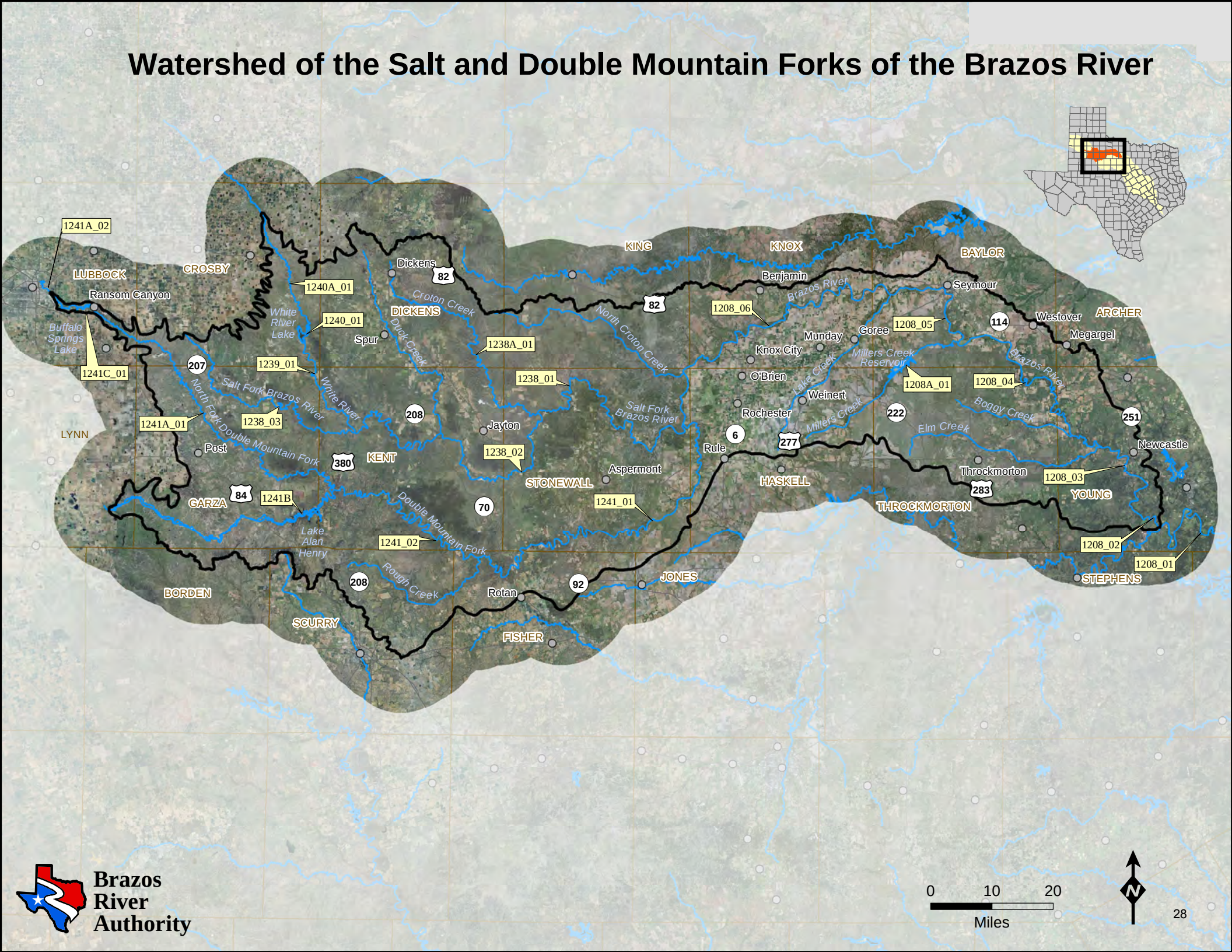
- Ammonia-Nitrogen (NH_3)
- Nitrate-Nitrogen (NO_3)
- Total Kjeldahl Nitrogen (TKN)
- Total Phosphorus (TP)
- Orthophosphate-Phosphorus (OPO_4)
- Chlorophyll *a* (Chl *a*)
- Bacteria (*E. coli* or Enterococcus)

3.3 Watershed Summaries

The purpose of the Watershed Summary section is to gain a better understanding of each watershed within the larger basin. A technical data analysis and discussion, watershed maps, selected time-series plots and descriptive statistics for each watershed are presented in the Watershed Summaries. Each watershed is mapped separately and includes a basemap depicting watershed boundaries, segments with names and AUs, county boundaries, cities and major roads. There is then a table containing information on watershed area, number of active surface water monitoring stations, current monitoring agencies, number of permitted dischargers, potential stakeholders and number of classified segments. Following this table are full descriptions of each segment, names of unclassified segments, AU designations with stations indicated in each that have been monitored within the last ten years. There is also a more detailed watershed map additionally depicting monitoring locations, discharge locations (although there are various types of permitted discharges: municipal, domestic, industrial, etc., for the purpose of this report, the Authority has listed all discharges in one category - Wastewater Outfalls), water quality impairments and selected water quality concerns.

The Watershed Summaries section of this report contains water quality assessment information about each of the classified segments in the Brazos Basin Clean Rivers Program assessment area. This section is presented as a result of Texas Commission on Environmental Quality and Brazos River Authority screening. This information is summarized in each watershed in a table entitled "**Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends.**" This table lists each classified and unclassified segment in the respective watershed with its descriptive name, type and attainability of its use, surface water quality standard, and nutrient screening criteria. It is important to remember that the information presented represents a snapshot in time and that water quality conditions are dynamic and can change over time. Furthermore, segments identified as having no impairments or concerns are not necessarily without problem. Rather, there may have been limited or no data available and all uses may not have been assessed.

Watershed of the Salt and Double Mountain Forks of the Brazos River



Brazos River Authority

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3.3.1 Watershed of the Salt and Double Mountain Forks of the Brazos River Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
6,500 mi^2	12	BRA, TCEQ	14	Cities of Lubbock, Aspermont, Throckmorton, Seymour	1208, 1238, 1239, 1240, 1241

Description of Segments:

1208: Brazos River Above Possum Kingdom Lake – From a point immediately upstream of the confluence of Cove Creek at Salem Bend in Young County to the confluence of the Double Mountain Fork Brazos River and the Salt Fork Brazos River in Stonewall County.

Segment Length: 189 miles
Assessment Units (Stations): 1208_02 (partial) (13641), 1208_03 (None), 1208_04 (11870), 1208_05 (11871), 1208_06 (None)

Unclassified Segments: **1208A**: Millers Creek Reservoir
Assessment Units (Stations): 1208A_01 (11679)

1238: Salt Fork of the Brazos River – From the confluence of the Double Mountain Fork Brazos River in Stonewall County to the most upstream crossing of SH 207 in Crosby County

Segment Area: 178 miles
Assessment Units (Stations): 1238_01 (12022), 1238_02 (13683), 1238_03 (None)

Unclassified Segment: **1238A**: Croton Creek
Assessment Units (Stations): 1238_01 (11553)

1239: White River – From the confluence of the Salt Fork Brazos River in Kent County to White River Dam in Crosby County.

Segment Length: 25 miles

Assessment Units (Stations): 1239_01 (None)

1240: White River Lake – From White River Dam in Crosby County up to the normal pool elevation of 2,369 feet (impounds White River).

Segment Area: 2,020 acres
Assessment Units (Stations): 1240_01 (12027, 16880, 16881)

Unclassified Segments: **1240A**: White River above White River Reservoir
Assessment Units (Stations): 1240A_01 (11552)

1241: Double Mountain Fork Brazos River – From the confluence with the Salt Fork Brazos River in Stonewall County to the confluence of the North Fork Double Mountain Fork Brazos River in Kent County.

Segment Area: 145 miles
Assessment Units (Stations): 1241_01 (12029), 1241_02 (None)

Unclassified Segment: **1241A**: North Fork Double Mountain Fork Brazos River
Assessment Units (Stations): 1241A_01 (11524, 11525, 11527), 1241A_02 (11534)

Watershed of the Salt and Double Mountain Forks of the Brazos River
FY12 Water Quality Monitoring and 2010 IR Status

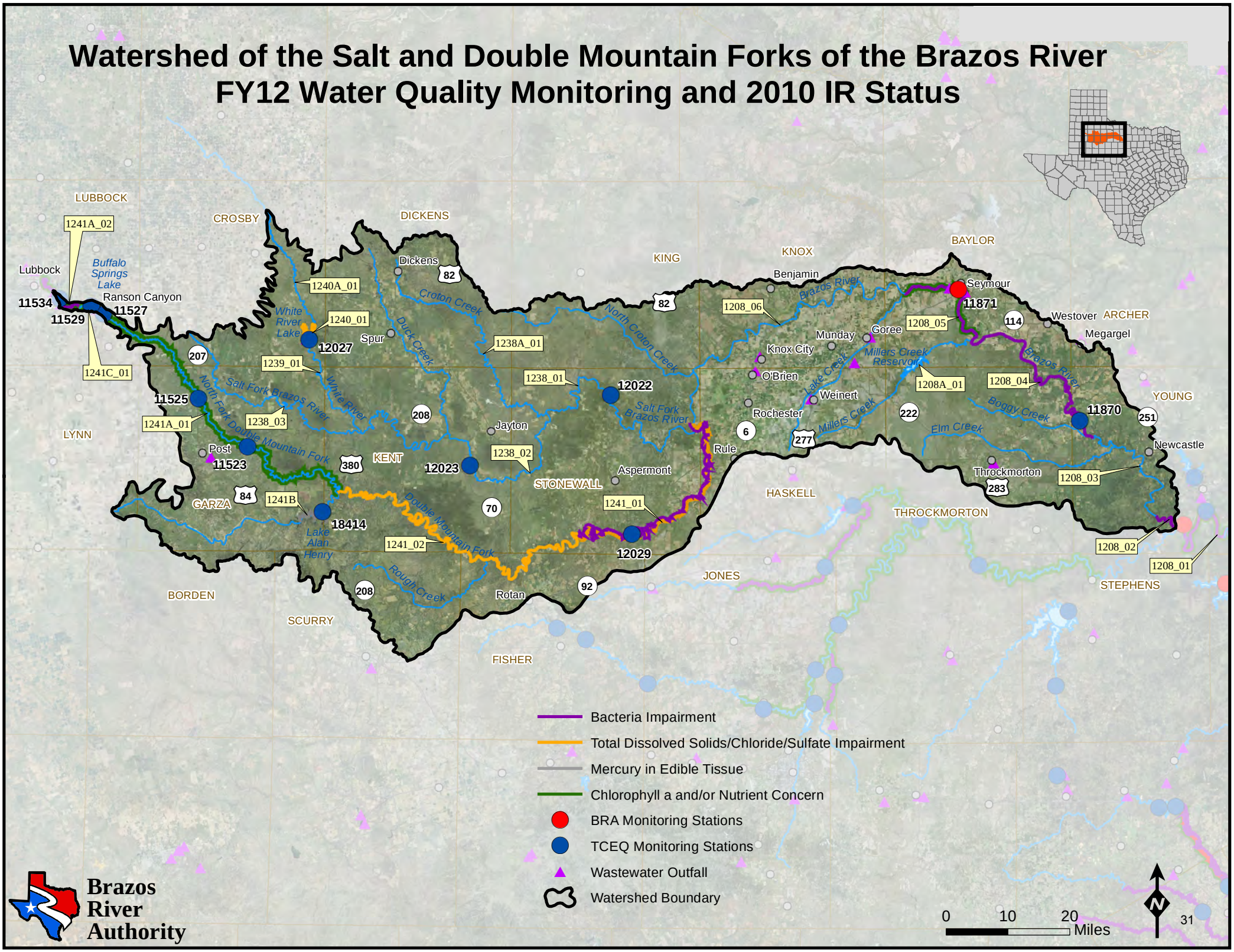


Table 3.3.1.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Salt Fork Double Mountain Fork Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1208	**Brazos River Above Possum Kingdom Lake**	**PCR**	**H**	**5,000**	**2,000**	**12,000**	**5.0/3.0**	**6.5-9.0↓**	**126**	**95**		**0.33↓**	**1.95**	**0.37↓**	**0.69↓**	**14.1**
1208A	Millers Creek Reservoir	PCR	H	5,000	2,000↑	12,000↑	5.0/3.0↓	6.5-9.0	126	95	15.65	0.11	0.37	0.05	0.20	
1238	**Salt Fork Brazos River**	**PCR**	**H**	**23000**	**4000↑**	**40000**	**5.0/3.0**	**6.5-9.0**	**35**	**93**		**0.33↓**	**1.95↓**	**0.37**	**0.69**	**14.1**
1238A	Croton Creek	PCR	H	23000	4000	40000	5.0/3.0	6.5-9.0	35	93		0.33	1.95	0.37	0.69	14.1
1239	**White River**	**PCR**	**H**	**100**	**100**	**500**	**5.0/3.0**	**6.5-9.0**	**126**	**92**		**0.33**	**1.95**	**0.37**	**0.69**	**14.1**
1240	**White River Lake**	**PCR**	**H**	**150↑**	**100↑**	**650↑**	**5.0/3.0**	**6.5-9.0**	**126↓**	**89**	**13.85**	**0.11↓**	**0.69**	**0.05↑**	**0.37**	
1240A	White River above White River Reservoir	PCR	H	190↑	90	780	5.0/3.0	6.5-9.0↓	126	89		0.33	1.95↑	0.37	0.69	14.1
1241	**Double Mountain Fork Brazos River**	**PCR**	**H**	**2630**	**2400**	**5500**	**5.0/3.0**	**6.5-9.0**	**126**	**95**		**0.33↓**	**1.95**	**0.37**	**0.69**	**14.1**
1241A	North Fork Double Mountain Fork Brazos River	PCR	L	2630	2400	5500	3.0/2.0	6.5-9.0	126	95		0.33	1.95↓	0.37	0.69	14.1
1241B	Lake Alan Henry	PCR	H	2630	2400	5500	5.0/3.0	6.5-9.0	126	95		0.11	0.69	0.05	0.37	26.7
1241C	Buffalo Springs Lake	PCR	H	2630	2400	5500	5.0/3.0	6.5-9.0	126↓	95		0.11	0.69↓	0.05	0.37	26.7

Salt Fork Double Mountain Fork Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1241D	South Fork Double Mountain Fork Brazos River upstream of confluence with North Fork Double Mountain Fork	PCR	H	2630	2400↓	5500	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or potion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Watershed of the Salt Fork and Double Mountain Forks of the Brazos River

The Watershed of the Salt and Double Mountain Forks of the Brazos River begins with the formation of the Double Mountain Fork of the Brazos River near Tahoka in Lynn County. The Salt Fork of the Brazos River is formed in southeastern Crosby County and flows approximately 175 miles before joining with the Double Mountain Fork in Stonewall County to form the main stem of the Brazos River. The Double Mountain Fork and Salt Fork both flow through rural areas with very little development. The land use is primarily agricultural and rangeland. The North Fork of the Double Mountain Fork does have limited perennial flow immediately below the City of Lubbock where several wastewater outfalls create a continuous flow of water. However, this wastewater driven flow typically does not reach the Double Mountain Fork due to high evaporative rates in this arid part of the state. Both the Double Mountain and Salt Forks are shallow streams that meander within the stream bed. Much of the watershed is underlain by geologic formations that are very high in salt content and contribute to the high levels of dissolved solids in the watershed and also contribute to high salinity in the main stem of the Brazos River.

Impairments in this watershed are primarily limited to dissolved solids in segments **1240** and **1241** (Figures 3.3.1.1 and 3.3.1.2), with the exception of an impairment for *E. coli* in segment **1241**. Concerns for elevated levels of bacteria and

Figure 3.3.1.1 **1240 Dissolved Solids**

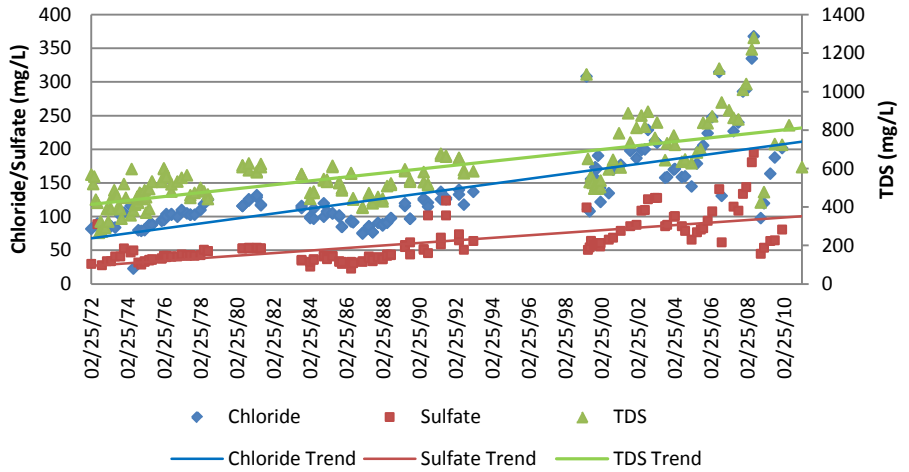
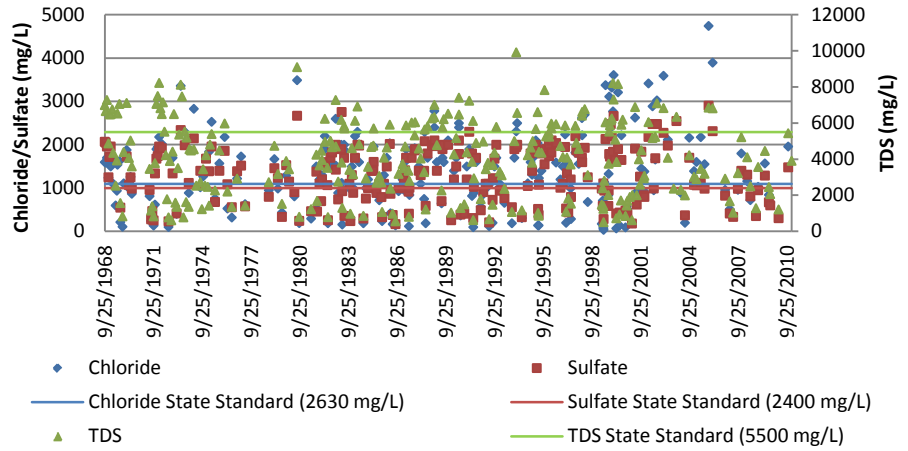


Figure 3.3.1.2 **1241 Chloride, Sulfate and TDS**



nutrient enrichment exist in the unclassified portions of segment **1241**. In addition, an impairment for mercury in edible fish tissue is in place for Lake Alan Henry (segment **1241B**). Water quality in the Salt Fork of the Brazos River, segment **1238**, supports all water quality standards. Dissolved solids are naturally high in this watershed because of the influence of the many brine springs. Although segment **1238** is not impaired for dissolved solids, there is an increasing trend in sulfate concentrations (Figure 3.3.1.3). Elevated levels of dissolved solids have resulted in impairments in both White River Lake (segment **1240**) and the Double Mountain Fork of the Brazos River (segment **1241**).

Figure 3.3.1.3 **1238 - Sulfate**

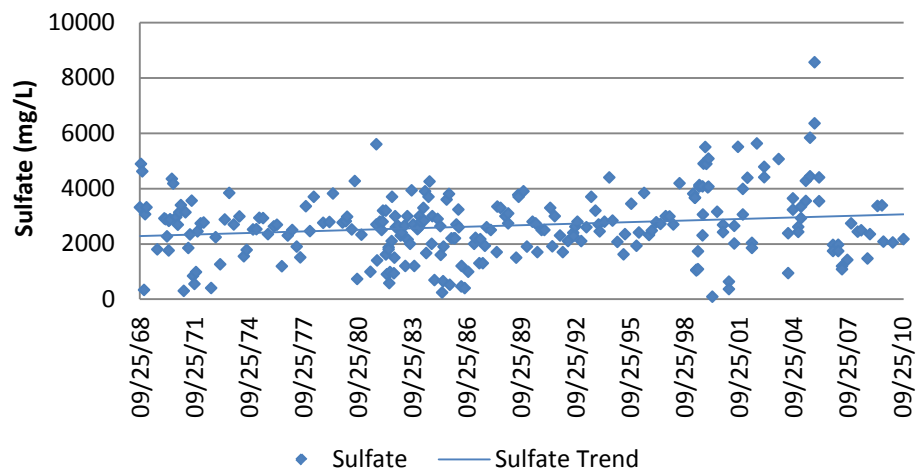
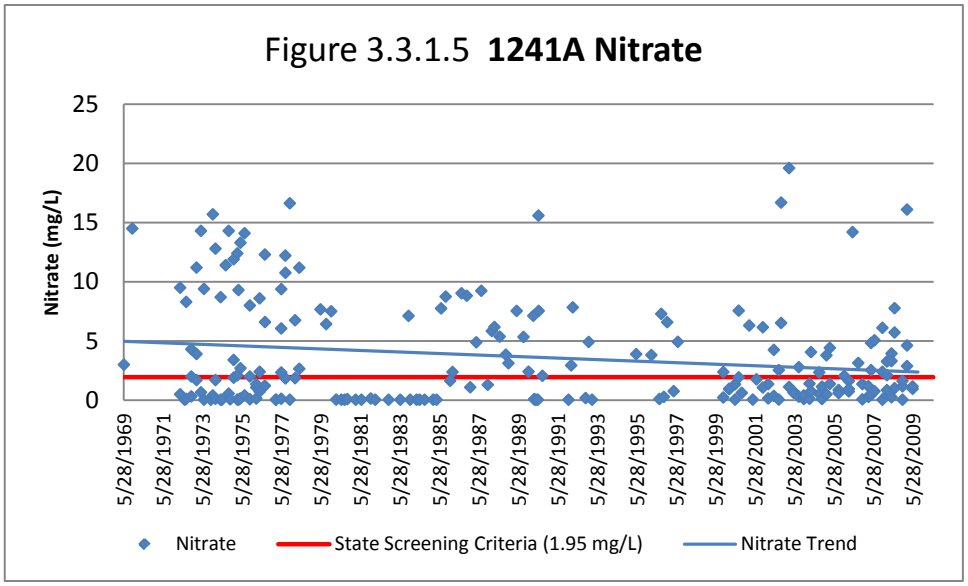


Figure 3.3.1.4 Station 12029 - DOUBLE MOUNTAIN FORK BRAZOS RIVER 91 METERS DOWNSTREAM OF US 83 SOUTH OF ASPERMONT.



The cyclical drought and flood pattern in Texas has quite an impact on the total dissolved solid concentration in this watershed as well as down the mainstem of the Brazos River. Drought conditions frequently affect most of the State of Texas; such was the case from 2005 through early 2007. Over this period, dissolved solids became even more concentrated than normal due to evaporation which reduced water levels while leaving dissolved solids in the remaining water. The drought broke in the spring of 2007 and rainfall continued through the summer. Flooding occurred in almost all parts of the Brazos River basin. These rainfall events had a diluting affect on chlorides. In just a few months time, the chloride levels in the mainstem went from the highest ever recorded to the lowest ever recorded. Chloride levels remain uncharacteristically low through the present, but are expected to gradually rise over the next few years with the return of drought conditions.

The North Fork Double Mountain Fork of the Brazos River (segment **1241A**) is impaired for *E. coli* and also has concerns for elevated levels of nutrients. Data collected at station 12029 (Figure 3.3.1.4) over the 7 year period of assessment demonstrates an impairment for elevated *E. coli* at station 12029. Additionally, while nutrient concentrations are a concern in this segment, nitrate data indicates a negative trend (Figure 3.1.1.5).

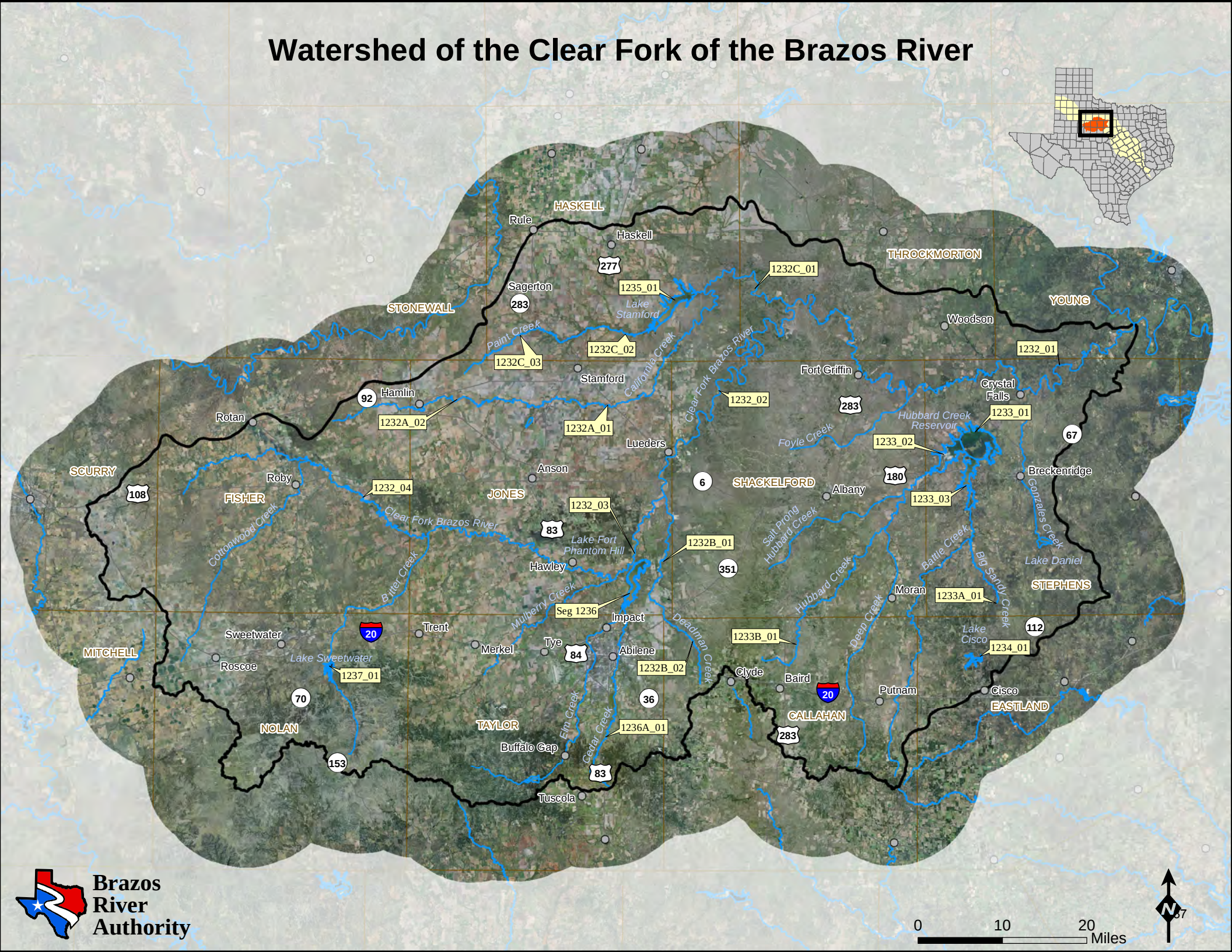
Special Studies:

An RUAA has been completed for **1208 – Brazos River Above Possum Kingdom Lake**.

Table 3.3.1.2 Water Quality Issues Summary

Water Quality Issue	Affected Area	Possible Influences/Concerns	Possible Actions Taken/to be Taken
Chloride/Sulfate/TDS	• Double Mountain Fork and White River Lake	• Natural geologic formations that are very high in salt content	• Standard revision to reflect the natural conditions • Place segment in 4c status
Bacteria	• North Double Mountain Fork • Brazos River Above Possum Kingdom Lake	• Likely nonpoint sources (NPS)	• A watershed evaluation is appropriate due to unknown NPS • an RUAA has been completed for segment 1208

Watershed of the Clear Fork of the Brazos River



Brazos River Authority

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3.3.2 Watershed of the Clear Fork of the Brazos River

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
5,728 mi^2	15	TCEQ	19	Cities of Abilene, Baird, Cisco, Merkel, Sweetwater, Albany, Breckenridge, Hamlin, Stamford, Haskell	1232, 1233, 1234, 1235, 1236, 1237

Description of Segments:

1232: Clear Fork of the Brazos River – From the confluence with the Brazos River in Young County to the most upstream crossing of US 180 in Fisher County.

Segment Length: 284 miles

Assessment Units (Stations): 1232_01 (11982), 1232_02 (11985, 11990, 11991, 18765, 18766), 1232_03 (11992), 1232_04 (11999, 12001)

*Unclassified Segment: **1232A**: California Creek, **1232B**: Deadman Creek, **1232C**: Paint Creek*

Assessment Units (Stations): 1232A_01 (11709), 1232B_01 (11695, 11696, 11697, 11698), 1232B_02 (11705), 1232C_01 (18764)

1233: Hubbard Creek Reservoir – From Hubbard Creek Dam in Stephens County up to the normal pool elevation of 1183 feet (impounds Hubbard Creek)

Segment Area: 15,250 acres

Assessment Units (Stations): 1233_01 (12002, 13888, 13889, 20537), 1233_02 (13881, 13883, 13885, 13886), 1233_03 (13879, 13880, 13882, 13884)

*Unclassified Segments: **1233A**: Big Sandy Creek, **1233B**: Hubbard Creek*

Assessment Units (Stations): 1233A_01 (13640), 1233B_01 (13639)

1234: Lake Cisco – From Williamson Dam in Eastland County up to the normal pool elevation of 1496 feet (impounds Sandy Creek).

Segment Area: 445 acres

Assessment Units (Stations): 1234_01 (12005, 18436, 18510)

1235: Lake Stamford – From Stamford Dam in Haskell County up to the normal pool elevation of 1416.8 feet (impounds Paint Creek).

Segment Area: 4,690 acres
Assessment Units (Stations): 1235_01 (12006)

1236: Fort Phantom Hill Reservoir – From Fort Phantom Hill Dam in Jones County up to the normal pool elevation of 1,636 feet (impounds Elm Creek).

Segment Area: 14,246 acres
Assessment Units (Stations): 1236_01 (12010, 12013, 20183)

1237: Lake Sweetwater – From Sweetwater Dam in Nolan County up to the normal pool elevation of 2,116.5 feet (impounds Bitter Creek).

Segment Area: 621 acres
Assessment Units (Stations): 1237_01 (None)

Watershed of the Clear Fork of the Brazos River
FY12 Water Quality Monitoring and 2010 IR Status

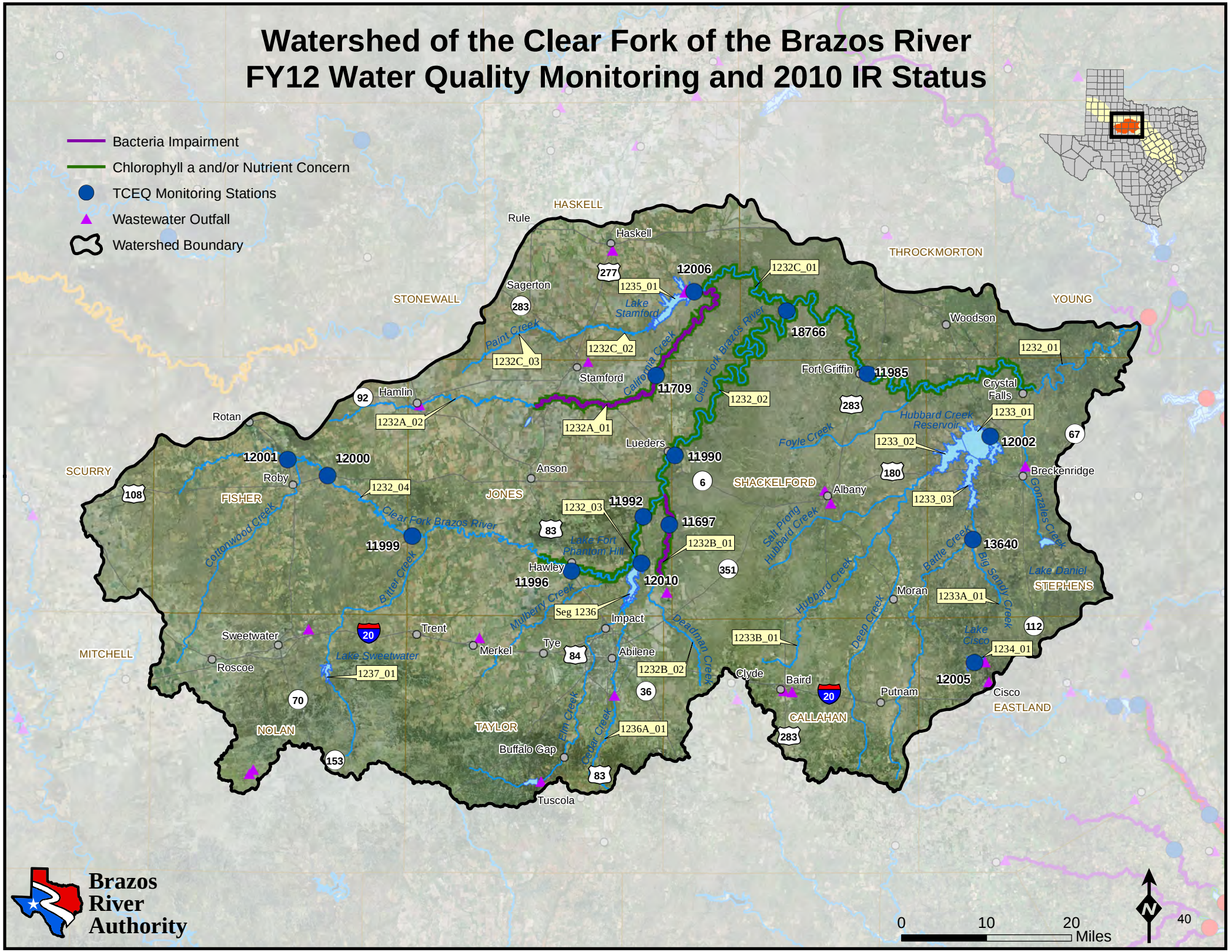


Table 3.3.2.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Clear Fork Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1232	**Clear Fork Brazos River**	**PCR**	**H**	**1250↓**	**2200↓**	**4900↓**	**5.0/3.0↓**	**6.5-9.0**	**126**	**93**		**0.33↓**	**1.95↑**	**0.37**	**0.69**	**14.1**
1232A	California Creek	PCR	H	1250	2200↓	4900↓	5.0/3.0	6.5-9.0	126	93		0.33↓	1.95↑	0.37↑	0.69	14.1↓
1232B	Deadman Creek	PCR	I	1250↓	2200↓	4900	5.0/3.0	6.5-9.0↑	126	93		0.33↓	1.95↑	0.37↓	0.69	14.1↓
1232C	Paint Creek	PCR	H	1250	2200	4900	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1233	**Hubbard Creek Reservoir**	**PCR**	**H**	**350**	**150↑**	**900**	**5.0/3.0**	**6.5-9.0**	**126↑**	**93**	**5.61↑**	**0.11↓**	**0.69**	**0.05↓**	**0.37**	
1233A	Big Sandy Creek	PCR	L	350↓	150↓	900	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1233B	Hubbard Creek	PCR	H	350↓	150	900	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1234	**Lake Cisco**	**PCR**	**H**	**75**	**75↓**	**350↓**	**5.0/3.0**	**6.5-9.0**	**126**	**93**	**5 .00↑**	**0.11↓**	**0.69**	**0.05↑**	**0.37↑**	
1235	**Lake Stamford**	**PCR**	**H**	**580↑**	**400**	**2100**	**5.0/3.0**	**6.5-9.0**	**126**	**93**	**16.85**	**0.11**	**0.69**	**0.05↑**	**0.37**	
1236	**Fort Phantom Hill Reservoir**	**PCR**	**H**	**130**	**150**	**550**	**5.0/3.0**	**6.5-9.0**	**126**	**93**		**0.11**	**0.69**	**0.05**	**0.37**	**26.7**
1237	**Lake Sweetwater**	**PCR**	**H**	**250**	**225**	**730**	**5.0/3.0**	**6.5-9.0**	**126**	**93**	**13.28**	**0.11**	**0.69**	**0.05**	**0.37**	

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Watershed of the Clear Fork of the Brazos River

The Clear Fork of the Brazos River begins in Fisher County and flows 284 miles east through Jones, Shackelford, Throckmorton, Stephens, and Young Counties, to its mouth on the Brazos River, near South Bend in southern Young County. The watershed drains approximately 5,728 square miles in the Central Great and Central Oklahoma/Texas plains, EPA Level III ecoregion. Land use is predominantly agricultural with Abilene representing the only urban area. There are five drinking water supply reservoirs within this watershed including Hubbard Creek Reservoir, Lake Cisco, Lake Stamford, Fort Phantom Hill Reservoir, and Lake Sweetwater.

All classified segments within the Clear Fork Watershed of the Brazos River meet water quality standards to support their designated uses. However, *E. coli* impairments are in place for two unclassified segments **1232A** and **1232B** (California and Deadman Creek) and nutrient concerns are present throughout segment **1232** (Figures 3.3.2.1 and 3.3.2.2)**.** Overall in segment **1232B**, there is an increasing trend in nitrate, however it should be noted that the first few years of monitoring resulted in low nitrate concentrations with increased concentrations beginning around 1985 and persisting until the late 1990s. Considering data only from the late 90's on, there is no statistical increasing trend. Because **1232B** is effluent dominated, it is reasonable to suggest that this is the result of a WWTP coming on line or changing processes in the mid 80's with improved operations and BMPs occurring from the late 90's to the present.

Figure 3.3.2.1 **1232 Nitrate**

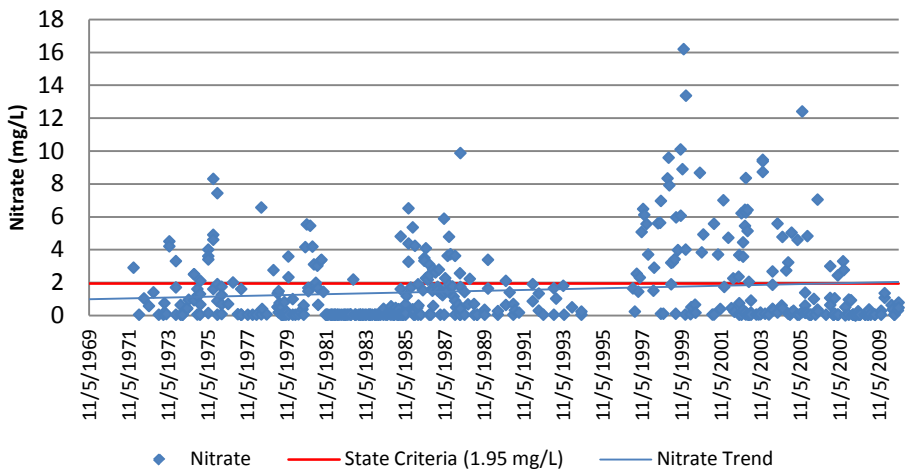
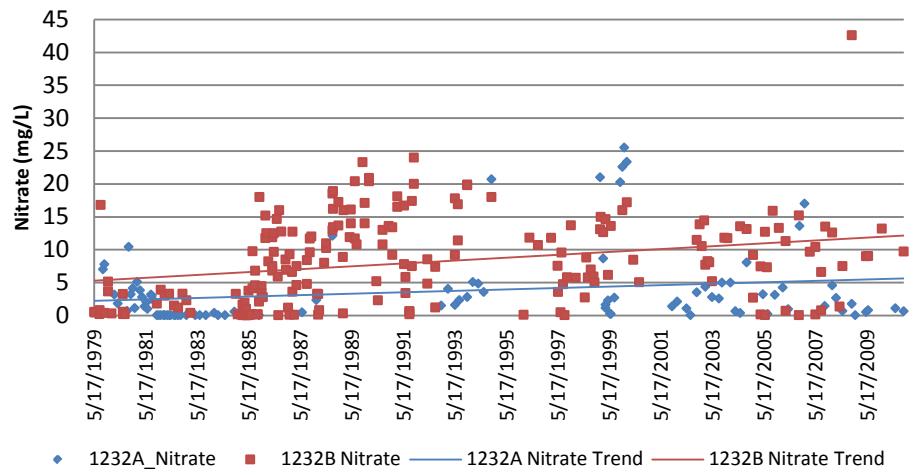


Figure 3.3.2.2 **1232A and 1232B Nitrate**



The 2010 Texas Integrated Report lists segment **1233A**, Big Sandy Creek, as a concern for near non-attainment for *E. coli*. Elevated levels of nutrients and bacteria in segment **1232A** (Figure 3.3.2.3) are likely attributed to nonpoint source pollution. Deadman Creek is an effluent dominated stream and municipal discharges are most likely the greatest contributor to the nutrient and bacteria loading in the stream. Other potential contributors in segment **1232B** (Figure 3.3.2.4) include agricultural runoff, urban runoff and wildlife.

Figure 3.3.2.3 Data collected at Station 11709 - CALIFORNIA CREEK AT FM 142 EAST OF STAMFORD is used to assess Segment 1232A_01.

Figure 3.3.2.4 Data collected at these four stations is used to assess Segment 1232B_01.

Special Studies:

Biological Assessments:

Segment 1232A, California Creek, an unclassified stream in the watershed of Clear Fork Brazos River Segment 1232, flows into Paint Creek just below Lake Stamford. The creek has not been assigned an aquatic life use (ALU) or dissolved oxygen (DO) criteria by TCEQ. Following TCEQ guidelines, a high ALU and 24-hour DO criteria of 5.0 mg/L (average)

and 3.0 mg/L (minimum) are presumed to apply, since flow is perennial. Biological assessments were performed at FM 142 east of Stamford, Station 11709, on June 29-30 and August 10-11, 2009. The purpose was to assess the current condition of aquatic life in the creek. Routine water quality monitoring data has suggested a degree of water quality degradation in recent years, and previous 305(b) assessments have identified concerns for nitrate and chlorophyll *a*.

In the initial event, during the non-critical portion of the index period, a datasonde was deployed and physical habitat and fish assessments were completed on June 29. Due to overnight rainfall and rising flow, the event had to be terminated on the morning of June 30. No water chemistry or benthic macroinvertebrate samples were collected, and no flow measurement was performed. The datasonde deployment period was 21 hours, versus the normal 24 hours, which necessitated calculation of a time-weighted DO average. Event results showed that DO concentrations achieved an exceptional ALU, while physical habitat and fish attained an intermediate ALU.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 6/29/09 physical habitat data, reflective of an intermediate ALU, were re-utilized. Dissolved oxygen concentrations achieved an exceptional ALU, while benthic macroinvertebrates and fish attained a limited ALU.

Regarding 305(b) assessment concerns, no nitrate data were obtained. The single chlorophyll *a* value generated, in August, did exceed TCEQ's screening level.

Biological components did not meet high ALU expectations during either event. Fish IBI scores were depressed due mainly to lack of benthic invertivore species, low prevalence of piscivorous species, and dominant numbers of red shiner *Cyprinella lutrensis*, a tolerant species. The low benthic IBI score was due mainly to low total number of taxa (11), and dominance by two relatively tolerant organisms, the caddisfly *Cheumatopsyche* and the riffle beetle *Stenelmis*.

A number of environmental factors may contribute to suppressed biological integrity. As reflected by the Habitat Quality Index, physical habitat is not particularly favorable, due mainly to steep, erodible stream banks and low channel sinuosity. Information from the present study, TCEQ's SWQMIS data base, and USGS historical flow reports shows that base flow is minimal, generally <0.2 cfs during dry weather. Physicochemical-related stresses may occur under those conditions, particularly during the summer. An example is that the maximum water temperature on 8/10/09 was 32.7 °C, near the criterion for Segment 1232 and potentially stressful to some aquatic species. Conductivity generally is fairly high and sometimes exceeds 8,000 µmhos/cm, a level that may exclude salt-sensitive taxa. Nutrient concentrations are often elevated, particularly nitrate which sometimes exceeds 7 mg/L. This promotes excessive primary production, as is

reflected by historical chlorophyll *a* levels exceeding 70 µg/L 64% of the time. At some point, exaggerated algal photosynthesis/respiration disrupts instream DO dynamics. A degree of disturbance was evident in fairly wide diel DO fluctuations during both 2009 events.

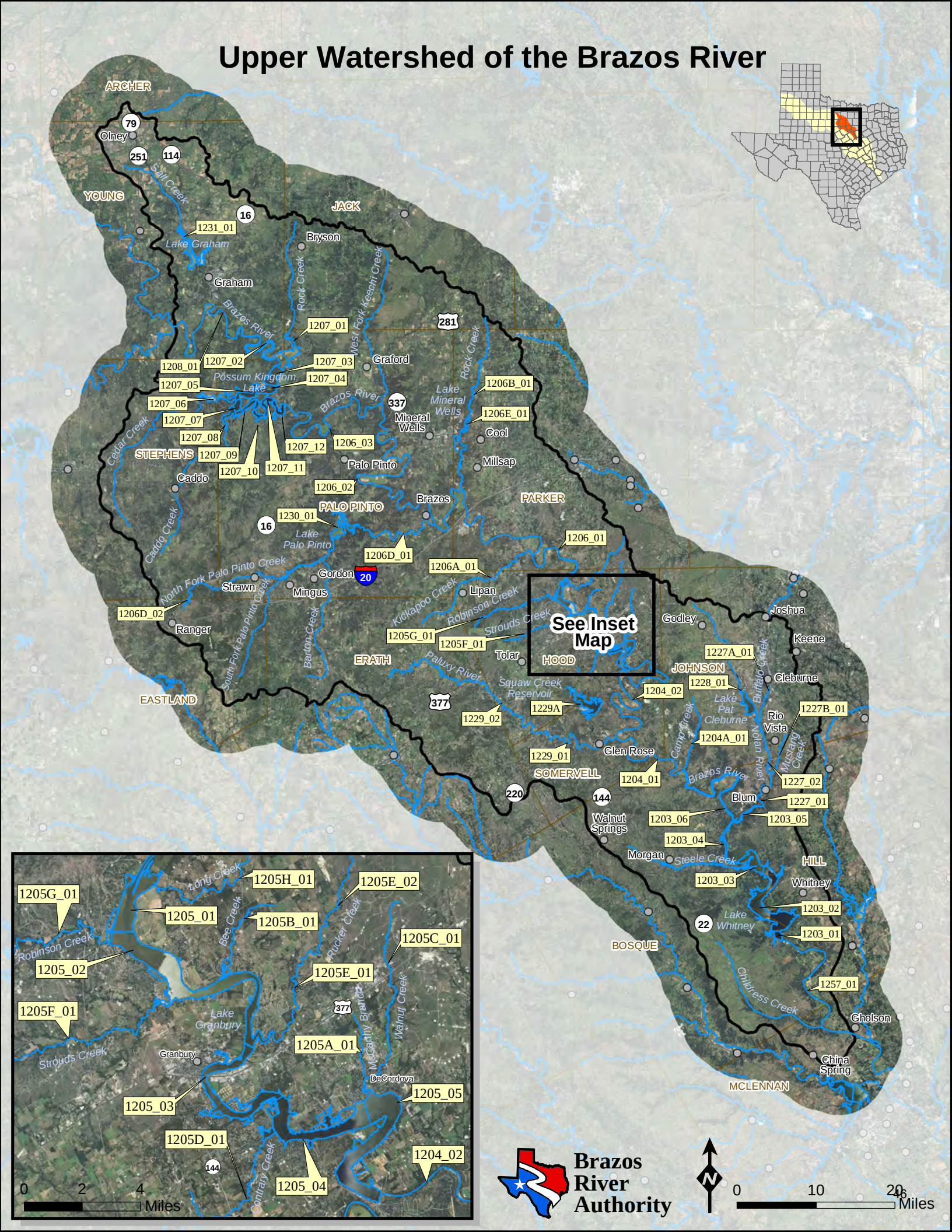
Other potentially detrimental hydrological influences include the fact that some species that might otherwise occur may be excluded by insufficient water volume during low flow. Maximum depth during the June event, when streamflow was 0.4 cfs, was only 0.76 m. Pool depths during flows <0.2 cfs, which regularly occur, may be insufficient to support some taxa such as larger species of fish. Similarly, limited depth of riffles and runs may exclude certain rheophilic species. Another consideration is that streamflow is flashy; during most years there are multiple rise events, with flow suddenly increasing from near zero to several thousand cfs when heavy rainfall occurs. This hydrological pattern is a product of the relatively arid climate together with the large drainage area (1,237 km^2). Such events undoubtedly produce severe scouring, and negatively affect aquatic life.

In conclusion, instream conditions are relatively harsh in California Creek, and a combination of stressful environmental factors limits biological integrity. Sensitive taxa are scarce, tolerant taxa predominate, and IBI scores are depressed. Natural factors appear to be primarily responsible. Anthropogenic influences may also be involved, but the significance is unknown.

Table 3.3.2.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria and Nutrient/Chlorophyll *a* concerns	• California Creek • Deadman Creek • California Creek (nutrients only)	• Municipal discharges • Nonpoint sources (NPS): agricultural runoff, urban runoff and wildlife	• Reevaluate permits • RUAA or standards review may be appropriate for NPS sources • More data collection • Watershed Review

Upper Watershed of the Brazos River



3.3.3 Upper Watershed of the Brazos River

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
4,725 mi^2	46	BRA, TCEQ	82	Cities of Whitney, Granbury, Morgan, Walnut Springs, Blum, Rio Vista, Glen Rose, Cleburne, Acton, Tolar, Godley, Ranger, Lipan, Cresson, Strawn, Mineral Wells, Graford, Graham, Olney; TXU Generation, Metroplex Quarries, Luminant Generation	1203, 1204, 1205, 1206, 1207, 1208, 1227, 1228, 1229, 1230, 1231, 1257

Description of Segments:

1203: Whitney Lake – From Whitney Dam in Bosque/Hill County to a point immediately upstream of the confluence of Camp Creek on the Brazos River Arm in Bosque/Johnson County and to a point immediately upstream of the confluence of Rock Creek on the Nolan River Arm in Hill County, up to the normal pool elevation of 533 feet (impounds Brazos River).

Segment Area: 23,560 acres

Assessment Units (Stations): 1203_01 (11851, 13987, 13988, 18443), 1203_02 (11855, 13989, 13990, 13992, 13993, 18788, 18789), 1203_03 (1399, 18654, 18790), 1203_04 (13994, 18791), 1203_05 (11854), 1203_06 (11853)

1204: Brazos Below Lake Granbury – From a point immediately upstream of the confluence of Camp Creek in Bosque/Johnson County to DeCordova Bend Dam in Hood County.

Segment Length: 52 miles

Assessment Units (Stations): 1204_01 (12029), 1204_02 (11856, 20213)

Unclassified Segments: **1204A**: Camp Creek

Assessment Units (Stations): 1204A_01 (17533)

1205: Lake Granbury – From DeCordova Bend Dam in Hood County to a point 100 meters upstream of FM 2580 in Parker County, up to normal pool elevation of 693 feet (impounds Brazos River).

Segment Area: 8,700 acres

Assessment Units (Stations): 1205_01 (20230), 1205_02 (11862, 20307), 1205_03 (11861), 1205_04 (None), 1205_05 (11860, 18740), 1205_SA1 (17930, 17931, 18004, 18005, 18851), 1205_SA2 (18006, 18007, 18008, 18009, 18010, 18011, 18012, 18013, 18014, 18015, 20221), 1205_SA3 (18017, 18018, 18019, 18020, 18021, 20214, 20219), 1205_SA4 (18022, 18023, 18024, 18025, 18026, 18027, 18028, 18029, 18030, 18031, 18032, 18033, 18034, 18035, 18036, 18037, 18038, 18039, 18040, 18739, 20215, 20216, 20217, 20223, 20224, 20225, 20226, 20231), 1205_SA5 (18041. 18042, 18043, 18044, 18045, 18738, 18741, 18742)

Unclassified Segments: **1205B**: Bee Creek

Assessment Units (Stations): 1205B_01 (18016)

1206: Brazos River Below Possum Kingdom Lake – From a point 100 meters upstream of FM 2580 in Parker County to Morris Sheppard Dam in Palo Pinto County.

Segment Length: 109 miles

Assessment Units (Stations): 1206_01 (13543, 18743, 18744, 18749), 1206_02 (11863, 18745, 18746), 1206_03 (11864, 13696, 18748)

Unclassified Segments: **1206D**: Palo Pinto Creek, **1206E**: Lake Mineral Wells

Assessment Units (Stations): 1206D_01 (11074, 16408, 18747), 1206E_01 (20160)

1207: Possum Kingdom Lake – From Morris Sheppard Dam in Palo Pinto County to a point immediately upstream of the confluence of Cove Creek at Salem Bend in Young County, up to the normal pool elevation of 1000 feet (impounds Brazos River).

Segment Area: 19,800 acres

Assessment Units (Stations): 1207_01 (14029), 1207_02 (11868), 1207_03 (14028), 1207_04 (14027), 1207_05 (11867), 1207_06 (14025), 1207_07 (None), 1207_08 (14019), 1207_09 (14020), 1207_10 (11866), 1207_11 (14023, 14024), 1207_12 (11865, 14022)

1208: Brazos River Above Possum Kingdom Lake – From a point immediately upstream of the confluence of Cove Creek at Salem Bend in Young County to the confluence of the Double Mountain Fork Brazos River and the Salt Fork Brazos River in Stonewall County.

Segment Length: 189 miles (for the entire segment, portions of which are in the Watershed of the Salt and Double Mountain Forks)

Assessment Units (Stations): 1208_01 (11869), 1208_02 (partial) (13641), 1208_03 (None), 1208_04 (11870), 1208_05 (11871), 1208_06 (None)

1227: Nolan River – From a point immediately upstream of the confluence of Rock Creek in Hill County to Cleburne Dam in Johnson County.

Segment Length: 16 miles

Assessment Units (Stations): 1227_01 (11966, 11967), 1227_02 (11968, 11970, 11971, 11972, 14450)

Unclassified Segments: **1227A**: Buffalo Creek

Assessment Units (Stations): 1227A_01 (11780)

1228: Lake Pat Cleburne – From Cleburne Dam in Johnson County up to the normal pool elevation of 733.5 feet (impounds Nolan River).

Segment Area: 1,500 acres

Assessment Units (Stations): 1228_01 (11974, 11975, 14447), 1228_02 (None)

1229: Paluxy River/North Paluxy River – From the confluence with the Brazos River in Somervell County to the confluence of Rough Creek in Erath County.

Segment Length: 57 miles

Assessment Units (Stations): 1229_01 (11976, 20232), 1229_02 (14481, 20343), 1229_03 (14245)

Unclassified Segments: **1229A**: Squaw Creek Reservoir

Assessment Units (Stations): 1229A_01 (17110)

1230: Lake Palo Pinto – From Palo Pinto Dam in Palo Pinto County up to the normal pool elevation of 867 feet (impounds Palo Pinto Creek).

Segment Area: 2,661 acres

Assessment Units (Stations): 1230_01 (11977)

1231: Lake Graham – From Graham Dam and Eddleman Dam in Young County up to the normal pool elevation of 1076.3 feet (impounds Salt Creek and Flint Creek).

Segment Area: 2,550 acres
Assessment Units (Stations): 1231_01 (11979)

1257: Brazos River Below Lake Whitney – From a point immediately upstream of the confluence of Aquilla Creek in McLennan County to Whitney Dam in Bosque/Hill County.

Segment Length: 27 miles
Assessment Units (Stations): 1257_01 (12044, 16782), 1257_02 (13642)

Upper Watershed of the Brazos River FY12 Water Quality Monitoring and 2010 IR Status

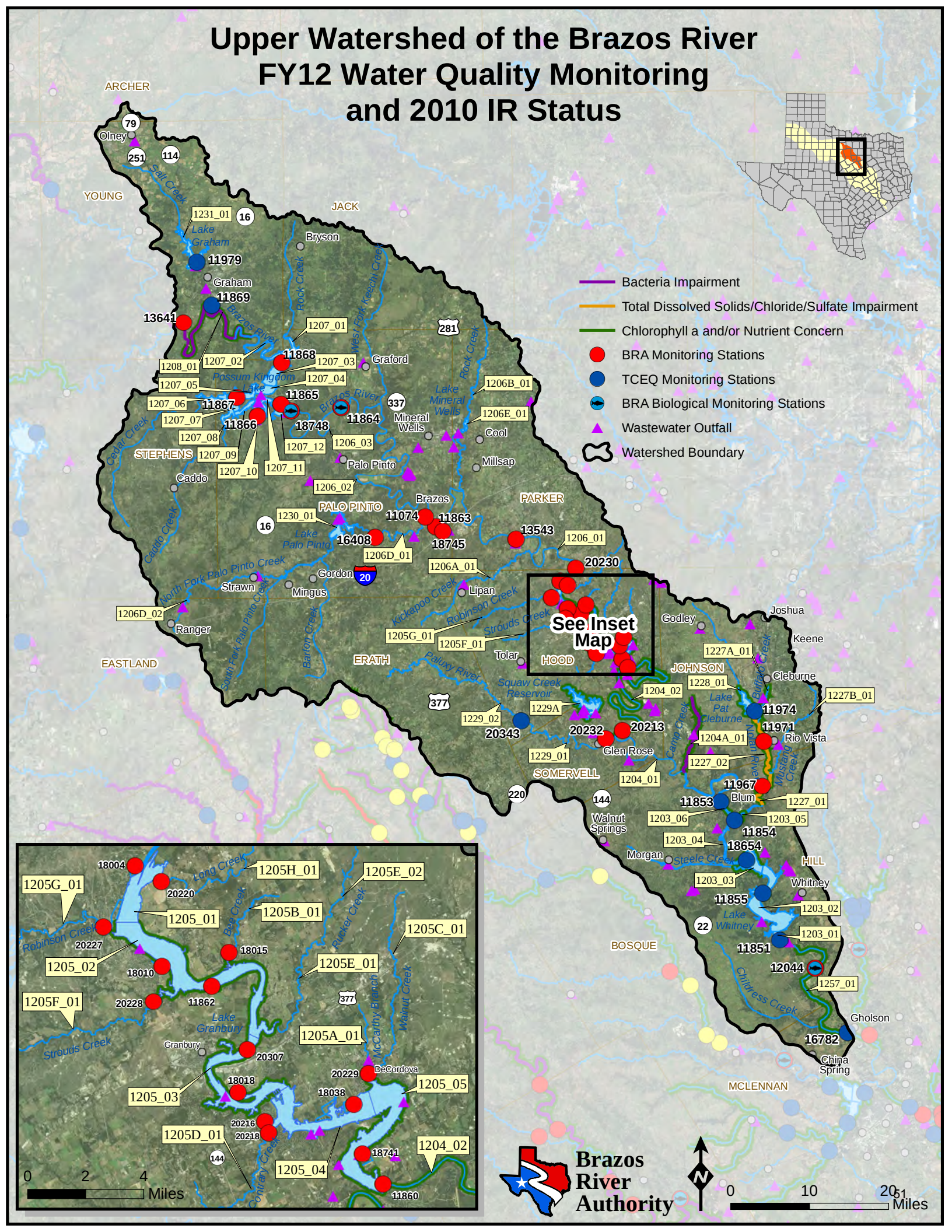


Table 3.3.3.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Upper Brazos Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1203	**Whitney Lake**	**PCR**	**H**	**670**	**320↓**	**1,500↓**	**5.0/3.0**	**6.5-9.0↑**	**126**	**93**	**18.34↑**	**0.11↑**	**0.37**	**0.05**	**0.20**	
1204	**Brazos Below Lake Granbury**	**PCR**	**H**	**750**	**380↓**	**1,600↓**	**5.0/3.0↑**	**6.5-9.0**	**126**	**91**		**0.33**	**1.95↑**	**0.37**	**0.69**	**14.1↑**
1204A	Camp Creek	PCR	L	750	380	1,600	3.0/2.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1205	**Lake Granbury**	**PCR**	**H**	**1,000**	**600↓**	**2,500**	**5.0/3.0**	**6.5-9.0**	**126↓**	**93**	**22.16↑**	**0.11↓**	**0.37**	**0.05**	**0.20**	
1205B	Bee Creek	PCR	L	1,000	600	2,500	3.0/2.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1206	**Brazos River Below Possum Kingdom Lake**	**PCR**	**H**	**1,036↑**	**595**	**2,325**	**5.0/3.0**	**6.5-9.0**	**126**	**90**		**0.33↓**	**1.95↓**	**0.37↓**	**0.69↓**	**14.1**
1206D	Palo Pinto Creek	PCR	H	1,036	595↓	2,325	5.0/3.0	6.5-9.0	126	90		0.33	1.95↓	0.37↓	0.69	14.1
1206E	Lake Mineral Wells	PCR	H	1,036	595	2,325	5.0/3.0	6.5-9.0	126	90		0.11	0.37	0.05	0.20	26.7
1207	**Possum Kingdom Lake**	**PCR**	**H**	**1,200↑**	**500↓**	**3,500↓**	**5.0/3.0**	**6.5-9.0↓**	**126↓**	**93**	**10.74↑**	**0.11**	**0.37↓**	**0.05↓**	**0.20↓**	
1208	**Brazos River Above Possum Kingdom Lake**	**PCR**	**H**	**5,000**	**2,000**	**12,000**	**5.0/3.0**	**6.5-9.0↓**	**126**	**95**		**0.33↓**	**1.95**	**0.37↓**	**0.69↓**	**14.1**
1227	**Nolan River**	**PCR**	**I**	**372↑**	**320↑**	**500↑**	**4.0/3.0↑**	**6.5-9.0↑**	**126**	**95**		**0.33↓**	**1.95↑**	**0.37↓**	**0.69↑**	**14.1**
1227A	Buffalo Creek	PCR	L	372	320	1,383	3.0/2.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1228	**Lake Pat Cleburne**	**PCR**	**H**	**100↑**	**100↑**	**300**	**5.0/3.0**	**6.5-9.0**	**126**	**93**	**19.04↑**	**0.11**	**0.37↓**	**0.05**	**0.20**	

Upper Brazos Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1229	**Paluxy River/North Paluxy River**	**PCR**	**H**	**50**	**100↓**	**500**	**5.0/3.0**	**6.5-9.0**	**126**	**91**		**0.33↓**	**1.95**	**0.37**	**0.69**	**14.1**
1229A	Squaw Creek Reservoir	PCR	H	50	100	500	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7
1230	**Lake Palo Pinto**	**PCR**	**H**	**100**	**100**	**450**	**5.0/3.0**	**6.5-9.0**	**126**	**93**		**0.11↓**	**0.37**	**0.05**	**0.20**	**26.7↑**
1231	**Lake Graham**	**PCR**	**H**	**200**	**75**	**500**	**5.0/3.0**	**6.5-9.0**	**126**	**95**	**6.07↑**	**0.11↓**	**0.37**	**0.05**	**0.20**	
1257	**Brazos River Below Lake Whitney**	**PCR**	**H**	**450**	**250↓**	**1,450**	**5.0/3.0**	**6.5-9.0**	**126↑**	**95**		**0.33↓**	**1.95**	**0.37**	**0.69↑**	**14.1↑**

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

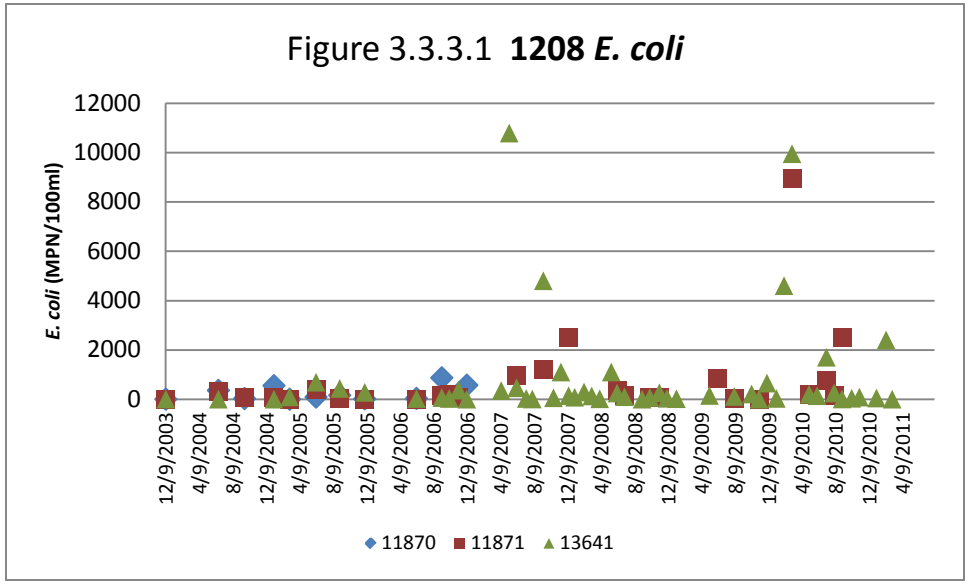
↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Upper Watershed of the Brazos River

The Upper Watershed of the Brazos River is one of the largest subbasins of the Brazos River, with the Brazos River stretching from Salt and Double Mountain Fork confluence to the impoundment at the Lake Whitney Dam. Some of the most scenic country along the Brazos River is found in the stretch of river downstream of Possum Kingdom Reservoir, where canoeing is a popular activity. The river remains wide with heavily vegetated banks that consist of elm, willow, oak, and juniper trees. The land use is largely agricultural with row-crop agriculture, rangeland and pasture land. Urban areas in close proximity to the river include the cities of Granbury, Mineral Wells and Glen Rose.

Impairments in the Upper Watershed of the Brazos River are limited to bacteria in the upper most portion of segment **1208** and chloride in segment **1227**. The Brazos River above Possum Kingdom is listed as having a concern for chlorophyll *a* in the portion of the segment upstream of Possum Kingdom to the confluence with Spring Creek. The nutrient sources causing the excessive algal growth are unknown. The most upstream portion of the segment in this watershed, AU 1208_01 and 1208_02 are listed as not supporting for bacteria. Elevated levels of bacteria are attributed to general nonpoint source pollution. Concerns for elevated levels of bacteria are present in segment **1208A** and depressed levels of oxygen in segments **1203** and **1208A** respectively. Concerns for elevated nutrient levels are present throughout the subbasin including concerns for non-attainment of the chlorophyll *a* standard in reservoir segments **1203**, **1205**, and **1228**. Nutrient concerns are evident in several stream segments and sub-segments including, segments **1204**, **1204A**, **1208**, **1227**, **1227A**, **1229A**, and **1257** (Table3.3.3.1).



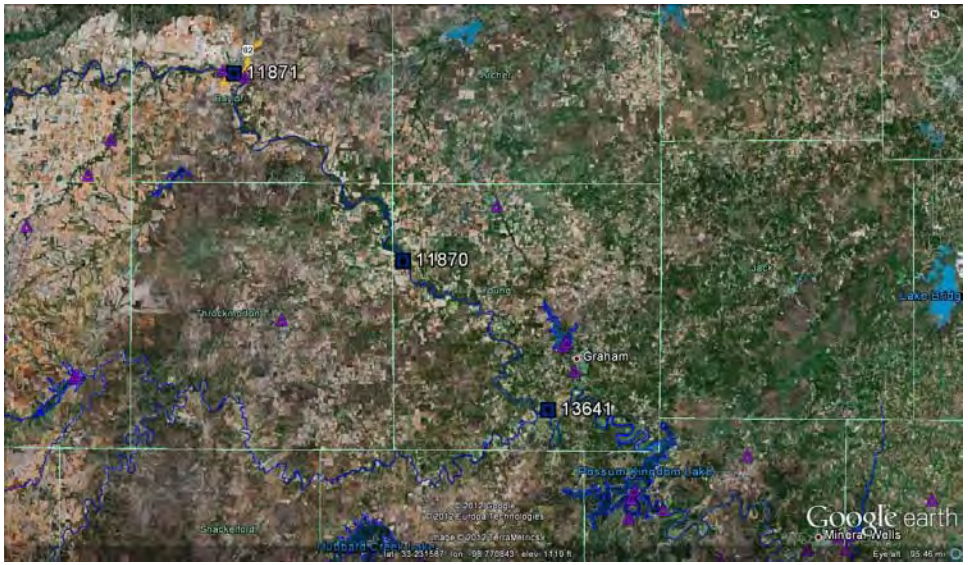
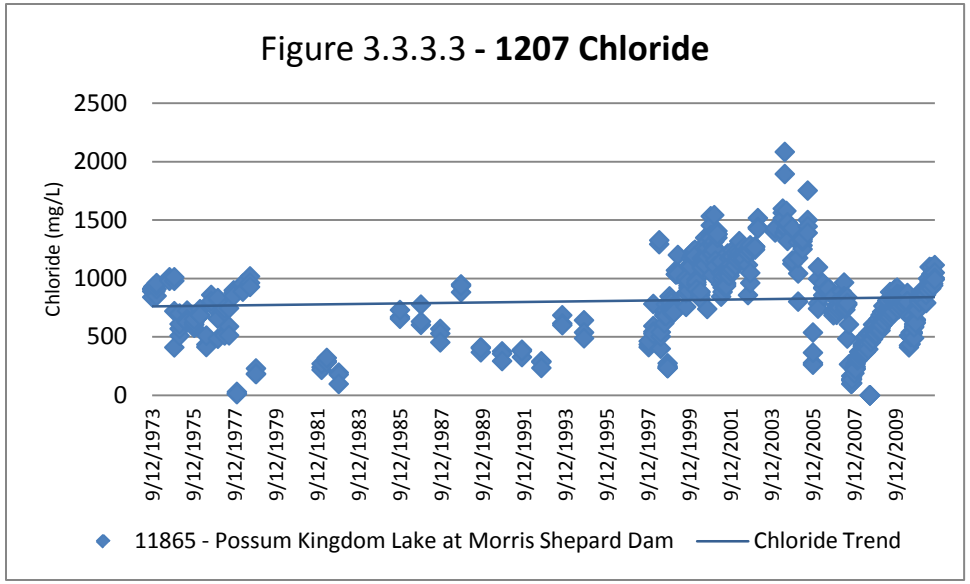
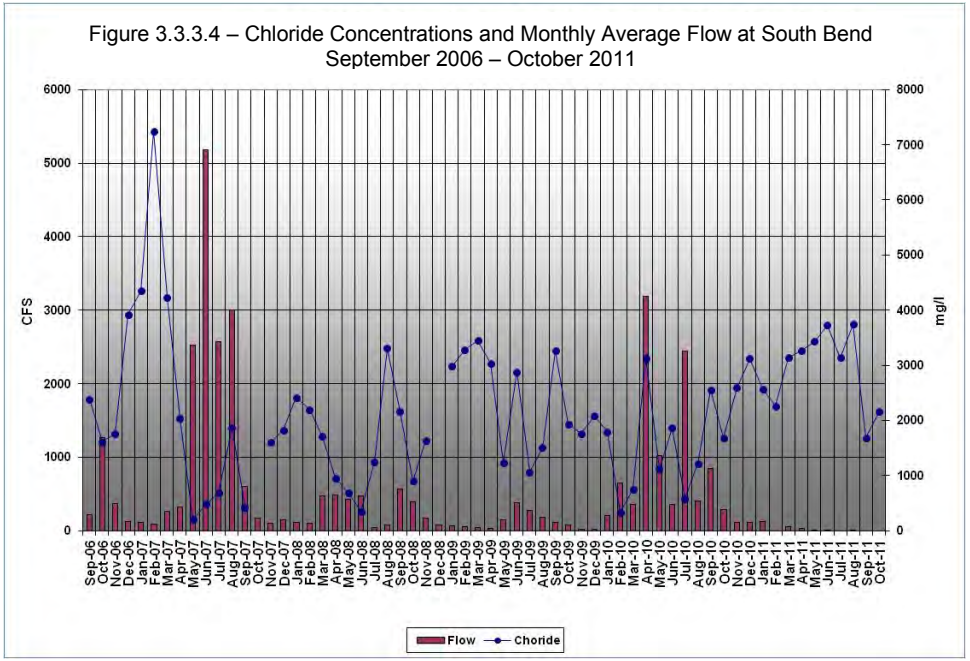


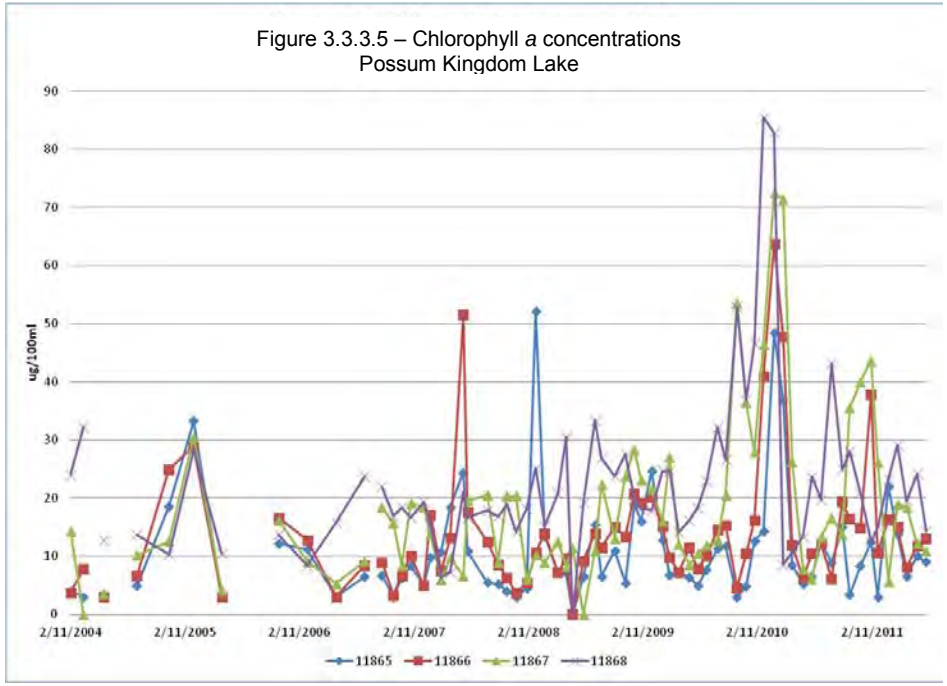
Figure 3.3.3.2 Data collected at Stations11871, 11870 and 13641 is used to assess Segment 1208.

Water quality data for segment **1208** indicates bacteria concerns at three monitoring locations (Figure 3.3.3.1 and Figure 3.3.3.2). *E. coli* data for stations 11870 and 13641 both show a geometric mean of 176 MPN/100ml. Analytical results for station 11871 indicate a concern for elevated *E. coli* with geometric means of 339 mpn/100ml.Possum Kingdom Lake (segment **1207**) is a large, scenic reservoir that is a source of drinking water and offers many recreational opportunities.

Historically, Possum Kingdom Lake was also utilized for hydroelectric generation, however, power generation ceased in 2007 and efforts are underway to permanently decommission the power generation facility. Segment **1207** is not listed as impaired; however, there continues to be an increasing trend in chloride levels throughout the reservoir (Figure 3.3.3.3). This is part of a larger pattern in the Upper Brazos Basin that shows a general rise in dissolved solid concentration. Naturally occurring salt-bearing geologic formations located in the Salt and Double Mountain Forks of the Brazos are the brine source responsible for the elevated levels of chloride and other dissolved solids found in the Upper Brazos River Basin and throughout the main stem of the Brazos River. Chloride levels often fluctuate and are largely influenced by flow. During extended dry periods, flows are low and chloride becomes concentrated. Conversely, periods of high flow often have a diluting effect on chloride concentrations (Figure 3.3.3.4)





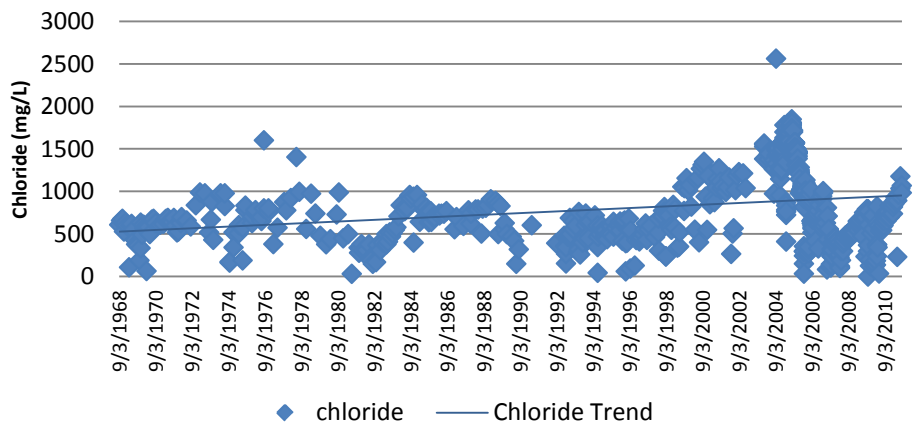


Chlorophyll *a* is not listed as an impairment or concern in the 2010 Texas Water Quality Inventory. However, it is evident that chlorophyll *a* concentrations are approaching or exceeding the state criterion of 10.74 *u*g/l for routine monitoring stations throughout Possum Kingdom Lake (Figure 3.3.3.5). The elevated levels of chlorophyll *a* may be attributed to wastewater outfalls and agricultural land use that affect the Brazos River before it enters the lake.

There are no impairments for the Brazos River below Possum Kingdom Lake (segment **1206**) however; concerns do exist for near non-attainment of macrobenthic communities and impaired habitat from degradation of riparian areas. The biological concerns documented in segment **1206** may be attributed in part to changes in the historical flow regime and from quarry operations in close proximity to the river. In addition, data continues to indicate an increasing trend in chloride concentrations throughout segment **1206** (Figure 3.3.3.6). It is difficult to ascertain the cause for the increased trend in chloride concentrations but it is likely a combination of increased periods of low flow conditions, increased water resource demands, and an increase in the number of waste water and industrial discharges, which are necessary to meet the needs of a growing population.

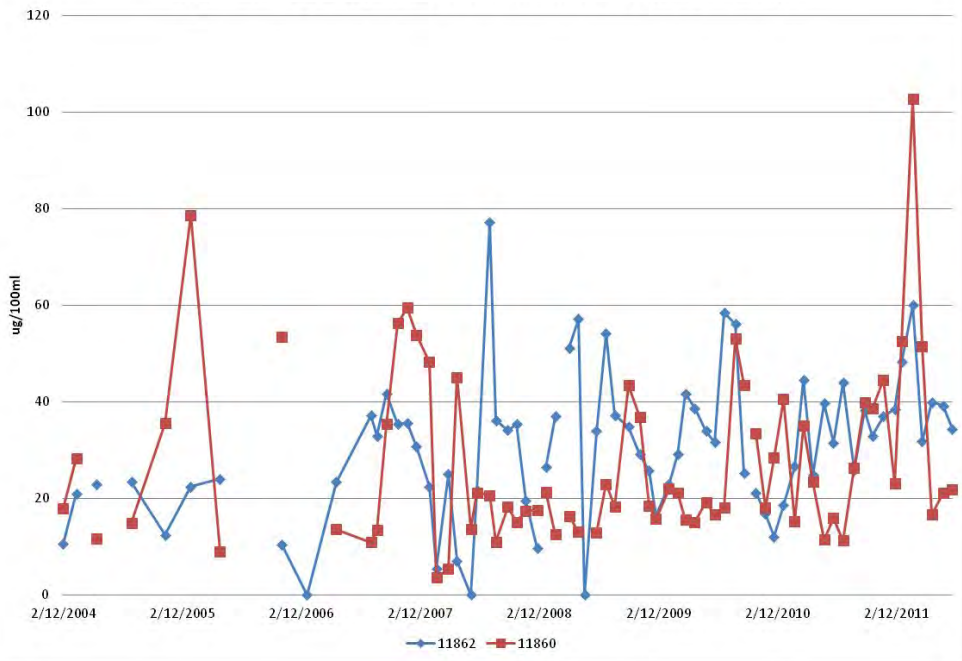
Lake Granbury (segment **1205**) is a popular central Texas reservoir that serves as an important source of water and provides recreational opportunities to surrounding communities. Lake Granbury has received much publicity from the toxic effects of golden algae on the fish community and from locally driven efforts to reduce bacteria levels documented in many of the lake's canals and coves. Lake Granbury is not impaired for any water quality parameter but concerns exist for increasing trends in chlorophyll *a* concentration. For the period of assessment, 37% of samples collected from station 11860 and 76% of samples collected from station 11862 were above the state chlorophyll *a* criterion of 22.16 *u*g/l for Lake Granbury (Figure 3.3.3.7). The increasing trend is likely the result of nutrient influx from upstream activities and infiltration from the many septic units that are present in the canals and coves.

Figure 3.3.3.6 - **1206 Historical chloride concentrations**



Long-term routinely monitored stations on the main body of the lake (stations 11860, 11861 and 11862) do not indicate elevated levels of bacteria. On the contrary, historical data indicates a decreasing trend in bacteria concentrations for the main body of the lake. However, elevated levels of bacteria have been documented in many of the man-made canals and coves in Lake Granbury and local concerns for the water quality in these areas eventually led to the development of the Lake Granbury Watershed Protection Plan (LGWPP). The LGWPP was a coordinated effort that included the cooperation of TCEQ, BRA, and local stakeholders on the identification and development of management measures to address the bacteria concerns. The LGWPP identified on-site sewage facilities as the primary source of bacterial contamination. In addition, the majority of the septic systems are located along the many canals and coves, where poor circulation creates stagnant conditions with little water exchange with the main body of the lake. The LGWPP was successfully completed in 2010 and implementation of selected management measures is currently ongoing (see Special Study Section).

Figure 3.3.3.7 – Chlorophyll *a* concentrations in Lake Granbury



The Nolan River, segment **1227**, is listed as impaired for chloride, sulfate, and TDS. The Nolan River is an effluent dominated stream. The contributing WWTP gets its source water from groundwater wells where the water contains a higher concentration of dissolved solids. Due to the naturally occurring nature of the increased solids concentrations, in 2010 a TDS standard change was proposed where the TDS standard would increase from 500 to 1383. If the change is accepted, data from the period of assessment will not demonstrate these impairments. The 2010 Integrated Report also lists segment **1227** as having concerns for nutrient enrichment. Station 11968 has a concern for elevated nutrients that are likely the result of a municipal point source discharge.

Segment **1204**, the Brazos River between Lake Granbury and Lake Whitney, is currently not listed as impaired but there is concern for elevated levels and increasing trends of chlorophyll *a* (Figure 3.3.3.8). The nutrient sources causing the excessive algal growth are unknown. In addition, elevated levels of *E. coli* in Camp Creek (segment **1204A**) are evident over the seven year period of assessment with a geometric mean of 142 MPN/100ml documented at station 17533.

Figure 3.3.3.8 - **1204 Chlorophyll *a***

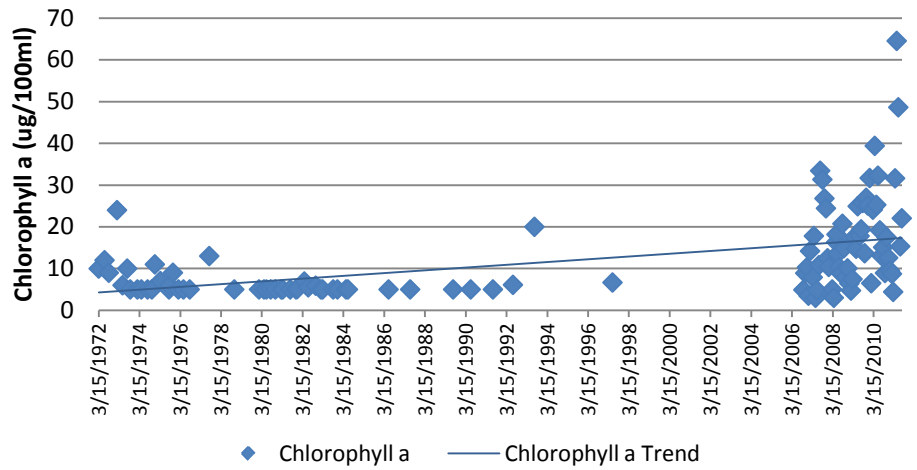
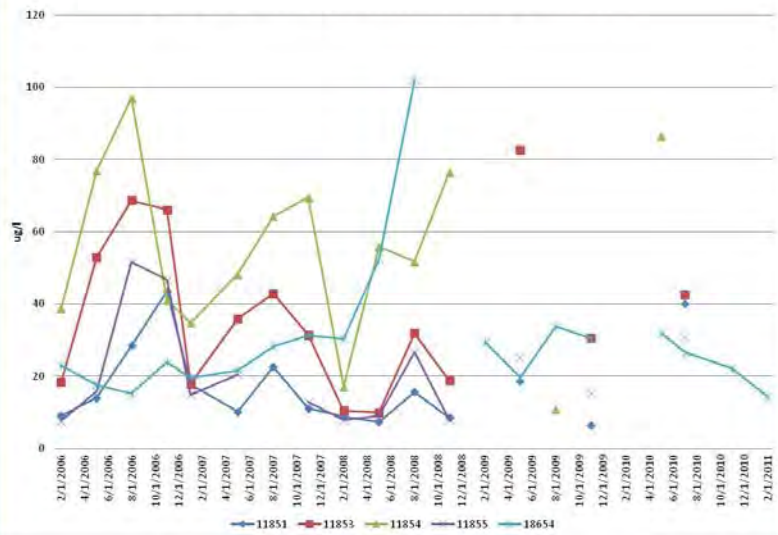


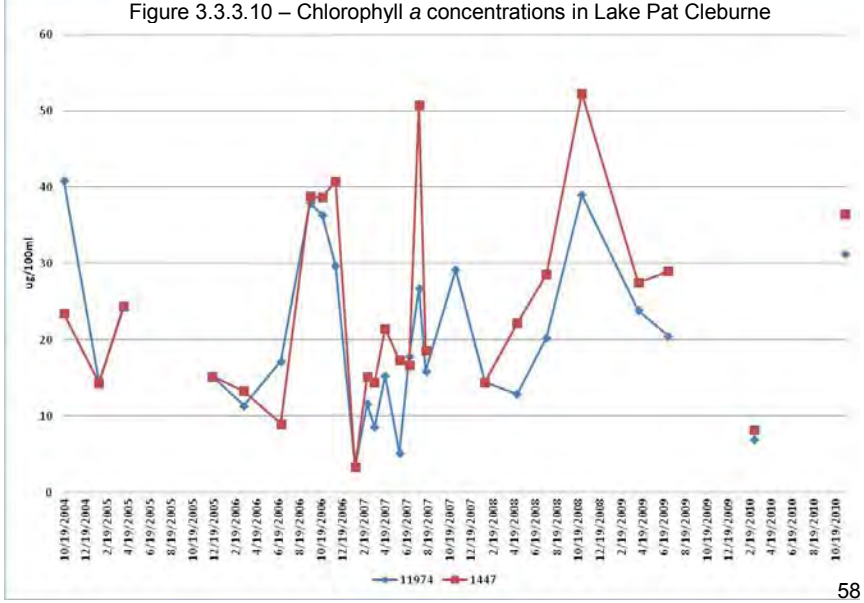
Figure 3.3.3.9 – Chlorophyll *a* concentrations in Lake Whitney



Lake Whitney, segment **1203**, is a large flood control reservoir that serves as an important source of recreation and hydropower. Although not impaired, Lake Whitney does have concerns for elevated levels of chlorophyll *a*, with a significant majority of data greater than the state criterion of 18.34 ug/100ml established for the reservoir (Figure 3.3.3.9). Nutrient inputs into Lake Whitney responsible for the elevated levels of chlorophyll *a* are attributed to nonpoint sources.

Lake Pat Cleburne, segment **1228**, is not impaired for any parameter but there is concern for elevated chlorophyll *a* concentrations over the state criterion of 19.04 (Figure 3.3.3.10).

Figure 3.3.3.10 – Chlorophyll *a* concentrations in Lake Pat Cleburne



The cause the elevated concentrations are unknown. It may be due to the shallow nature of the reservoir. There are no impairments or concerns of note in segments **1257**, **1229**, **1230** or **1231**.

Special Studies:

Additional information about the completed Lake Granbury Watershed Protection Plan and the ongoing implementation project may be found at http://www.brazos.org/gbWPP.asp and http://lakegranburywatershed.org/.

An RUAA has been completed for segment **1208**.

Biological Assessments:

Segment **1204**, the Brazos River below Lake Granbury, has a designated high aquatic life use, and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). Biological assessments were conducted at FM 200 northeast of Glen Rose, Station 20213, on 5/19-20/08 and 8/21-22/08. The objective was to evaluate the current condition of aquatic life in the river, primarily in response to public concern over possible decline of the fishery, and secondarily for routine monitoring purposes. Episodic fish kills resulting from golden algae blooms have been documented in the reach since 2000.

In the initial event, during the non-critical portion of the index period, dissolved oxygen concentrations achieved an exceptional aquatic life use, fish a high aquatic life use, and physical habitat and benthic macroinvertebrates an intermediate aquatic life use.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 5/19/08 physical habitat data, which reflected achievement of an intermediate aquatic life use, were re-utilized. Dissolved oxygen concentrations achieved an exceptional aquatic life use, and fish and benthic macroinvertebrates a high aquatic life use.

Failure of physical habitat to attain a high rating was a product of limited instream cover, relatively steep banks, low channel sinuosity, and an unstable substrate due to predominance of sand. Despite less-than-optimal habitat conditions, the fish community was healthy and achieved the designated high aquatic life use during both events. Game fish species were fairly well represented (first event: 33 largemouth bass up to 20.5 inches in length, two channel catfish up to 15.5

inches in length, and one flathead catfish 4 inches in length; second event: 15 largemouth bass up to 19 inches in length, one white bass 9.5 inches in length, and one channel catfish).

The condition of the fish community indicated favorable water quality conditions during the study period. It also reflected a lack of known adverse effects by golden algae during the winter of 2007-2008 (see "Golden Alga Bloom Expanded Status Reports " – http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/ga/status2.phtml#brazos), which appeared related to dilution of the system by high rainfall during the spring and summer of 2007. Golden algae-induced fish kills are known to have occurred in the vicinity in the winters of 2000-2001, 2004-2005 (particularly severe), and 2005-2006 (Joan Glass, Texas Parks and Wildlife Department, personal communication). Whereas episodic impacts on the fishery have occurred since 2000, a recovery period of at least a year preceded the 2008 assessment events, which partially accounts for the healthy situation that was observed. Future impacts are possible, particularly during dry years when dissolved solids build up in the system and conditions become favorable for golden algae blooms and toxin production.

There were no obvious water quality factors during the 5/19-20/08 event which would account for aquatic life use nonattainment by benthic macroinvertebrates. Indications are that physical habitat limitations and hydrological characteristics may have been primarily responsible. Environmental attributes which create relatively harsh instream conditions for aquatic invertebrates include predominance of a shifting sand substrate not conducive for invertebrate colonization, and frequent, attenuated flow fluctuations resulting from upstream reservoir operations. Biological observations were relatively similar to conditions previously documented for three upstream Brazos River sites, in Segment 1206 below Possum Kingdom Reservoir, where fish communities generally scored high, but benthic macroinvertebrates and physical habitat intermediate. Thus, conditions in Segment **1204**, as represented by the reach near Glen Rose, appear typical for the middle portion of the Brazos River.

Segment **1206**, the Brazos River below Possum Kingdom Lake has a designated high aquatic life use (ALU), and 24-hour dissolved oxygen (DO) criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). Aquatic life monitoring was conducted at SH 16 near Graford, Station 18748, in a reach where little biological information exists. Site inclusion is part of a long-term effort by BRA to characterize ecological conditions throughout the Brazos River mainstem. The 2010 305(b) assessment identified concerns for impaired habitat and macrobenthic assemblages further downstream. The main objectives of the present effort were to determine if similar concerns exist in the upper end of the segment, and to evaluate the condition of the fish assemblage in light of episodic fish kills that have occurred since 2000 as a result of golden algae blooms.

A biological assessment was conducted April 6-7, 2011 during the non-critical portion of the index period. Streamflow was 119 cfs. DO concentrations achieved an exceptional ALU, physical habitat and fish a high ALU, and benthic macroinvertebrates a limited ALU. Except for the macrobenthic component, the findings reflected favorable environmental conditions. The depressed macrobenthic rating was a product of very low taxa richness (10), and dominance by relatively tolerant taxa, primarily Chironomidae and *Cheumatopsyche*. Physical habitat and most water quality characteristics were very suitable, but salinity was elevated and appeared to be the main factor suppressing macrobenthic integrity. National chloride criteria for protection of freshwater life are 230 mg/L (chronic) and 860 mg/L (acute) (USEPA 1988). The New Hampshire Department of Environmental Services, in adopting that acute toxicity criterion, derived a specific conductance equivalent of 2,755 µS/cm (NHDES 2011). Chloride (905 mg/L) and mean specific conductance (3,732 µS/cm) exceeded those levels at SH 16, so exclusion of sensitive macrobenthic taxa was not surprising.

Elevated salinity, which typifies this portion of the river, is a product of natural salt-bearing formations in the Salt Fork and Double Mountain Fork watersheds (BRA 2011). Water quality and biological conditions observed at SH 16 would be expected to extend longitudinally, until tributary inflows dilute salinity to less stressful levels. Macrobenthic integrity probably increases incrementally over a downstream gradient as dilution progresses, with the geographical extent of impairment varying according to extant water quality conditions. In 2005-06, salinities were elevated and macrobenthic integrity was suppressed at three sites in the vicinity of US 281, some 114 km downstream, indicating that adverse effects normally extend at least that far downstream. Excessive dissolved solids undoubtedly were a stress-inducing factor at those sites, although cause-and-effect relationships were somewhat clouded by less-than-optimal physical habitat characteristics. Water quality data from two sites further downstream indicate that elevated chloride concentrations typically persist through the entire segment. At Dennis (13543), 94% of the 139 determinations have exceeded the national chronic criterion, and 40% the national acute criterion. At a Lake Granbury headwater site (20230), 94% of the 62 determinations have exceeded the national chronic criterion, and 6.5% the national acute criterion. Macrobenthic assemblages probably are inhibited through the entire segment most of the time due to natural salinity limitations, but aquatic life monitoring data are needed from the lower 60 km to answer that question. If the segment ultimately proves to be inherently incapable of supporting a high ALU based on macrobenthic integrity, there would be water quality standards implications.

In comparing SH 16 attributes to aforementioned 305(b) concerns for other portions of the segment, benthic macroinvertebrates were impaired, but habitat wasn't. Historical failure of habitat to attain a high ALU in downstream reaches has been a product of little instream cover; few riffles; predominantly sand substrate; steep, erodible banks; and

low channel sinuosity. Physical habitat at SH 16 is much more suitable, because of greater instream cover, prevalence of riffles, and substrate stability due to predominance of gravel and cobble.

Fish assemblage integrity was greater than macrobenthic integrity, a pattern previously observed at the three sites near US 281. This relationship was not surprising given that invertebrates generally are more sensitive than vertebrates to chloride (USEPA 1988). Regarding the final objective, fish assemblage attributes indicated lack of significant effects by golden algae during months leading up to the event. A review of TPWD's golden algae status webpage supports that conclusion, in that no fish kills were reported in the reach during 2011.
http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/ga/status2.phtml#brazos

Plans to conduct a second aquatic life monitoring event in September, during the 2011 critical period, were unsuccessful due to atypical hydrological conditions resulting from extended high-volume releases from Possum Kingdom Lake. High flow persisted well into October, past the end of the critical period. The site has been included on BRA's 2012 monitoring schedule for a one-time assessment during the critical period, to supplement the 2011 dataset. The condition of the macrobenthic assemblage will be of particular interest, to determine if initial indications were characteristic.

Segment **1257**, the Brazos River below Lake Whitney has a designated high aquatic life use (ALU), and 24-hour dissolved oxygen (DO) criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). Biological assessments were conducted at FM 2114 southeast of Laguna Park, Station 12044, on March 25-26 and August 3-4, 2009. The main objective was to generate baseline data, as little biological information exists for the segment. A secondary purpose was to evaluate the condition of the fish assemblage, in light of episodic fish kills that have occurred since 2000 as a result of golden algae blooms.

In the initial event, during the non-critical portion of the index period, DO concentrations achieved an exceptional ALU, and physical habitat, benthic macroinvertebrates, and fish a high ALU.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 3/25/09 physical habitat data, which reflected achievement of a high ALU, were re-utilized. DO concentrations attained an exceptional ALU based on the 24-hr. mean, but a limited ALU based on the 24-hr. minimum. Benthic macroinvertebrates and fish attained a high ALU.

The depressed DO minimum (2.8 mg/L) in August resulted from nocturnal respiration by an extremely dense growth of *Najas*, fostered by non-limiting nutrient concentrations and high water clarity resulting from the effects of Whitney Dam.

The findings provided further evidence that where rocky-bottomed riffles or runs occur in the middle Brazos, the benthic macroinvertebrate assemblage generally attains a high ALU. A reduced macrobenthic ALU rating typically occurs in middle Brazos reaches predominated by sand substrates. The condition of the fish assemblage at FM 2114 reflected favorable instream conditions and a lack of known adverse effects by golden algae since 2006 (http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/ga/status2.phtml#brazos).

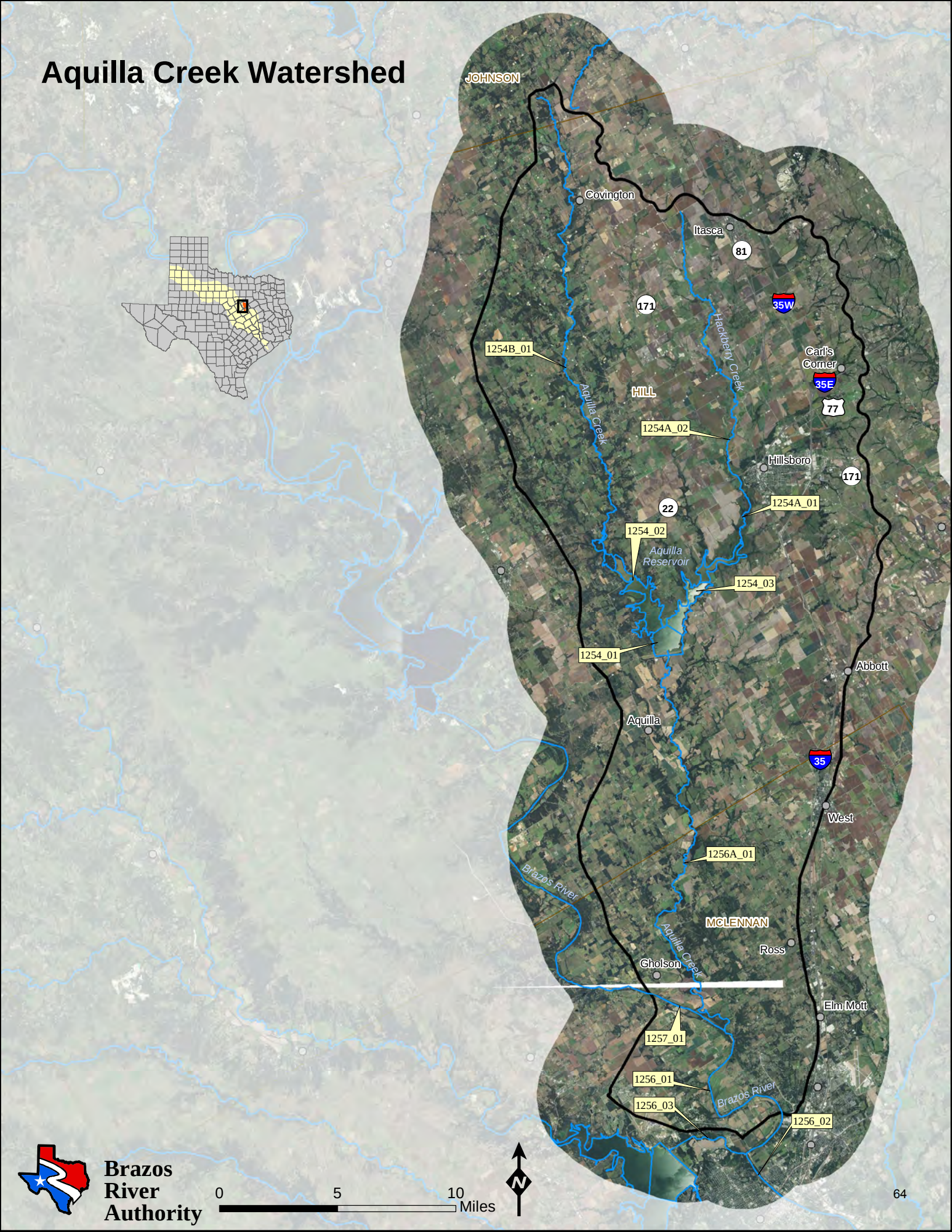
In conclusion, high ALU expectations were met by physical habitat and biological components. Depressed nocturnal DO concentrations during August did not exert noticeable impacts on biological integrity, and overall results indicated healthy environmental conditions.

Three stations in the Upper Watershed of the Brazos River, 11864 - Brazos River at FM 4 north of Palo Pinto, 13543 - Brazos River immediately upstream of FM 1189 south of Dennis, and 20213 - Brazos River at FM 200 northeast of Glen Rose are undergoing an in-stream flow study in support of the BRA's proposed systems operation permit. Extensive habitat and biological data collection efforts will occur at various flow regimes to better assess the impact that varying water levels have on aquatic communities.

Table 3.3.3.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria	• Brazos River Above Possum Kingdom Lake	• Likely nonpoint sources (NPS)	• A watershed evaluation is appropriate due to unknown NPS • an RUAA has been completed for segment 1208
TDS/Chloride/Sulfate	• Nolan River	• Municipal point source	• A standard update was proposed in 2010 and if accepted the segment will no longer be impaired.
Nutrient /Chlorophyll *a* concerns	• Throughout the watershed	• Municipal point source; Unknown Nonpoint source	• Reevaluate permits • Watershed evaluation due to unknown NPS

Aquilla Creek Watershed



3.3.4 Aquilla Creek Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
466 mi^2	6	BRA, TCEQ	3	Cities of Hillsboro, Itasca, Covington	1254, 1256

Description of Segments:

1254: Aquilla Reservoir - From Aquilla Dam in Hill County up to the normal pool elevation of 537.5 feet (impounds Aquilla Creek)

Segment Area: 3,935 acres

Assessment Units (Stations): 1254_01 (12127, 13821, 13824), 1254_02 (12128, 13827), 1254_03 (12129, 13825, 17321), 1254_SA1 (None), 1254_SA2, (13828, 18461, 18462, 18463, 18464), 1254_SA3 (13826, 18466, 18467, 18468)

Unclassified Segment: **1254A:** Hackberry Creek 20 miles

Assessment Units (Stations): 1254A_01 (13654), 1254A_02 (None)

Unclassified Segment: **1254B:** Aquilla Creek upstream of Aquilla Reservoir 28.1 miles

Assessment Units (Stations): 1254B_01 (13643)

1256: Brazos River/Lake Brazos - From the low water dam forming Lake Brazos in McLennan County to a point immediately upstream of the confluence of Aquilla Creek in McLennan County (includes the Bosque River Arm to the Waco Lake Dam)

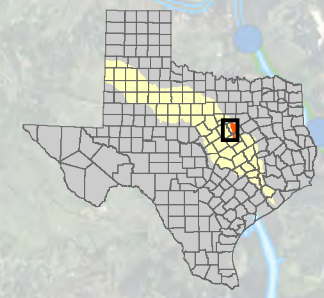
Segment Length: 43 miles

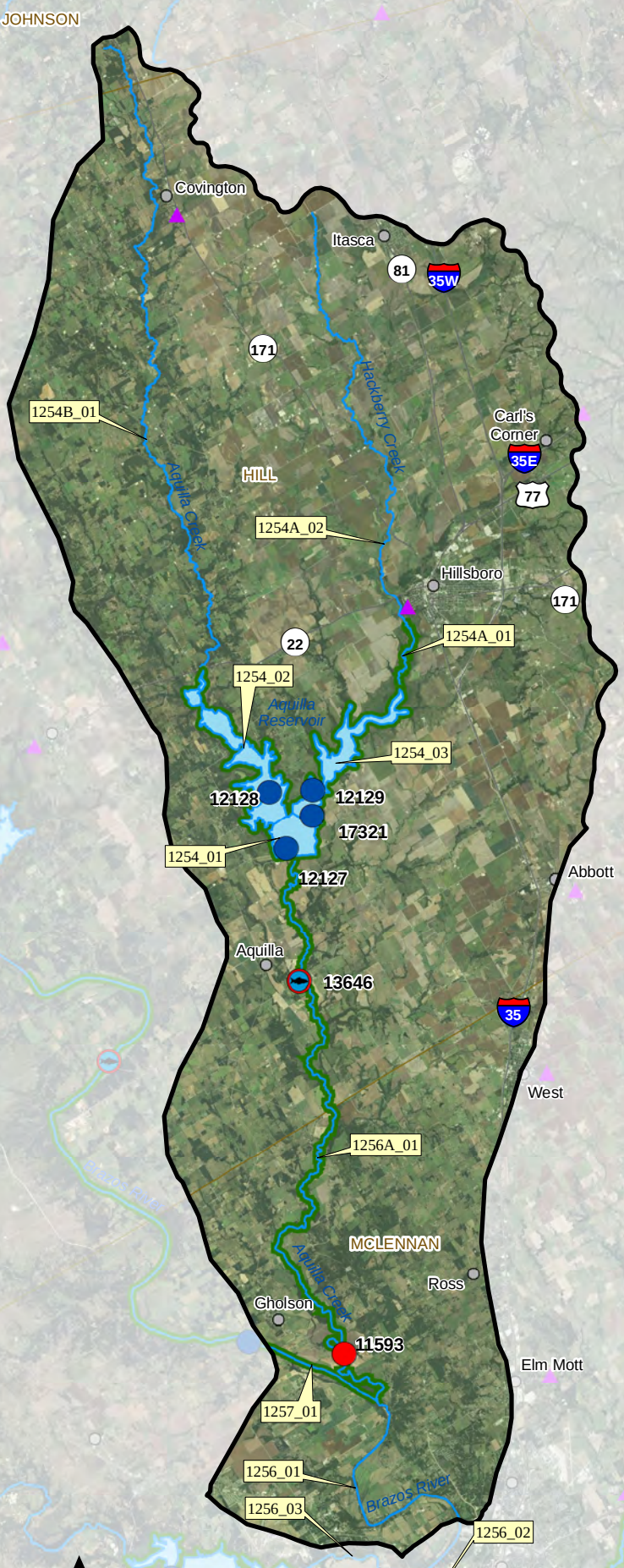
Assessment Units (Stations): 1256_01 (12043), 1256_02 (12041, 14226), 1256_03 (11626, 14948, 18521)

Unclassified Segments: **1256A**: Aquilla Creek 24.7 miles

Assessment Units (Stations): 1256A_01 (11592, 11593, 13646)

Aquilla Creek Watershed FY12 Water Quality Monitoring and 2010 IR Status





Chlorophyll a and/or Nutrient Concern

BRA Monitoring Stations

TCEQ Monitoring Stations

BRA Biological Monitoring Stations

Wastewater Outfall

Watershed Boundary

Brazos River Authority

0 5 10 Miles

N

Table 3.3.4.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Aquilla Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[4] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1254	**Aquilla Reservoir**	**PCR**	**H**	**110 ↓**	**310↓**	**600↓**	**5.0/3.0**	**6.5-9.0**	**126↑**	**90**	**14.10**	**0.11 ↓**	**0.37**	**0.05**	**0.2 ↓**	
1254A	Hackberry Creek	PCR	H	110↓	310↓	600	5.0/3.0↓	6.5-9.0↓	126	90↑		0.11	0.37	0.05	0.2	14.10
1254B	Aquilla Creek	PCR	**H**	110	310	600	5.0/3.0	6.5-9.0	126	90		0.11	0.37	0.05	0.2	14.10
1256	**Brazos River/Lake Brazos**	**PCR**	**H**	**400**	**200**	**1,150↓**	**5.0/3.0↑**	**6.5-9.0**	**126**	**95**		**0.33↓**	**1.95**	**0.37**	**0.69**	**14.10**
1256A	Aquilla Creek	PCR	L	400	200↓	1,150	3.0/2.0↓	6.5-9.0↓	126	95		0.33	1.95	0.37↓	0.69	14.10

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Aquilla Watershed

Aquilla Reservoir, at 3,020 acres, is the major drinking water source for Hill County. Previous concerns over high atrazine levels were addressed by TCEQ and TSSWCB by means of a TMDL and cooperation of local producers in implementing BMPs for the application of atrazine. All sections have concerns for nitrate enrichment possibly due t o permitted discharges, agricultural runoff and other nonpoint source runoff. The Hackberry Creek arm (**1254_03**) has concerns for arsenic and nickel in sediment. It is suspected that the arsenic came from the arsenic acid cotton defoliant used for

decades in the highly agricultural area around Aquilla Reservoir. The nickel is believed to be a historical remnant from industrial activities in the Hillsboro area.

The 2010 assessment finds concerns for depressed DO in Hackberry Creek (**1254A**) as well as concerns for ammonia, nitrate, and orthophosphate.

Aquilla Creek below Aquilla Lake dam to the confluence with the Brazos River (**1256_03**) is in full support of its limited aquatic life use classification and primary contact recreation status. However, there are concerns for elevated nitrate levels likely due to permitted discharges, agricultural runoff and other nonpoint source runoff.

The Lake Brazos AU **1256_02** is listed as having concerns for chlorophyll *a*. Elevated chlorophyll *a* levels are most likely a result of municipal discharges and urban runoff, both which can transport high levels of nutrients to water bodies.

The Bosque River section (**1256_03**) below Lake Waco to the confluence with the Brazos River is currently in full attainment for all assessed parameters.

Special Studies:

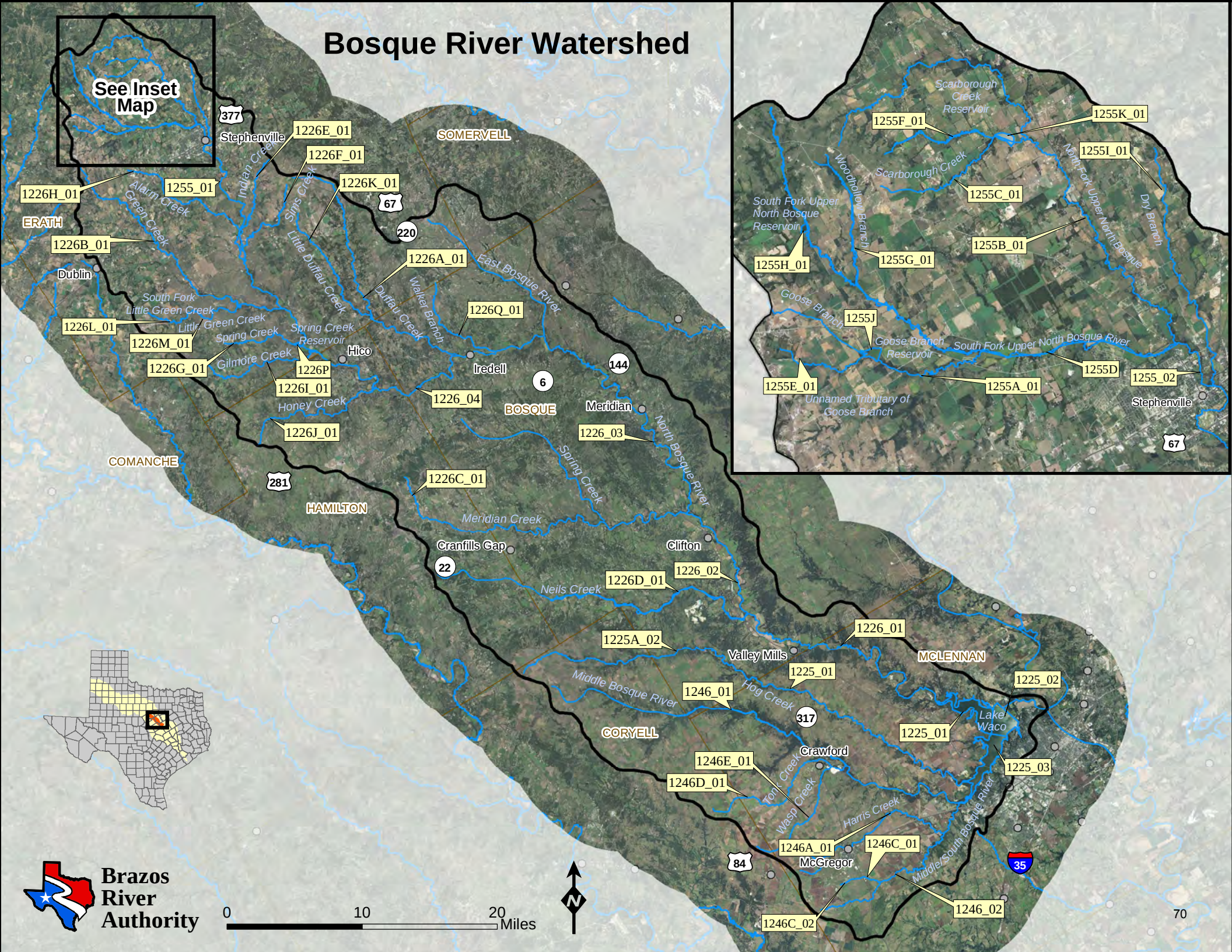
A TMDL for atrazine has been implemented. More information can be viewed here:
http://www.tceq.texas.gov/waterquality/tmdl/10-aquilla.html

The section of Aquilla Creek below the dam is undergoing an in-stream flow study in support of the BRA's proposed systems operation permit. Extensive habitat and biological data collection efforts will occur at various flow regimes to better assess the impact that varying water levels have on aquatic communities.

Table 3.3.4.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Depressed DO	• 1254A	• Permitted discharges, agricultural runoff and other nonpoint source runoff	• Reevaluate permits and fertilizer application rates • UAA
High chlorophyll *a*	• 1256_2	• Municipal discharges and urban runoff	• Reassessment of standard • Address urban storm water runoff
Elevated nutrient levels	• 1254, 1256A	• Permitted discharges, agricultural runoff and other nonpoint source runoff	• Reevaluate permits and fertilizer application rates

Bosque River Watershed



3.3.5 Bosque River Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
1,652 mi^2	44	BRA, TCEQ, TIAER	12	Cities of Stephenville, Iredell, Hico, Meridian, Clifton, Cranfills Gap, Valley Mills, Crawford, McGregor	1225, 1226, 1246, 1255

Description of Segments:

1225: Lake Waco – From Lake Waco Dam in McLennan County to a point 100 meters upstream of FM 185 on the North Bosque River Arm in McLennan County and the confluence of the Middle Bosque River on the South Bosque River Arm in McLennan County, up to the normal pool elevation of 461 feet (impounds Bosque River)

Segment Area: 7,178 acres

Assessment Units (Stations): 1225_01 (11945, 11946, 11947, 16995, 17204, 17205, 17206, 18543, 18544), 1225_02 (11942, 11943, 11944, 16996, 17207, 17208, 17209, 18541, 18542), 1225_03 (11599, 11600, 11948, 16997, 17210, 17211, 18539, 18540)

Unclassified Segment: **1225A**: Hog Creek

Assessment Units (Stations): 1225A_01 (11601, 17212, 18849), 1225A_02 (None)

1226: North Bosque River – From a point 100 meters upstream of FM 185 in McLennan County to a point immediately above the confluence of Indian Creek in Erath County

Segment Length: 103 miles

Assessment Units (Stations): 1226_1 (11951, 11953, 11954, 17605), 1226_2 (11956, 17500, 18379, 18380), 1226_3 (11958, 11960, 18003), 1226_04 (11961, 11962, 15123, 15694)

Unclassified Segments: **1226A**: Duffau Creek, **1226B**: Green Creek,**1226C**: Meridian Creek, **1226D**: Neils Creek, **1226E**: Indian Creek, **1226F**: Sims Creek, **1226G**: Spring Creek, **1226H**: Alarm Creek, **1226I**: Gilmore Creek, **1226J**: Honey Creek, **1226K**: Little Duffau Creek, **1226L**: South Fork Little Green Creek, **1226M**: Little Green Creek, **1226N**: Indian Creek Reservoir, **1226O**: Sims Creek Reservoir, **1226P**: Spring Creek Reservoir, **1226Q**: Walker Branch

Assessment Units (Stations): 1226A _01 (11810, 17607), 1226B_01 (13486, 17609), 1226C_01 (14908, 17243), 1226D_01 (11826), 1226E_01 (17235), 1226F_01 (17240), 1226G_01 (17242), 1226H_01 (17604), 1226I_01 (17610), 1226J_01 (17611), 1226K_01 (17608), 1226L_01 (13488), 1226M_01 (17606), 1226N_01 (17234), 1226O_01 (17239), 1226P_01 (17241), 1226Q_01 (20533)

1246: Middle Bosque/South Bosque River – From the confluence with the South Bosque River in McLennan County to the confluence of Cave Creek and Middle Bosque Creek on the Middle Bosque River in McLennan County to FM 2671 on the South Bosque River in McLennan County

Segment Length: 47 miles
Assessment Units (Stations): 1246_01 (12093, 17612), 1246_02 (12094, 17228, 17229, 20308)

Unclassified Segments: **1246A**: Harris Creek, **1226B**: Commanche Springs Spring Brook, **1246C**: Unnamed Tributary of South Bosque River, **1246D**: Tonk Creek, **1246E**: Wasp Creek
Assessment Units (Stations): 1246A_01 (None), 1246B_01 (None), 1246C_01 (11617), 1246C _02 (None), 1246D_01 (17232), 1246E_01 (17233, 18802)

1255: Upper North Bosque River – From a point immediately above the confluence of Indian Creek in Erath County to the confluence of the North Fork and South Fork of the Bosque River in Erath County

Segment Length: 17.5 miles
Assessment Units (Stations): 1255_01 (11963, 11964), 1255_02 (17226)

Unclassified Segments: **1255A**: Goose Branch, **1255B**: North Fork Upper North Bosque River, **1255C**: Scarborough Creek, **1255D**: South Fork North Bosque River, **1255E**: Unnamed Tributary of Goose Branch, **1255F**: Unnamed Tributary of Scarborough Creek, **1255G**: Woodhollow Branch, **1255H**: South Fork Upper North Bosque River Reservoir, **1255I**: Dry Branch, **1255J**: Goose Branch Reservoir, **1255K**: Scarborough Creek Reservoir
Assessment Units (Stations): 1255A_01 (17215), 1255B_01 (17413), 1255C_01 (17221, 17222), 1255D_01 (17218, 17602), 1255E_01 (17213, 17214), 1255F_01 (17223), 1255G_01 (17217), 1255H_01 (17219), 1255I_01 (17603), 1255J_01 (17612), 1255K_01 (17224)

Bosque River Watershed FY12 Water Quality Monitoring and 2010 IR Status

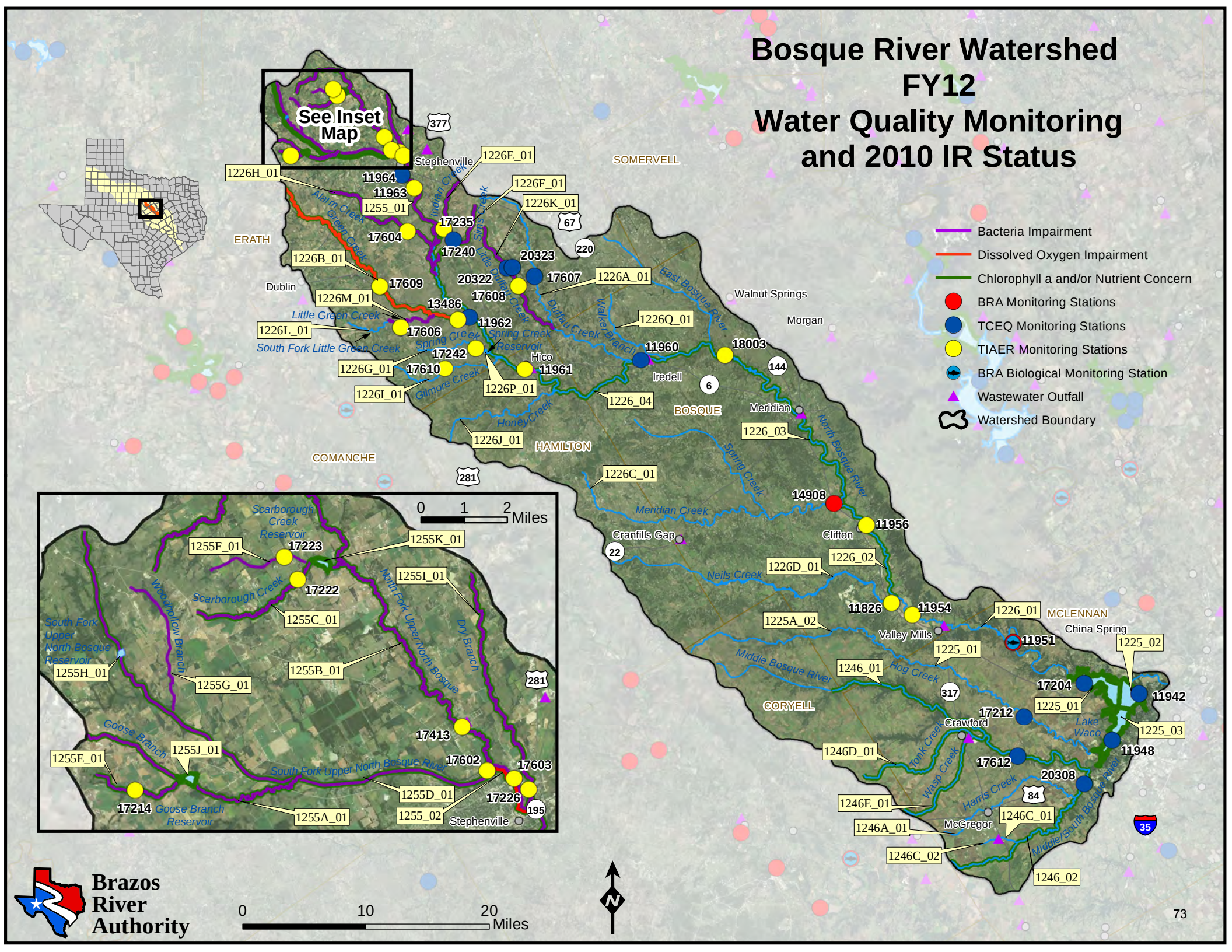


Table 3.3.5.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Bosque River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1225	**Waco Lake**	**PCR**	**H**	**60**	**60**	**400**	**5.0/3.0**	**6.5-9.0**	**126**	**93**	**23.16 ↑**	**0.11 ↓**	**0.37**	**0.05**	**0.20 ↓**	
1225A	Hog Creek	PCR	L	60	60	400	3.0/2.0	6.5-9.0	126	93	23.16	0.11	0.37	0.05	0.20	
1226	**North Bosque River**	**PCR**	**H**	**100**	**100**	**540**	**5.0/3.0**	**6.5-9.0**	**126**	**91**		**0.33 ↓**	**1.95**	**0.37**	**0.69**	**14.1**
1226A	Duffau Creek	PCR	H	100	100	540	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37 ↓	0.69	14.1
1226B	Green Creek	PCR	L	100	100	540	3.0/2.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1 ↓
1226C	Meridian Creek	PCR	L	100	100	540	3.0/2.0	6.5-9.0	126	91		0.33	1.95 ↓	0.37	0.69 ↓	14.1 ↓
1226D	Neils Creek	PCR	L	100	100	540	3.0/2.0	6.5-9.0	126	91		0.33	1.95	0.37 ↓	0.69	14.1
1226E	Indian Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1226F	Sims Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1226G	Spring Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69 ↓	14.1
1226H	Alarm Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1226I	Gilmore Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1226J	Honey Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1

Bosque River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1226K	Little Duffau Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1226M	Little Green Creek	PCR	M	100	100	540	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1226N	Indian Creek Reservoir	PCR	H	100	100	540	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7
1226O	Sims Creek Reservoir	PCR	H	100	100	540	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7
1226P	Spring Creek Reservoir	PCR	H	100	100	540	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7
1246	**Middle/South Bosque**	**PCR**	**H**	**50**	**260**	**700**	**5.0/3.0**	**6.5-9.0**	**126**	**91**		**0.33 ↓**	**1.95 ↑**	**0.37**	**0.69**	**14.1**
1246A	Harris Creek	PCR	H	50	260	700	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1246B	Comanche Springs Spring Brook	PCR	H	50	260	700	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1246C	Unnamed Tributary of South Bosque River	PCR	H	50	260	700	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1246D	Tonk Creek	PCR	H	50	260	700	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1246E	Wasp Creek	PCR	M	50	260	700	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255	**Upper North Bosque River**	**PCR**	**I**	**200**	**150**	**1000**	**4.0/3.0**	**6.5-9.0**	**126**	**91**		**0.33 ↓**	**1.95**	**0.37 ↓**	**0.69**	**14.1**

Bosque River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1255A	Goose Branch	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255B	North Fork Upper North Bosque River	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255C	Scarborough Creek	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255D	South Fork North Bosque River	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255E	Unnamed Tributary of Goose Branch	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255F	Unnamed Tributary of Scarborough Creek	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255G	Woodhollow Branch	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255H	South Fork Upper North Bosque River Reservoir	PCR	H	200	150	1000	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7
1255I	Dry Branch	PCR	M	200	150	1000	2.0/1.5	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1255J	Goose Branch Reservoir	PCR	H	200	150	1000	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7
1255K	Scarborough Creek Reservoir	PCR	H	200	150	1000	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.20	26.7

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation

[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Bosque River Watershed

The Bosque River watershed drains into Waco Lake before discharging into the Brazos River downstream of Waco Lake, in McLennan County. Approximately 74 percent of the drainage area of the Bosque watershed is comprised of the North Bosque River watershed. The predominant land use is agricultural, range and pasture land, and Confined Animal Feeding Operations (CAFO). A large amount of environmental and water quality research has been conducted in the North Bosque watershed to address elevated levels of phosphorus and bacteria, particularly in the North Bosque River segments **1226** and **1255**. Segment **1255** and many sub-segments of **1255 (A-G and I)** and **1226 (E,F,H,K,M)** are

Figure 3.3.5.1 **1255 Ammonia, TKN, OPO4 P**

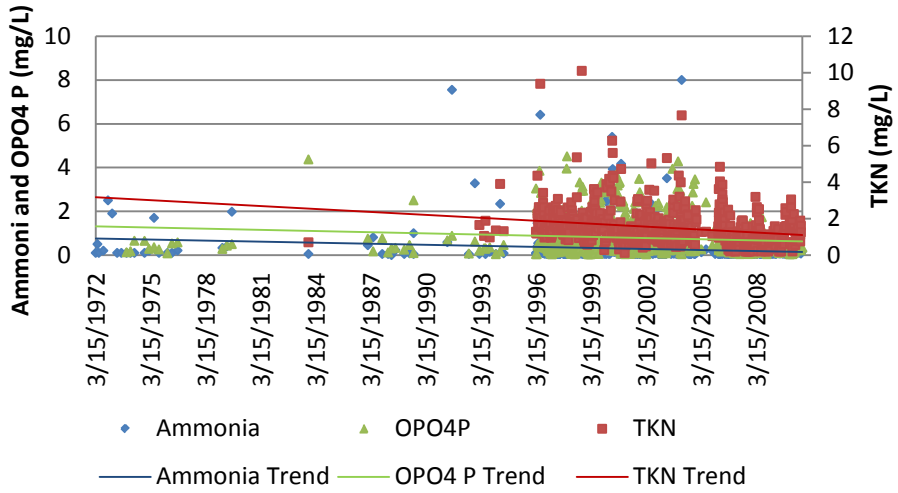
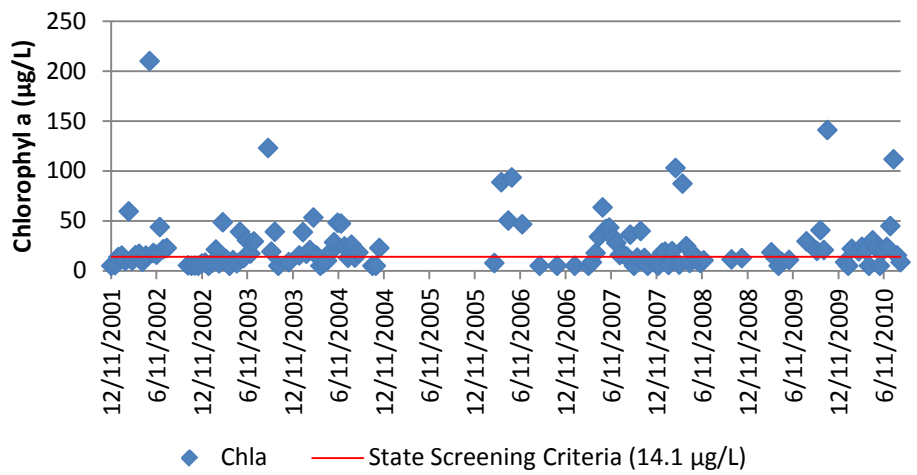


Figure 3.3.5.2 **Station 17226 - Chlorophyll *a***



impaired for bacteria with concerns for elevated levels of nutrients and chlorophyll *a* (Table 3.3.5.1). Segments **1255** and **1226B** are also impaired for dissolved oxygen. Although nutrient concentrations are at levels of concern, the long-term trend data suggests that nutrient concentrations in **1255** are being reduced (Figure 3.3.5.1). This may be evidence that BMPs implemented through the TMDL process has made an impact. But the relatively high amounts of available nutrients are still reflected in the high levels of chlorophyll *a* measured at station 17226, North Bosque River at FM 8. Chlorophyll *a* analyses results from this station show that 53 percent of the samples exceed the screening level of 14.1

*u*g/L (Figure 3.3.5.2). This monitoring station is located downstream of two permitted outfalls located north of the Stephenville area, in Erath County. The drainage above this monitoring station drains a portion of Erath County that has a relatively dense number of CAFO operations (Figure 3.3.5.3). Both wastewater treatment plant (WWTP) effluent downstream and the CAFOs located upstream of this monitoring station are potential contributors to nutrient enrichment and elevated bacteria levels in this segment.

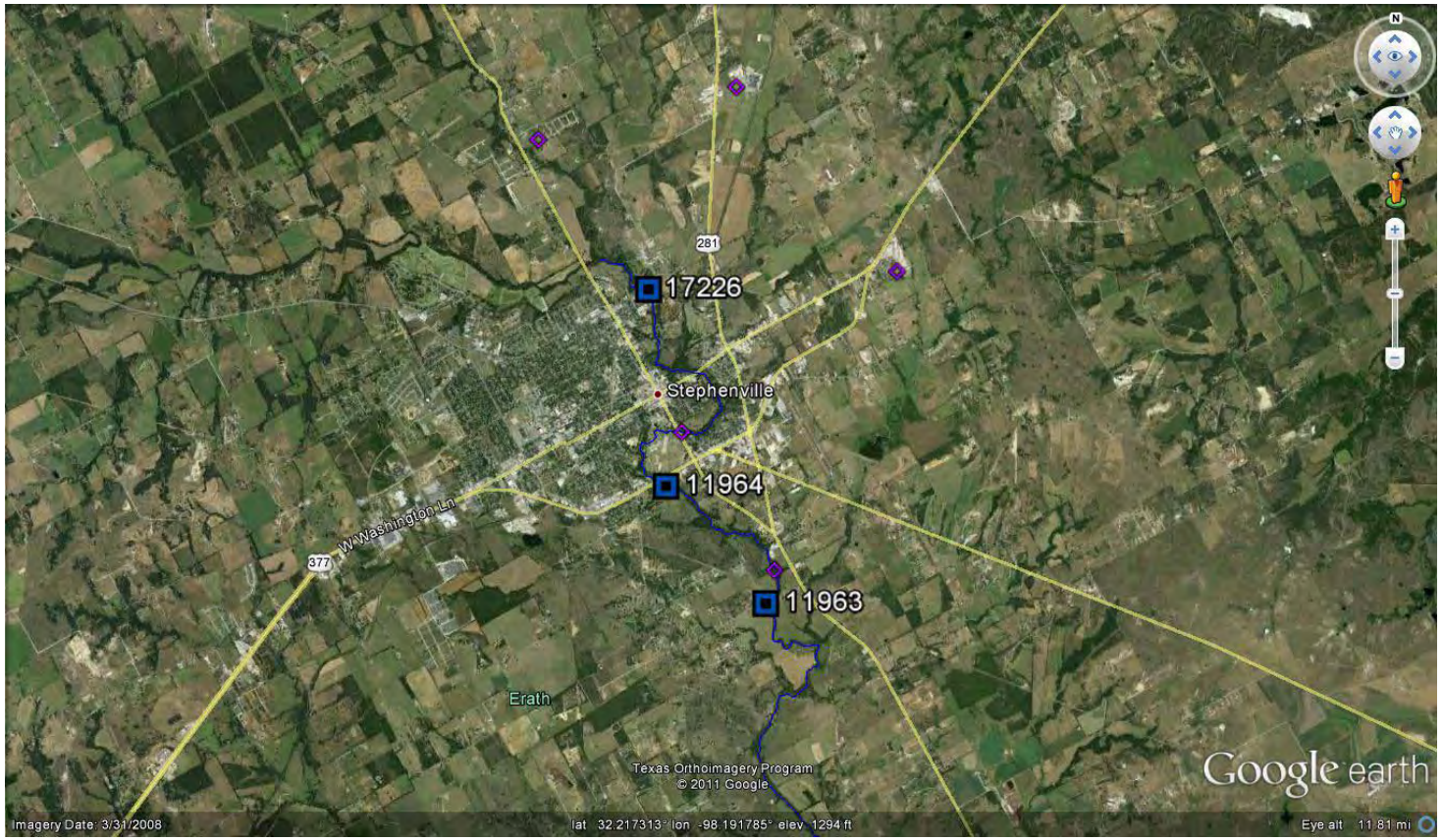
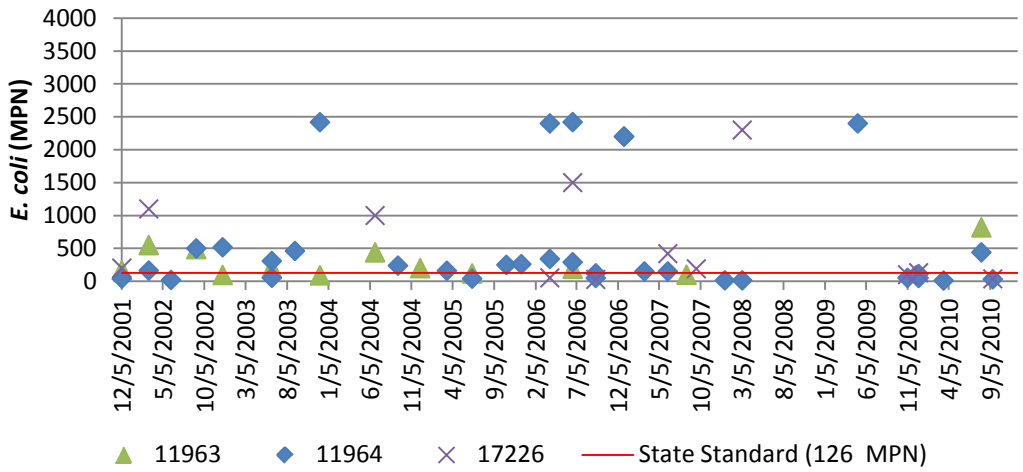


Figure 3.3.5.3 Segment 1255 Upper North Bosque River showing three monitoring stations and wastewater treatment outfall locations.

Segment **1255** has levels of *E. coli* bacteria that do not support the TCEQ water quality standard criteria. Data analyses from the most recent nine years of monitoring continue to support the bacterial impairment in this segment with a

geometric mean of 243.3 MPN in the 2010 IR and including data through December 2010, 239.8 MPN (Figure 3.3.5.4). There are no statistically significant trends in the *E. coli* data.

Figure 3.3.5.4 **Three Stations in Segment 1255 - *E. coli***



Segment **1226** of the North Bosque River has concerns related to dissolved oxygen, nutrient levels and chlorophyll *a* with several sub-segments listed as impaired for bacteria **(1226E,F,H,K,M)** and one **(1226B)** impairment for dissolved oxygen. Station 13486, Green Creek at Erath CR 269 (Figure 3.3.5.5), is characterized by high levels of chlorophyll *a* which is indicative of nutrient enrichment and may contribute to the low dissolved oxygen. Long-term trend data however indicate a significant decrease in TKN and chlorophyll *a* (Figure 3.3.5.6).

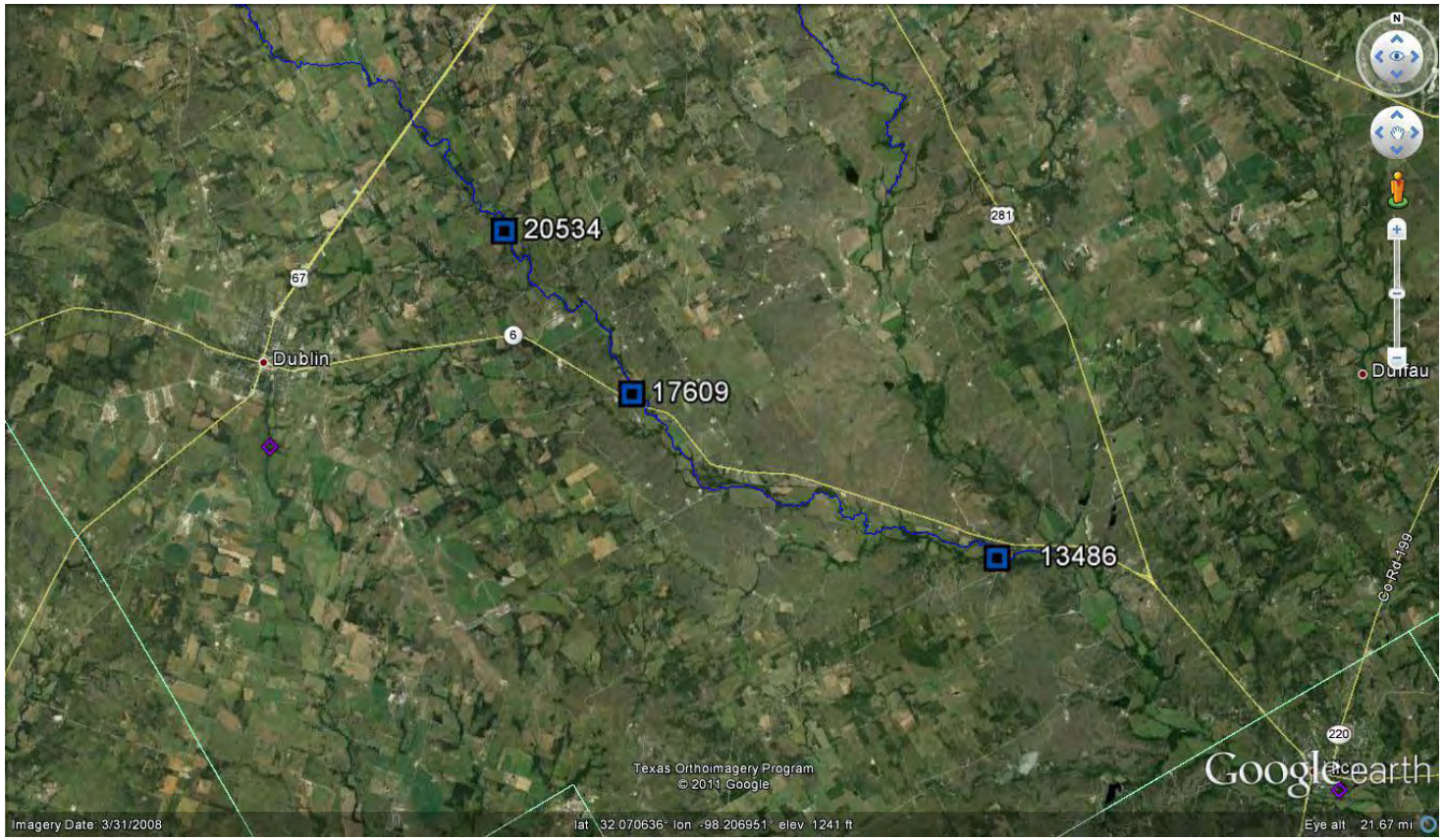
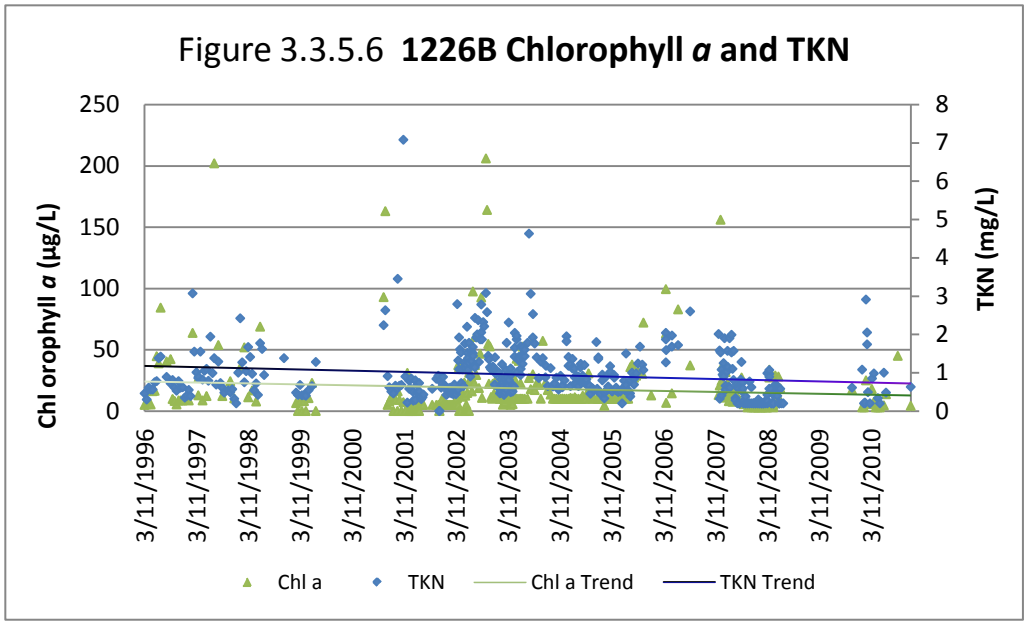
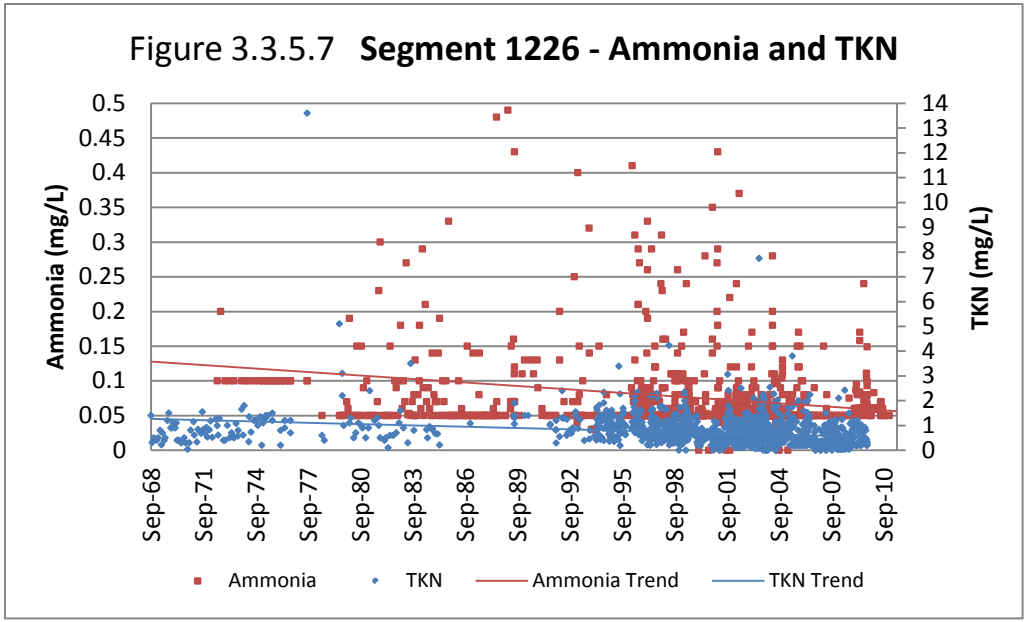


Figure 3.3.5.5 Segment 1226B Green Creek showing three monitoring stations and wastewater treatment outfall locations.



Further downstream on the main stem of the North Bosque River, long-term trending data indicate statistically significant decreasing trends in ammonia and TKN (Figure 3.3.5.7) while there are still elevated concentrations of chlorophyll *a* in Segment **1226**.



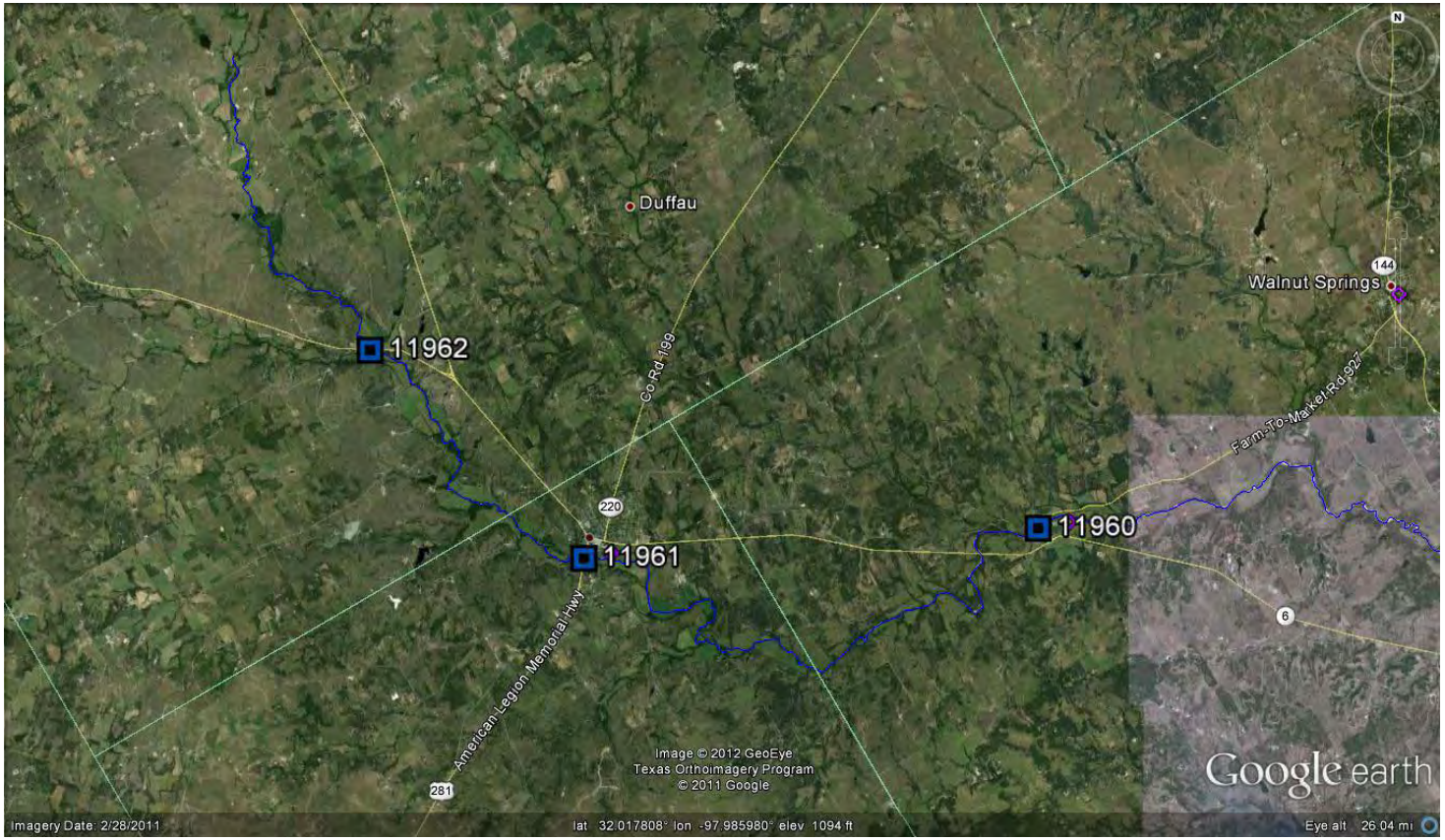


Figure 3.3.5.8 Most upstream portion of Segment 1226 North Bosque River showing three monitoring stations and wastewater treatment outfall locations.

Stations 11962, 11960, and 11960 all have data results that indicate elevated levels of chlorophyll *a*. Station 11962 and 11961 are located above the town of Hico in **1226_04** and station 11960 is located just upstream of Iredell in **1226_03** (Figure 3.3.5.8). The middle portion of the North Bosque River, **1226_03** from the confluence with Meridian Creek upstream to confluence with Duffau Creek in Bosque County including station 11960 shows a decreasing trend in TP and OPO4P although there is still a concern for chlorophyll *a* which could contribute to the DO concern further downstream in **1226_02**.

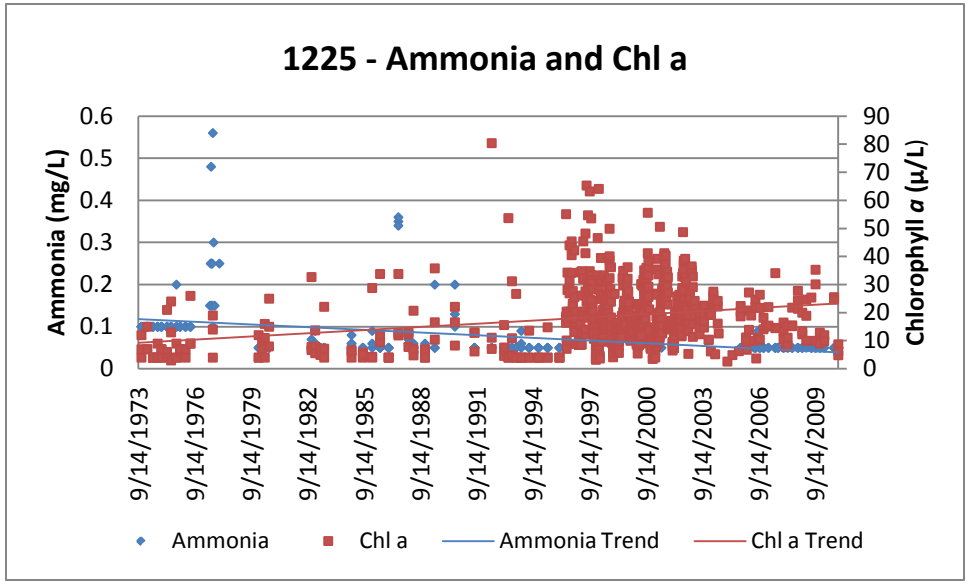
Trending data for stations in both **1226_04** and **1226_03** show a decreasing trend in chlorophyll *a*, however; 32 percent of samples in the entire Segment **1226** analyzed over the 2012 assessment period still exceed the screening criteria of 14.1 *u*g/L.

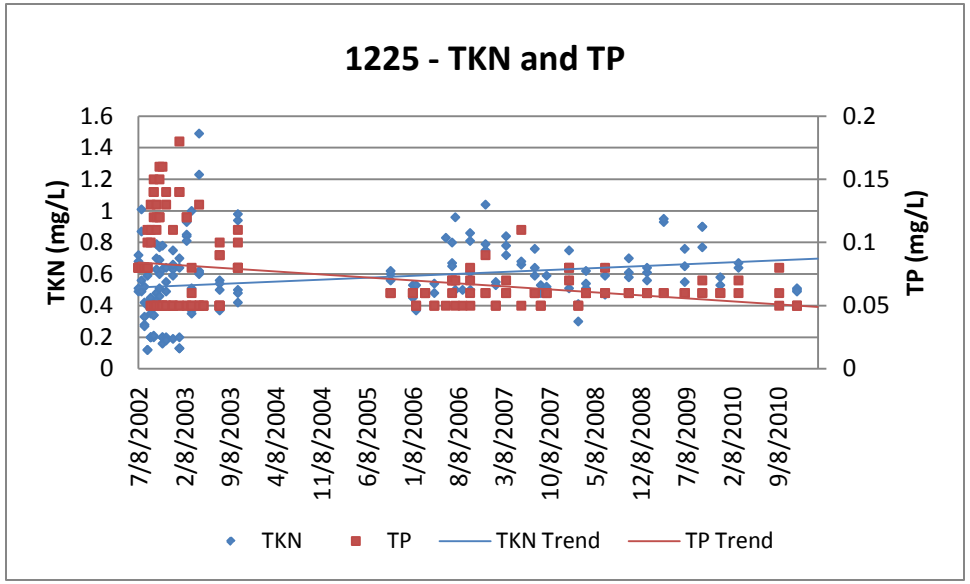
A TMDL has been completed and implemented for this segment. The goal of the TMDL is to restore the water quality in these segments so that they meet the state's standard criteria. The implementation of the TMDL was designed to reduce annual concentrations of orthophosphate phosphorus and five index sites along the North Bosque River. Reductions goals were site-specific, but ranged from 39 to 62 percent, with an overall goal of approximately 50 percent reduction.

Segment **1225**, Lake Waco (Figure 3.3.5.9), receives all of the drainage from the Bosque River watershed and is the source of drinking water for the City of Waco and many surrounding communities. The 2010 IR report includes segment **1225** as having a concern for nutrient enrichment and algal growth. Long-term trend analyses indicate increasing trends in TKN and chlorophyll *a* concentrations although there are decreasing trends in ammonia and total phosphorus (Figure 3.3.5.10).

Figure 3.3.5.9 Segment 1225 – Waco Lake.

Figure 3.3.5.10 **1225 Nutrient and Chlorophyll *a* Trends**





Special Studies:

A TMDL has been completed and implemented for segments **1226** and **1225**.

Biological Assessments:

Segment **1226** – North Bosque River - BRA conducted biological assessments on the North Bosque River at Coopers Crossing (Figure 3.3.5.11) west of China Spring (Station 11951) in May and July 2009. The site integrates effects of most water quality influences in the watershed, due to its location in the lower reach a short distance upstream from Lake Waco. BRA has earmarked the site for long-term aquatic life monitoring, in light of public concern for water quality in the river and lake, a shortage of historical biological data, and past 305(b) concerns for depressed dissolved oxygen, excessive algal growth, elevated orthophosphorus and chlorophyll *a*, and fish community impairment. Further rationale is to monitor instream changes resulting from an ongoing Total Maximum Daily Load project, and to evaluate the effectiveness of best management practices for dairy operations in the watershed. The 2009 events were a follow-up to an initial set of assessments conducted in June and August 2008. During all four events, physical habitat, benthic

Figure 3.3.5.11. Station 11951 – North Bosque River at Coopers Crossing.

macroinvertebrates, and fish have met, and generally exceeded, high aquatic life use expectations, indicating favorable environmental conditions. The only negative implication thus far has been a physical anomaly that occurred in benthic macroinvertebrates during July 2009, when 33% of the specimens were affected by dark-colored tissue necrosis on parts of the body. Although the specific cause is unknown, some type of sediment-associated stressor is suspected.

One aquatic life monitoring event was conducted in 2011, in April during the non-critical portion of the index period. DO concentrations and fish achieved an exceptional ALU, and physical habitat and benthic macroinvertebrates a high ALU. There was no sign of disease in benthic macroinvertebrates. Similarly to previous years, all components of the assessment met or exceeded high ALU expectations, again indicating a general prevalence of favorable environmental conditions. Previous 305(b) concerns for portions of the segment (depressed DO; excessive algal growth; elevated orthophosphorus and chlorophyll *a*; impaired fish and macrobenthic assemblages) did not translate to adverse effects on diel DO concentrations, physical habitat, or biological integrity at Station 11951 during April 2011.

Plans to conduct a second aquatic life monitoring event during the 2011 critical period were unsuccessful due to effects of extreme drought. Although pools persisted, there was no flow, and a decision was made not to perform the assessment in light of atypical hydrological conditions that persisted through the entire critical period. The site has been included on BRA's 2012 monitoring schedule for a one-time assessment during the critical period, to supplement the 2011 dataset. This in turn forced a revision of long-range strategy, in that the subsequent round of aquatic life monitoring had to be postponed from 2013 to 2014 to maintain two-year spacing.

Segment **1246** - Middle Bosque/South Bosque River - BRA conducted biological assessments on the South Bosque River (1246) at FM 2837 (Figure 3.3.5.12) southwest of Woodway (Station 20308) in May and September 2009. The site is in the lower portion of the segment a short distance upstream from Lake Waco, and conditions there integrate effects of most water quality influences in the watershed. The objectives were to evaluate the current condition of aquatic life in the

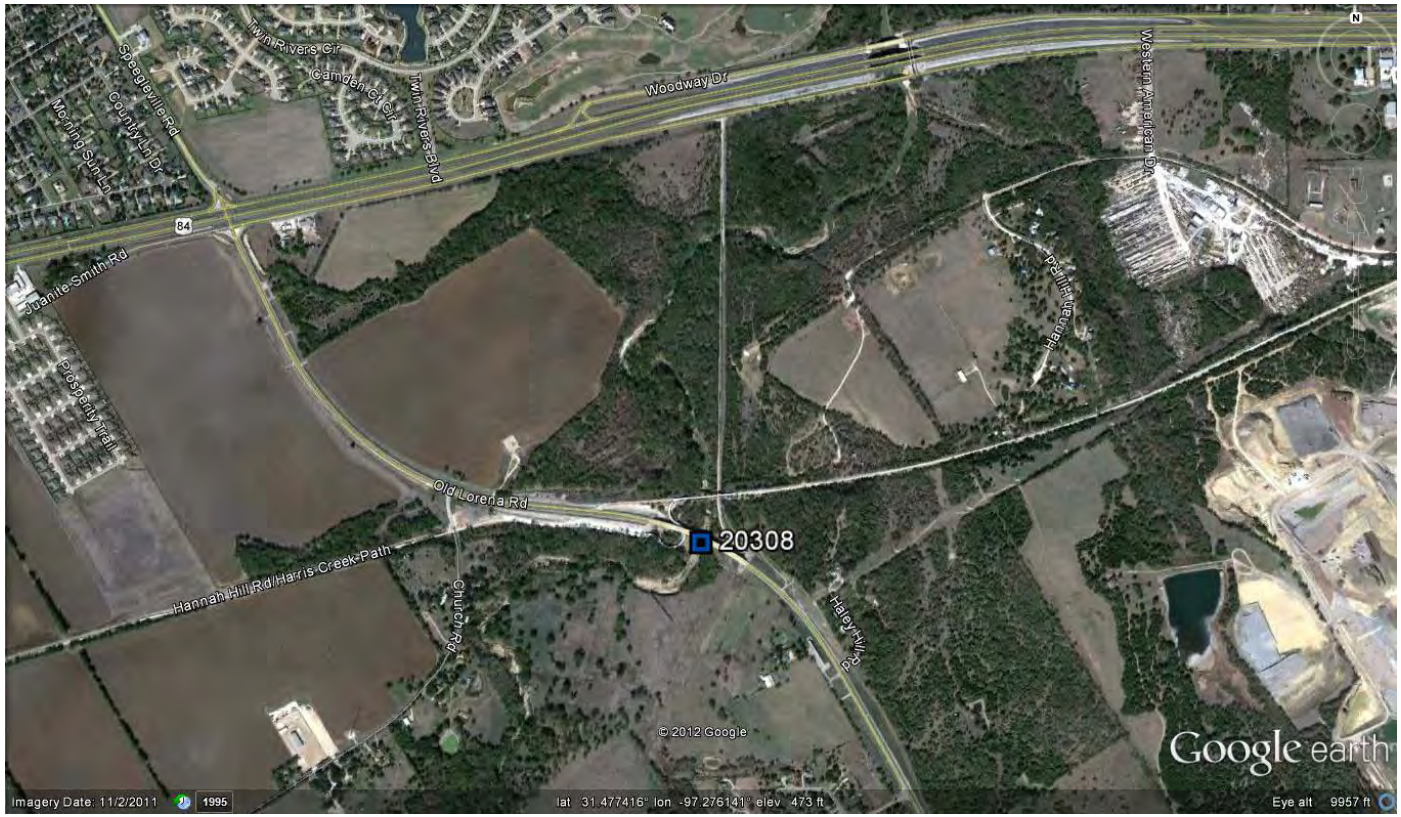


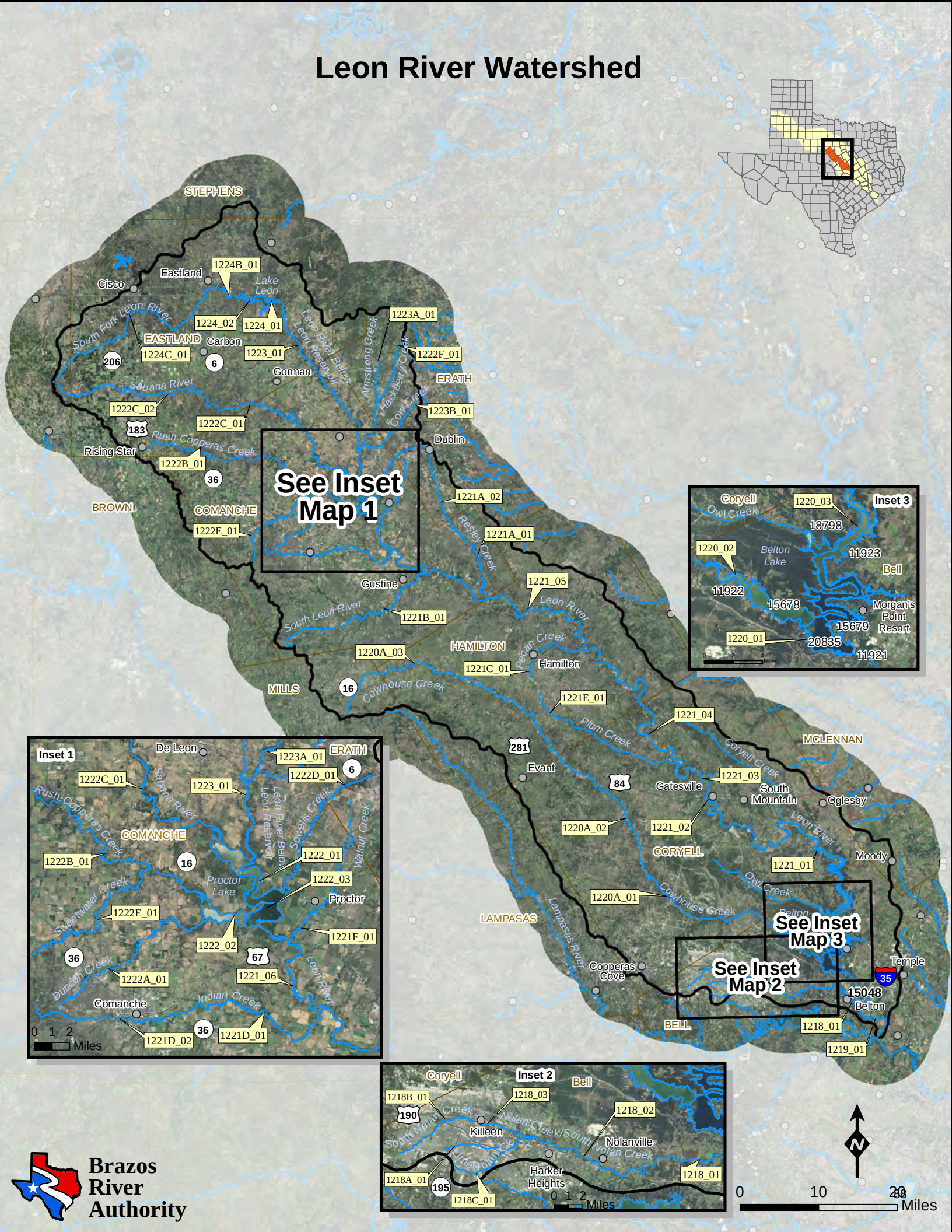
Figure 3.3.5.12 Station 20308 – South Bosque River at FM 2837.

river, in light of public concern for water quality in the river and lake, a shortage of biological data available for the 305(b) assessment, and past 305(b) concerns for nitrate and fecal coliform bacteria. P hysical habitat, benthic macroinvertebrates, and fish met high aquatic life use expectations during both events, indicating favorable environmental conditions. The level of biological integrity during the second event was surprising, given that a two-month period of no flow occurred during the summer. Flow resumed only 18 days prior to the event, following significant rainfall. The results indicate that perennial pools in the reach provide important refuges for aquatic life, with emigration into riffles and runs occurring rapidly once flow resumes.

Table 3.3.5.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria Impairment	• Upper North Bosque and 72% of its tributaries • 33% of the tributaries to the North Bosque River	• small, rural streams with little assimilative capacity with no to low flow for most of the year, when water is present it is a result of storm event and associated runoff • stormwater runoff from rural sources including CAFOs	• For most of these, an RUAA has been completed and is under review for the to determine if the bacteria standards for these are appropriate
DO Impairment	• Upper North Bosque River and one tributary to the North Bosque River	• significant algal community resulting from high nutrient concentrations • insufficient quantity of water to buffer against high ambient air temperatures	• A UAA is in progress to determine if the DO standards for these are appropriate
Nutrient or Chlorophyll *a* Concerns	• Throughout watershed in 58% of the segments assessed	• small, rural streams with little assimilative capacity with no to low flow for most of the year, when water is present it is a result of storm event and associated runoff • wastewater treatment plant (WWTP) effluent • stormwater runoff from rural sources including CAFOs	• Continue with Implementation Plan

Leon River Watershed



3.3.6 Leon River Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
3730 mi2	38	BRA, TCEQ	36	Cities of Killeen, Harker Heights, Copperas Cove, Morgan's Point, Gatesville, Moody, Oglesby, Evant, Hamilton, Gustine, Comanche, Dublin, Rising Star, De Leon, Gorman, Eastland; Ft. Hood	1218, 1219, 1220, 1221, 1222, 1223, 1224

Description of Segments:

1224: Leon Reservoir – From Leon Dam in Eastland County up to the normal pool elevation of 1375 feet (impounds Leon River)

Segment Area: 1663 acres
Assessment Units (Stations): 1224_01 (11939), 1224_02 (11941)

Unclassified Segment: **1224A**: Lake Olden, **1224B**: Leon River above Leon Reservoir, **1224C**: South Fork Leon River
Assessment Units (Stations): each unclassified segment has only one AU

1223: Leon River below Leon Reservoir – From a point immediately upstream of the confluence of Mill Branch in Comanche County to Leon Dam in Eastland County

Segment Length: 33.1 miles
Assessment Units (Stations): 1223_01 (11938)

Unclassified Segments: **1223A**: Armstrong Creek, **1223B**: Cow Creek
Assessment Units (Stations): 1223A_01 (15765, 17539), 1223B_01 (17540, 18046)

1222: Proctor Lake – From Proctor Dam in Comanche County to a point immediately upstream of the confluence of Mill Branch in Comanche County, up to the normal pool elevation of 1162 feet (impounds Leon River)

Segment Length: 4,610 acres

Assessment Units (Stations): 1222_01 (11936, 14036, 14037, 14038), 1222_02 (11937, 14034, 14035), 1222_03 (11935, 14032, 14033, 18434)

Unclassified Segments: **1222A**: Duncan Creek, **1222B**: Rush-Copperas Creek, **1222C**: Sabana River, **1222D**: Sowells Creek, **1222E**: Sweetwater Creek, **1222F**: Hackberry Creek
Assessment Units (Stations): 1222A_01 (11825, 17544), 1222B_01 (11824, 17538), 1222C_01 (13647), 1222C _02 (None), 1222D_01 (11827), 1222E_01 (17541), 1222F_01 (17543)

1221: Leon River below Proctor Lake – From a point 100 meters (110 yards) upstream of FM 236 in Coryell County to Proctor Dam in Comanche County

Segment Length: 167 miles
Assessment Units (Stations): 1221_01 (11925, 11926, 11927), 1221_02 (11928, 17501), 1221_03 (17545), 1221_04 (11929, 11930), 1221_05 (11932, 15769, 18781), 1221_06 (17591), 1221_07 (11934)

Unclassified Segments: **1221A**: Resley Creek, **1221B**: South Leon River, **1221C**: Pecan Creek, **1221D**: Indian Creek, **1221E**: Plum Creek, **1221F**: Walnut Creek
Assessment Units (Stations): 1221A_01 (11808, 17377, 17477), 1221A _02 (17376), 1221B_01 (11817), 1221C_01 (11807, 17547), 1221D_01 (11818), 1221D_02 (17542); 1221E_01 (18405), 1221F_01 (17379, 18406)

1220: Belton Lake – From Belton Dam in Bell County to a point 100 meters (110 yards) upstream of FM 236 in Coryell County, up to the normal pool elevation of 594 feet (impounds Leon River)

Segment Length: 12,300 acres
Assessment Units (Stations): 1220_01 (11921, 15676), 1220_02 (11922), 1220_03 (11923)

Unclassified Segments: **1220A**: Cowhouse Creek
Assessment Units (Stations): 1220A_01 (None), 1220A_02 (11805), 1220A _03 (17546)

1219: Leon River below Belton Lake – From the confluence with the Lampasas River in Bell County to Belton Dam in Bell County

Segment Length: 16.6 miles
Assessment Units (Stations): 1219_01 (11916)

1218: Nolan Creek/South Nolan Creek – From the confluence with the Leon River in Bell County to a point 100 meters (110 yards) upstream to the most upstream crossing of US 190 and Loop 172 in Bell County

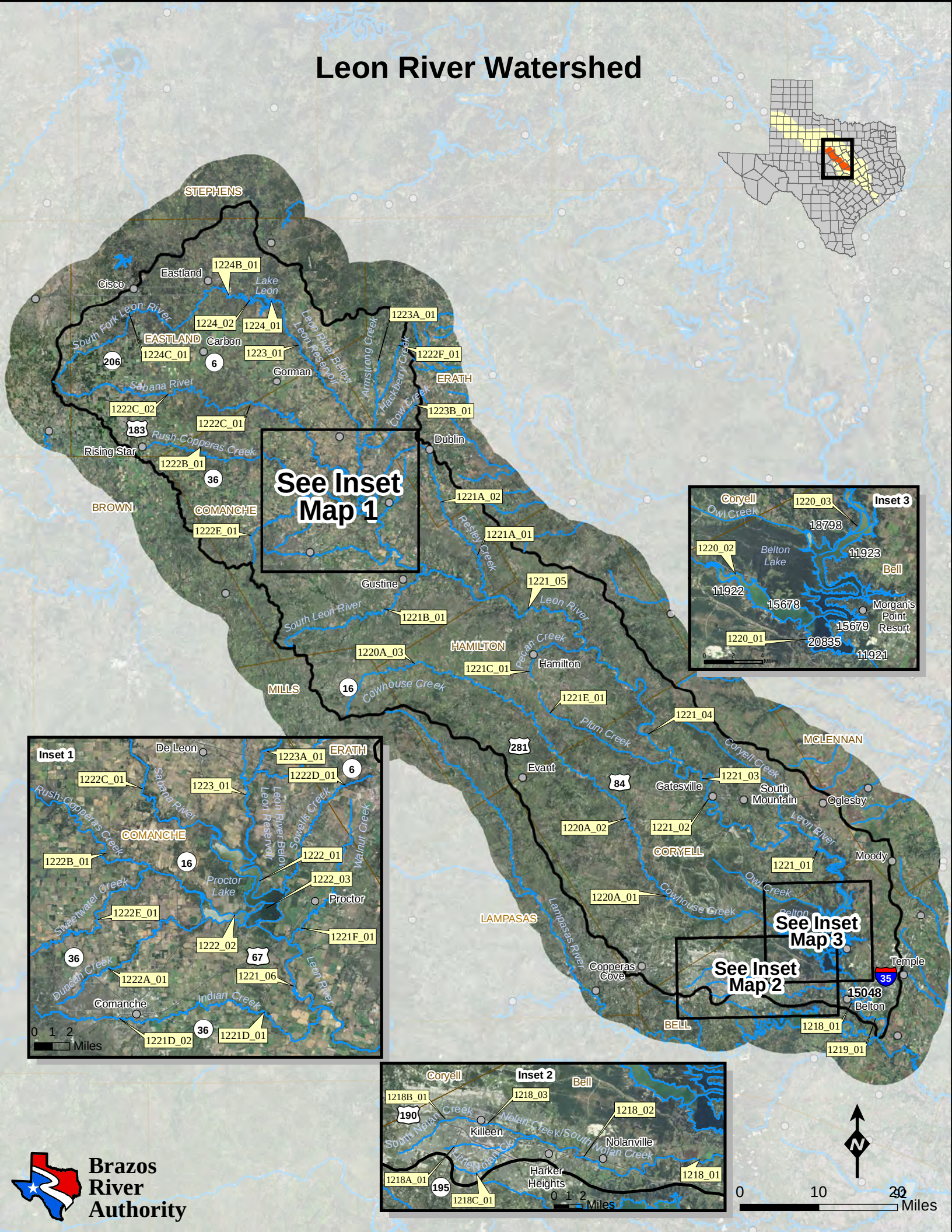
Segment Length: 28.4 miles

Assessment Units (Stations): 1218_01 (None), 1218_02 (11907, 11913, 18826, 18827, 18828), 1218_03 (15271)

Unclassified Segments: **1218A**: Unnamed Tributary to Little Nolan Creek, **1218B**: South Nolan Creek, **1218C**: Little Nolan Creek

Assessment Units (Stations): 1218A_01 (18833), 1218B_01 (18829), 1218C_01 (18834)

Leon River Watershed



Brazos River Authority

Table 6.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Leon River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1218	**Nolan Creek/South Nolan Creek**	**PCR**	**H**	**100**	**75↓**	**500**	**5.0/3.0**	**6.5-9.0↑**	**126**	**93**		**0.33↓**	**1.95↑**	**0.37↓**	**0.69↓**	**14.1**
1218A	Unnamed tributary to Little Nolan Creek	PCR	H	100	75	500	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1218B	South Nolan Creek	PCR	H	100	75	500	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1218C	Little Nolan Creek	PCR	H	100	75	500	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1219	**Leon River Below Belton Lake**	**PCR**	**H**	**150**	**75↓**	**500**	**5.0/3.0↑**	**6.5-9.0↑**	**126**	**91↑**		**0.33↓**	**1.95↑**	**0.37↓**	**0.69↓**	**14.1**
1220	**Belton Lake**	**PCR**	**H**	**100↓**	**75↓**	**500↓**	**5.0/3.0**	**6.5-9.0↑**	**126↓**	**93**	**26.70↑**	**0.11↓**	**0.37**	**0.05**	**0.20**	
1220A	Cowhouse Creek	PCR	H	100↓	75↓	500↓	3.0/2.0↓	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1↑
1221	**Leon River below Proctor Lake**	**PCR**	**H**	**150**	**100**	**900**	**5.0/3.0↑**	**6.5-9.0**	**126↓**	**90**		**0.33↓**	**1.95↑**	**0.37**	**0.69**	**14.1↑**
1221A	Resley Creek	PCR	H	150	100	900	2.0/1.5	6.5-9.0↓	126	90		0.33	1.95	0.37↓	0.69	14.1↑
1221B	South Leon River	PCR	H	150↓	100↓	900↓	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37↓	0.69	14.1↑
1221C	Pecan Creek	PCR	H	150	100	900	4.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37	0.69	14.1↑
1221D	Indian Creek	PCR	H	150↓	100↓	900	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37↓	0.69	14.1
1221E	Plum Creek	PCR	H	150	100	900	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37	0.69	14.1
1221F	Walnut Creek	PCR	H	150	100	900	3.0/2.0	6.5-9.0	126	90		0.33	1.95	0.37↓	0.69	14.1
1222	**Proctor Lake**	**PCR**	**H**	**200**	**75**	**500↓**	**5.0/3.0↑**	**6.5-9.0↑**	**126**	**93↑**	**26.70↑**	**0.11**	**0.37**	**0.05**	**0.20**	

Leon River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1222A	Duncan Creek	PCR	H	200	75	500↑	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1↑
1222B	Rush-Copperas Creek	PCR	H	200	75	500	3.0/2.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1222C	Sabana River	PCR	H	200	75	500	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1222D	Sowells Creek	PCR	H	200	75	500	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1222E	Sweetwater Creek	PCR	H	200	75	500	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1222F	Hackberry Creek	PCR	H	200	75	500	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1223	**Leon River Below Leon Reservoir**	**PCR**	**H**	**480↓**	**130↓**	**1240↓**	**5.0/3.0↓**	**6.5-9.0**	**126**	**93**		**0.33**	**1.95**	**0.37**	**0.69**	**14.1**
1223A	Armstrong Creek	PCR	H	480	130	1240	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1223B	Cow Creek	PCR	H	480	130	1240	2.0/1.5	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1224	**Leon Reservoir**	**PCR**	**H**	**150↓**	**75↓**	**500↓**	**5.0/3.0**	**6.5-9.0↑**	**126**	**93**	**26.70↑**	**0.11↓**	**0.37**	**0.05↑**	**0.20**	
1224A	Lake Olden	PCR	H	150	75	500	5.0/3.0	6.5-9.0	126	93	26.70	0.11	0.37	0.05	0.20	
1224B	Leon River above Leon Reservoir	PCR	H	150	75	500	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1224C	South Fork Leon River	PCR	H	150	75	500	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Leon River Watershed

The northernmost tributaries of the Leon River watershed originate in the eastern portion of Callahan County and flows into the mainstem Leon River in Eastland County. From this confluence, the river courses through Comanche, Coryell, Hamilton, and finally reaches Bell, encompassing a total area of 3,533 square miles. There are three impoundments on the mainstem, Leon Reservoir, Proctor Lake, and Lake Belton. These waterbodies are used primarily for recreation, flood control and municipal water supply. Land use in the watershed is primarily rangeland and improved pastureland with areas of mixed forestland. The watershed also hosts a number of municipalities, approximately 50 confined animal feeding operations and row crop agriculture.

Many concerns and impairments can be found throughout this watershed, in both the lentic and lotic environments. There are many segments and sub-segments on the 303(d) list for only bacteria (Segments**1218**, **1220A**, **1221**, **1221B**, **D**, **F**, **1222A**, **B**, **C**, **E**, **1223A**) or both bacteria and depressed dissolved oxygen (Segments **1221A**, **1223**). Mainstem and tributaries alike have multiple concerns for use based on increased levels of nitrate, orthophosphate, total phosphorus, as well as chlorophyll *a*, and depressed dissolved oxygen levels.

Segment **1224** of the Leon River watershed is the only segment, AUs included, of the seven that does not have any impairments or concerns within. While Leon Reservoir has a statistically significantly increasing trend of pH, chlorophyll *a*, and total phosphorus, none are a concern at this time.

The entire Segment **1223** is impaired for bacteria and depressed dissolved oxygen and is listed on the 303(d) list. In addition **1223A** is impaired for bacteria and on the 303(d) list and there is a concern for use on **1223B** (Figure 3.3.6.1). The figure below indicates all samples taken in the past 10 years, excluding one sample which was above 4,500 MPN/100 mL. There are WWTPs that discharge effluent into this segment; however, the majority of the pollution can be attributed to nonpoint source input. There are a number of animal feeding operations located in the area, as well as an abundance of agricultural land in use, and abundant wildlife which may contribute to the NPS pollution problem. While there are statistically significant declines in chloride, sulfate, and TDS in this segment, there is also a depression in dissolved oxygen concentration (Figure 3.3.6.2), which has led to the impairment of Segment **1223**. This depressed dissolved oxygen is likely due to the presence of primary producers in the water indicated by increased chlorophyll *a* concentrations. An abundance of aquatic vegetation or algae in a system leads to large variation in the levels of dissolved oxygen. Depending on temperature and sunlight, ranges can reach relatively high dissolved oxygen levels at the height of photosynthesis, and very low levels at the base of this process.

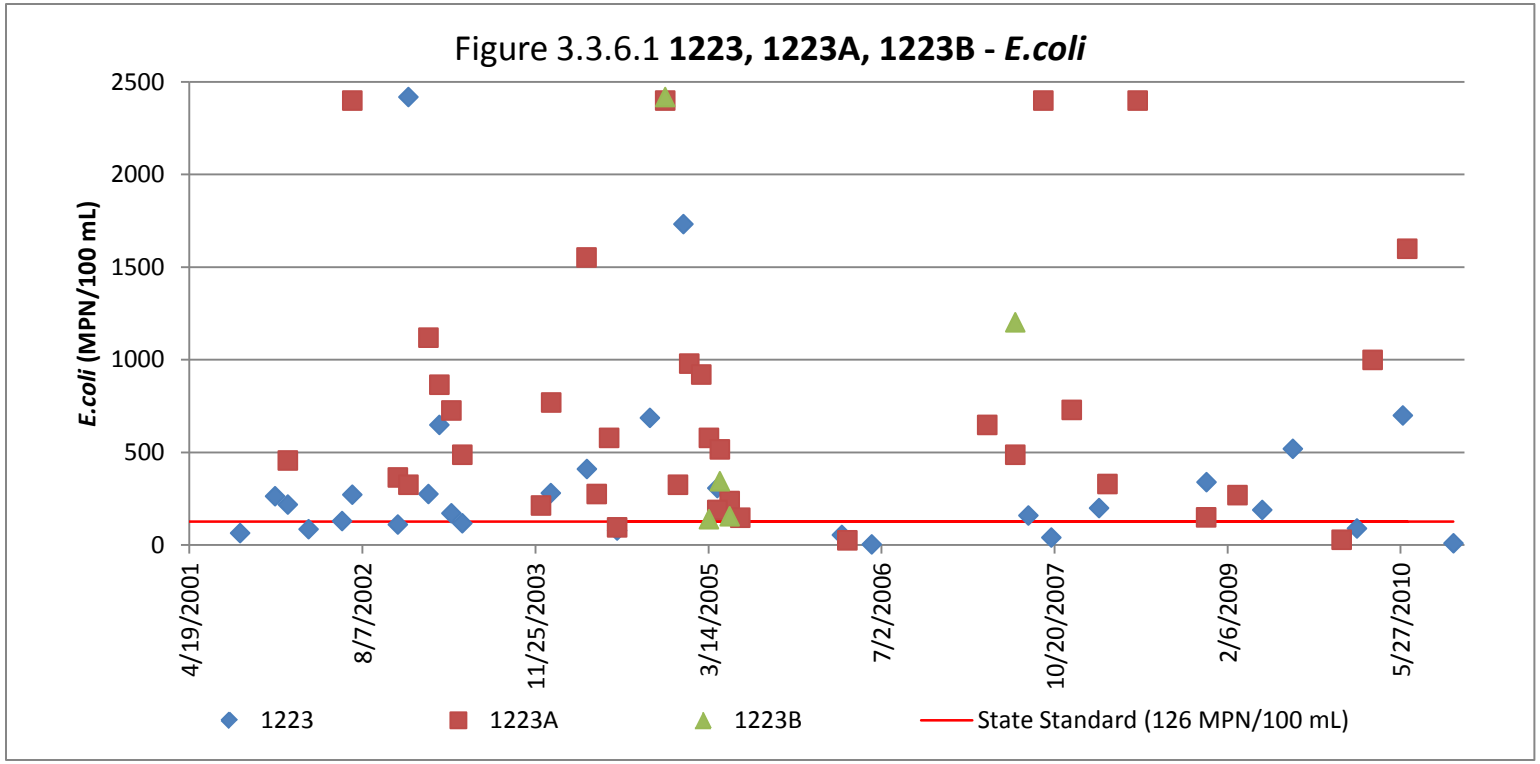


Figure 3.3.6.1 **1223, 1223A, 1223B - *E.coli***
E.coli (MPN/100 mL)
2500
2000
1500
1000
500
0
4/19/2001
8/7/2002
11/25/2003
3/14/2005
7/2/2006
10/20/2007
2/6/2009
5/27/2010
1223
1223A
1223B
State Standard (126 MPN/100 mL)

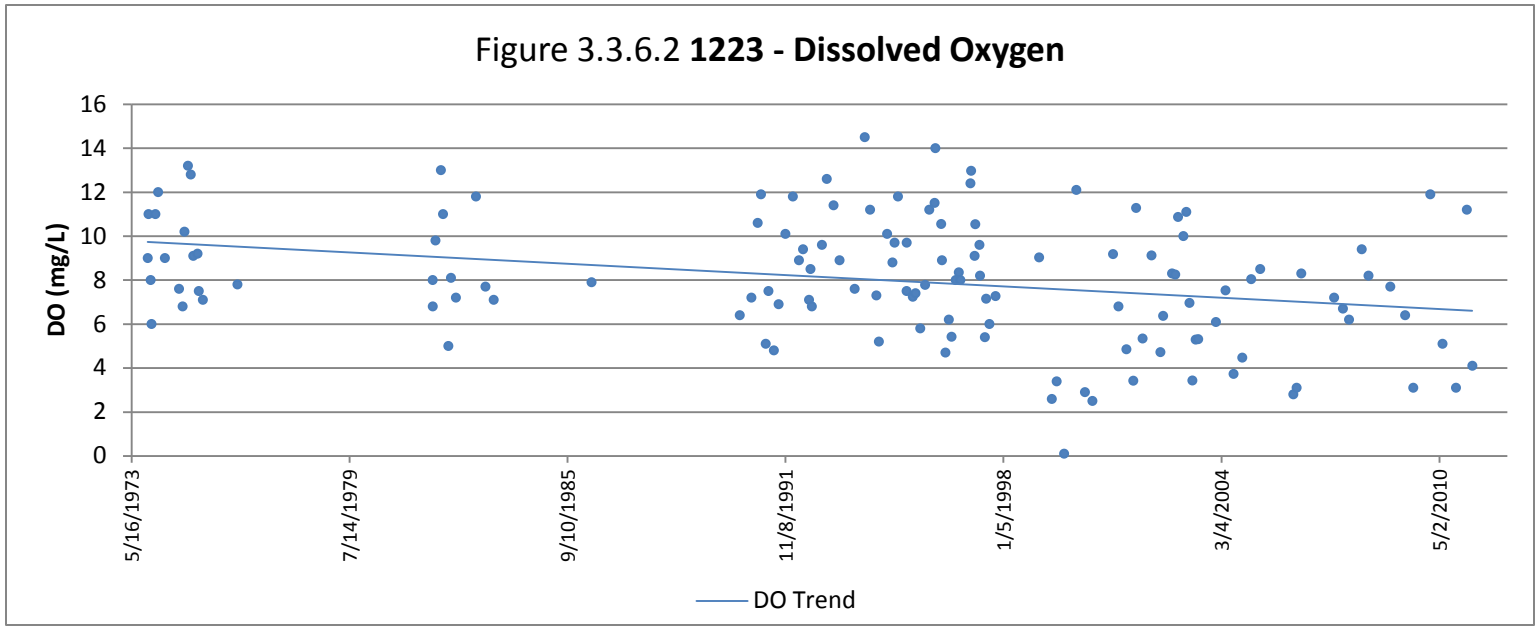
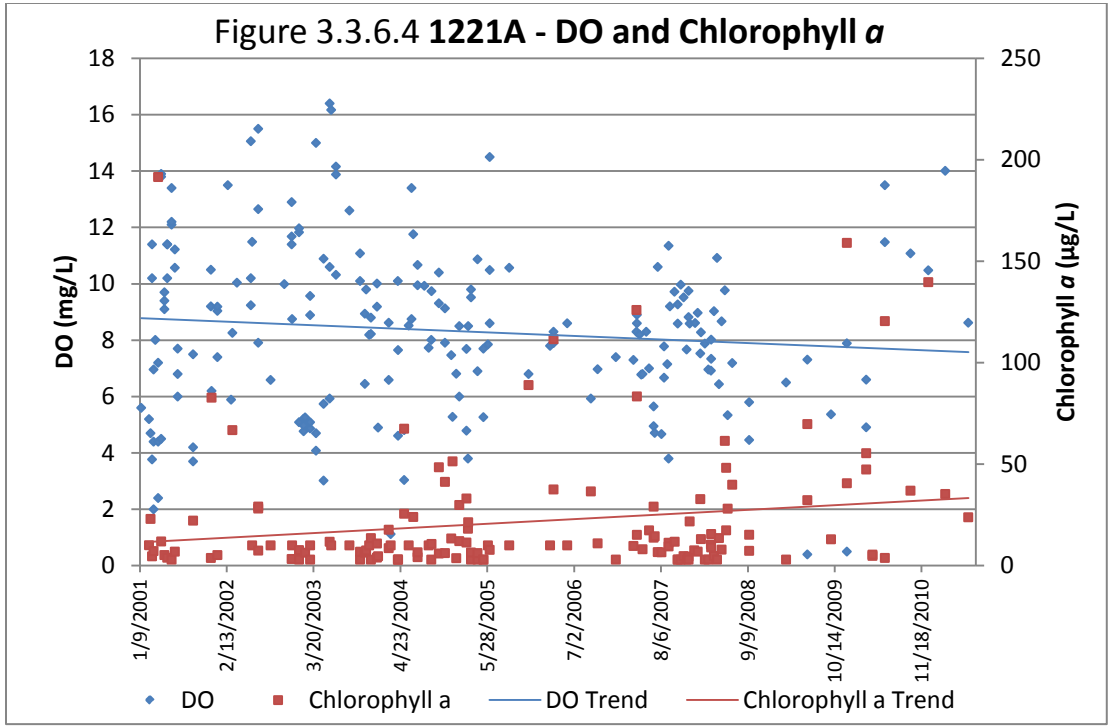


Figure 3.3.6.2 **1223 - Dissolved Oxygen**
DO (mg/L)
16
14
12
10
8
6
4
2
0
5/16/1973
7/14/1979
9/10/1985
11/8/1991
1/5/1998
3/4/2004
5/2/2010
DO Trend

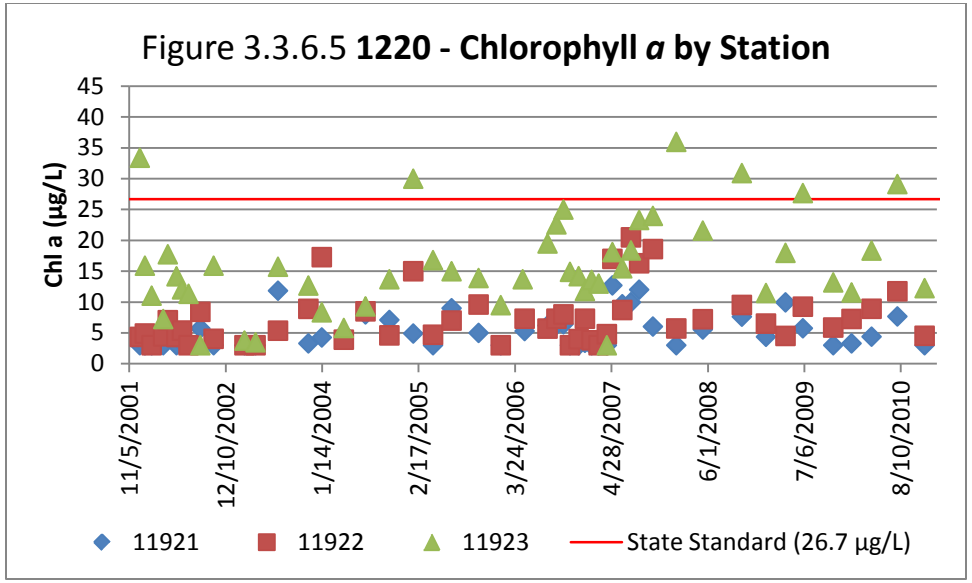
Segment **1222**, Proctor Lake proper, has two concerns for use, chlorophyll *a* and total phosphorus. These concerns can most likely be attributed to the agricultural and grazing landscape that surrounds the lake. While there is no impairment for bacteria in the lake itself, five of the six sub-segments have an impairment for bacteria, and the remaining have a concern for use classification. Segments **1222A**, **B**, **C**, and **E** have all been listed on the 303(d) list for these impairments. Analysis of historical data does not show a statistically significant trend in either direction for the levels of bacteria. The majority of these tributaries flow through rural land where farming is a common practice.

Segment **1221** has several impairments and concerns as well. Impairments for bacteria can be found in **1221** and **1221A**, **B**, **D**, **F**, all of which are listed on the 303(d) list. Segment **1221A** is also listed on the 303(d) list for depressed dissolved oxygen. As is common in this watershed, CAFOs are present as well as abundant wildlife in the land around the mainstem and its tributaries. **1221D**, Indian Creek (Figure 3.3.6.3), is one of the tributaries that may be influenced by these operations. The figure below illustrates the low flow and build up of macrophytes. The excessive growth of vegetation is a direct result of the bacteria and nutrients introduced into the stream. Segment **1221** has a statistically significant upward trend of both dissolved oxygen and chlorophyll *a*, both of which have a concern for use. As aquatic vegetation increases, the levels of dissolved oxygen may be pushed to extremes, causing this high significant trend. Segment **1221A** shows the opposite effect of vegetation (Figure 3.3.6.4) with a concern for use based upon the high level of chlorophyll *a* and an impairment based upon depressed dissolved oxygen. One improvement in this segment is the delisting of segment **1221C**, which was previously impaired for use due to high bacteria levels.

Figure 3.3.6.3. Segment1221D Indian Creek

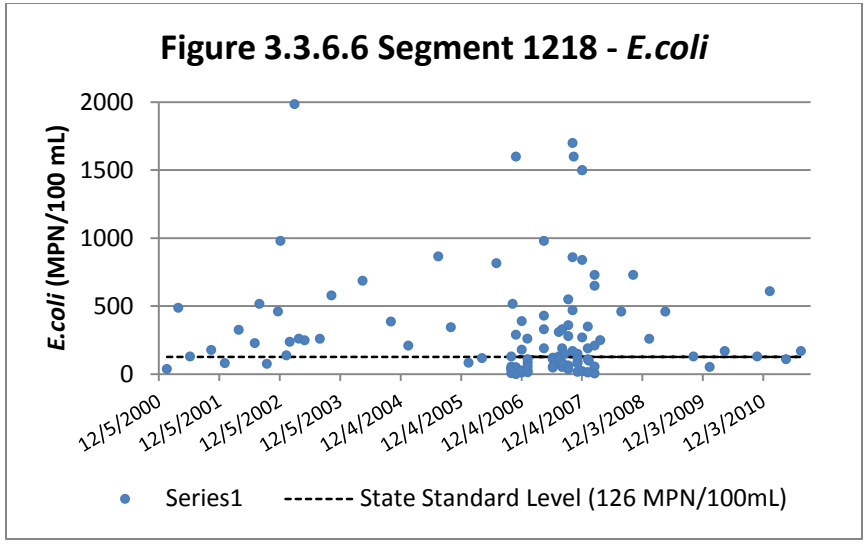


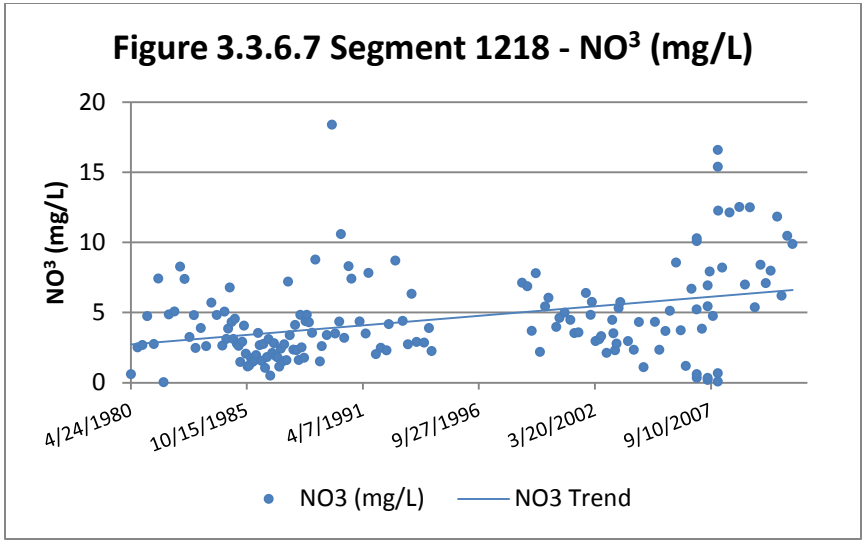
Segment **1220** is composed of Belton Lake and one sub-segment, Cowhouse Creek. There are no concerns or impairments on Belton Lake in regards to water quality. There is a historical trend downward in the level of bacteria detected in the lake, but conversely a statistically significant upward trend in chlorophyll *a*. This upward trend can be attributed to one site in particular, station 11923, the Leon River arm of Belton Lake. The levels of chlorophyll *a* at this specific location are, on average, higher that the other two stations that are located on the lake itself (Figure 3.3.6.5). Segment **1220A** is listed as impaired for bacteria and on the 303(d) list. This tributary flows through a largely rural area and is influenced by nonpoint source pollution most likely from agricultural land. While there is no concern for depressed dissolved oxygen, there is a statistically significant downward trend.



Segment **1219**, the Leon River below Belton Lake has no impairments, but a concern for nitrate and orthophosphate. As this segment of the watershed runs along the eastern side of Belton, much of the concern for these water quality parameters can be attributed to urban runoff, and other nonpoint source pollution.

Nolan Creek/South Nolan Creek (Segment **1218**) is on the 303(d) list based on high bacteria levels (Figure 3.3.6.6). This figure illustrates the 60% of bacteria samples that exceeded the state standard level, with four of these samples being above the 2000 MPN/100 mL level. This can be attributed to the highly urbanized area, Fort Hood, Killeen, Belton, and Harker Heights, and the runoff associated with it. Also, wastewater discharges and possibly poorly functioning septic systems are located along this segment, and can also contribute to the problems associated with elevated bacteria levels. Also associated with the nonpoint source and point source pollution concern for use levels of nitrate, orthophosphate, and total phosphorus have been detected. Nitrate levels in this segment are trending upward, and could lead to further problems in the system (Figure 3.3.6.7).





Special Studies:

RUAAs were completed for Nolan Creek/South Nolan Creek, **1218**; Leon River Below Proctor Lake, **1221**; Resley Creek, **1221A**; South Leon River, **1221B**; Pecan Creek, **1221C**; Indian Creek,**1221D**; Plum Creek, **1221E**; Walnut Creek, **1221F**; Duncan Creek, **1222A**; Sweetwater Creek, **1222E**; Leon River Below Leon Reservoir, **1223**; Armstrong Creek, **1223A**. The report is out for public comment.

Segment **1221**, the Leon River below Proctor Lake, was scheduled for a TMDL, but in 2006 the BRA was asked to take the lead in developing a WPP for the Leon River. As of right now a draft WPP has been developed and submitted to the EPA for approval. Routine monitoring is being conducted by the BRA in order to develop a long-term database of water quality. Please click here for more information on the Leon River Watershed Protection Plan that addresses issues in this segment. In Segment **1221A**, Resley Creek, a UAA in progress by the BRA

.

Biological Assessments:

Segment **1221A**, Resley Creek, an unclassified tributary of Leon River Segment 1221, has not been assigned an aquatic life use (ALU) or dissolved oxygen criteria by TCEQ. In the 305(b) process, the creek has been assessed using a minimal ALU and 24-hour dissolved oxygen criteria of 2.0 mg/L (average) and 1.5 mg/L (minimum), based on a presumption that the creek is intermittent without perennial pools.

Assessment unit 01 (AU_01), the lower 33 km of the creek, is the reach of interest due to its inclusion on the 2010 303(d) list for depressed dissolved oxygen (DO). The impairment is in Category 5c, meaning additional data are needed before further water quality regulatory actions are initiated. An Aquatic Life Assessment (ALA), the prescribed tool for addressing such situations, is a two-year study conducted on unclassified water bodies not in TSWQS Appendix D, identified in previous 305(b) assessments as not supporting the presumed ALU due to depressed DO. The purposes of an ALA are to verify indications of use nonsupport, and identify an appropriate ALU and corresponding DO criteria. Data collection requirements, outlined in SWQM Procedures Manual Volume 2, consist of four biological assessments (two during year 1 and two during year 2), five 24-hr. DO monitoring events during year 1, and two to five 24-hr. DO monitoring events during year 2 depending on year 1 results. Data discussed here represent 2010 (year 1) results of an ALA designed to provide needed information for Resley Creek AU_01.

Initially, 2002-2010 flow severity data from the TCEQ SWQMIS database were reviewed to characterize instream hydrology. At three monitoring sites in the lower portion of the creek (FM 2823, CR 392, and CR 394), many instances of no flow with pools have been recorded. In addition, there have been 12 instances where the streambed was dry, including four during the present study. Lack of water has been documented during six years of the 9-year period of record, identifying that as a typical, recurring hydrological condition. Dryness has most frequently been observed during the months of August - October. The analysis indicates that an “intermittent without perennial pools” hydrological classification is appropriate for Resley Creek AU_01.

Next, a rainfall analysis was performed to determine whether 2010 climatic conditions, and by inference, instream hydrology, were normal. Rainfall records examined included TWDB quadrangle 610 data for the 70-yr. period of 1940-2009, and 2010 data from the nearest official NWS rainfall gage at Waco, TX. The evaluation provides a general, area-wide indication, and only approximates conditions in the Resley Creek subwatershed given that the records are regional and derived from gages somewhat geographically removed. For the analysis, “percent of normal” represents recent totals divided by 70-yr. period-of-record totals. First, 2009 data were examined to provide an idea of antecedent hydrological conditions. The 2009 rainfall total (41.28 in.) was 126 percent of normal (32.89 in.), which implies that instream flows

were slightly above normal at the beginning of the ALA study period. Next, cumulative conditions for January - September 2010 were reviewed. The total for that nine-month period (35.17 in.) was 142 percent of normal (24.76 in.), implying that instream flows through the 2010 study period were somewhat higher than during most years. Finally, month-to-month rainfall conditions were examined for January - September 2010. As typifies the Texas climate, monthly totals were erratic. Based on percent-of-normal calculations, January and September were very wet (271-318 %); March, April, June, and July moderately wet (129-184 %); February moderately dry (57 %); and May and August very dry (19-21 %).

Intermittency developed in July 2010, despite the fact that the year, and particularly the months of June and July, were wetter than normal. This suggests that instream conditions during most years probably are harsher than during the 2010 study period. The development of midsummer intermittency during a wetter-than-normal year further supports an "intermittent without perennial pools" hydrological classification.

Two sites were assessed for the ALA - at FM 2823 south of Dublin (Station 17377), in the upper portion of the assessment unit; and at CR 392 northwest of Hamilton (Station 17477), in the lower portion. Initial assessments were conducted April 7-8, 2010, during the non-critical portion of the index period. Continuous flow had existed for at least one month, as indicated by site visits on March 9 and 23, and probably for at least four months, judging from a December 10, 2009 site visit and monthly rainfall patterns for January - April 2010. The duration of continuous flow in intermittent streams has a critical influence on colonization and establishment of aquatic assemblages, and in this case definitely should have been long enough to allow development of maximal biological integrity. As March and April were moderately wet months, instream flows during the April event probably were slightly above normal for the time of year. At FM 2823, flow was 1.63 cfs, DO concentrations rated exceptional, physical habitat and fish high, and benthic macroinvertebrates limited. At CR 392, flow was 5.9 cfs, DO concentrations rated exceptional, physical habitat high and benthic macroinvertebrates and fish intermediate.

A second set of 24-hr. DO data was collected in May, also during the non-critical portion of the index period. As a result of very little rainfall that month, instream flows were only 10-15% of levels observed in April, and probably were somewhat atypically low for the time of year. At FM 2823 on May 20-21, flow was 0.19 cfs, and DO concentrations reflected a limited ALU. At CR 392 on May 13-14, flow was 0.96 cfs, and DO concentrations attained an exceptional ALU.

A third set of 24-hr. DO data was collected on July 22-23, during the critical portion of the index period. Despite June and July being moderately wet months, there was no flow at either site. Sizeable pools were present at both locations, however. DO regimes within pools were very similar at the two sites, with concentrations achieving an intermediate ALU based on the 24-hr. mean, and a limited ALU based on the 24-hr. minimum.

The sites were revisited on August 25, also during the critical portion of the index period, with the intent of conducting a second round of biological assessments and a fourth round of 24-hr. DO monitoring. As in July, there was no flow at either site. Substantial drying had occurred, as August was an extremely hot, dry month. Only ephemeral, shallow, stagnant pools remained in the study reaches, one at FM 2823, and four at CR 392. At each location, pools occupied less than 20% of the study reach. Upon visual inspection, it was concluded that none of the pools constituted adequate habitat for supporting significant aquatic life, and no biological or 24-hr. DO data were collected.

The last 2010 visit was on September 22. A considerable amount of rain fell in the area on September 7-8 (3.55 inches at the NWS Stephenville gage), but soil moisture evidently was so low, due to an exceptionally dry month of August, that little surface runoff occurred. Hydrological conditions had not changed appreciably, as there still was no flow. Pools were not substantially larger, and again were judged to be inadequate for supporting significant aquatic life. As in August, no biological or 24-hr. DO data were collected.

Year 1 data collection objectives were not fully achieved, as only one set of biological data and three sets of 24-hr. DO data were generated. Sampling had to be curtailed after the July event due to drying and lack of sufficient water to support significant aquatic life or allow data collection to be performed. The level of accomplishment was dictated by stream hydrology.

Year 1 results indicate that when substantial flow is present (>1.5 cfs), as in April 2010, AU_01 is capable of supporting an exceptional ALU based on DO concentrations, a high ALU based on physical habitat, an intermediate-to-high ALU based on fish, and a limited-to-intermediate ALU based on benthic macroinvertebrates. At such flow levels, ecological conditions are relatively similar at the two sites, with all assessment components slightly to greatly exceeding a minimal ALU.

No biological data were collected at flows below 1.5 cfs, or during intermittent conditions. However, May DO concentrations at CR 392 infer that biological integrity similar to levels observed in April should be maintained at flows as low as 1 cfs. At extreme low flow, as observed at FM 2823 in May (0.19 cfs), DO concentrations are somewhat depressed, but cursory indications suggest that aquatic assemblages do not significantly deteriorate under those conditions.

Continued drying resulted in no flow by midsummer, which appears typical. As shown by the July datasets, DO levels hover in the limited-to-intermediate ALU range as long as sizeable pools persist, and levels of biological integrity similar to April probably are maintained. As drying progresses and pools shrink, aquatic assemblages undoubtedly deteriorate.

From an undetermined point in the latter stages of drying, down to dryness, the creek loses the capability to support significant aquatic life, as in August and September 2010.

Regarding the DO regime, concentrations in all 24-hr. monitoring events, encompassing different hydrological stages, exceeded a presumed minimal ALU, which contradicts the current 303(d) listing. All measurements were taken when the creek was flowing or when sizeable pools were present. Concentrations probably decline as pools shrink, although that has not been documented. No levels were observed that would be particularly stressful to aquatic life. Fish in habitats that experience cyclical DO depression, such as progressive hypoxia that develops during drying stages in intermittent streams, are able to behaviorally and physiologically acclimate and withstand extremely low concentrations. This was observed in another 2010 BRA study on Thompsons Creek in Brazos County, where high fish integrity was maintained in isolated pools that had extremely low DO concentrations.

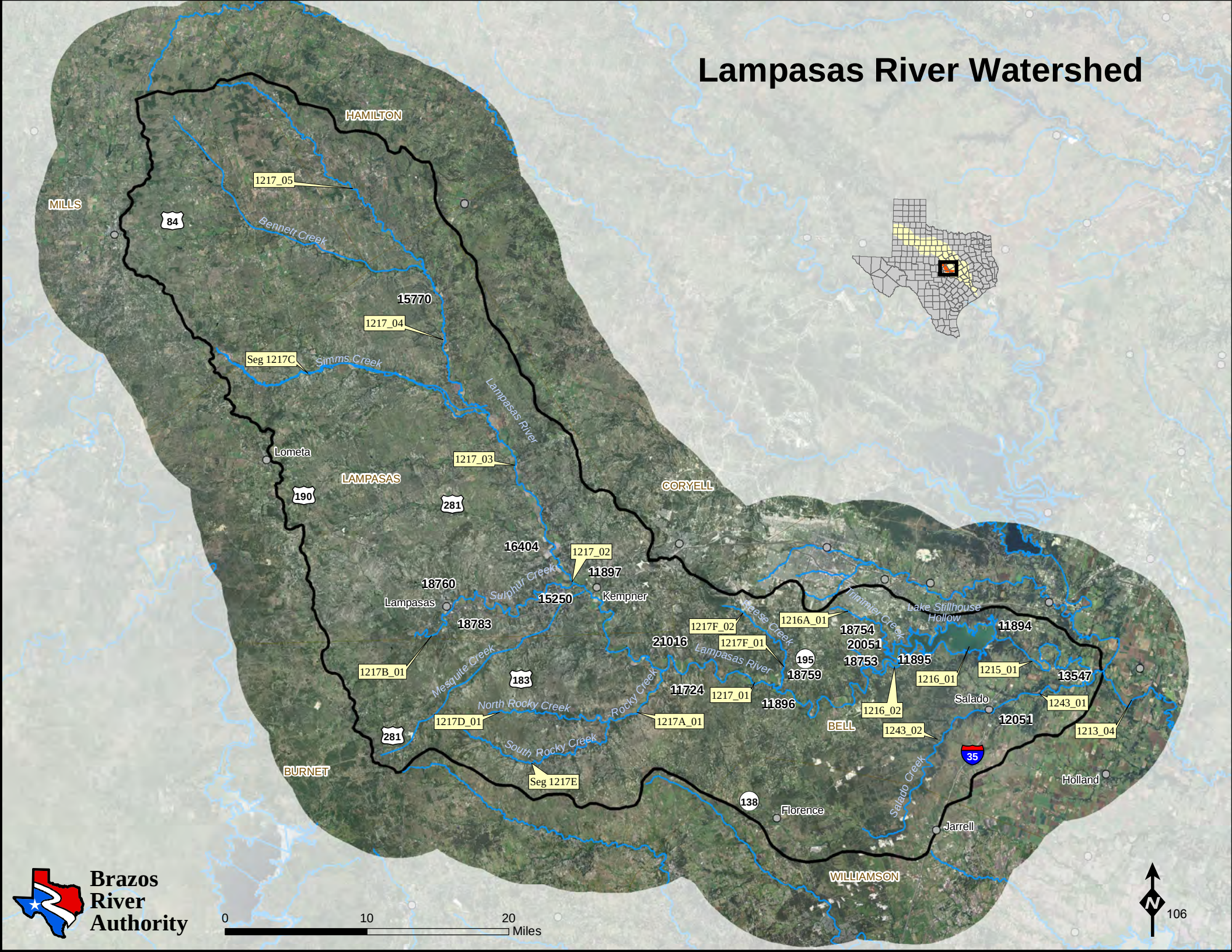
Intermittent stream ecology is very complex and dynamic, as hydrological changes continually induce variability. Factors that influence aquatic assemblages (and instantaneous biological assessment results) include spatial and temporal variability, types and proximities of refugia where aquatic life can survive during intermittency, and migrational mechanics through which recolonization occurs following resumption of flow. Other variables, particularly important during drying stages, include DO dynamics, temperature extremes, buildups of potentially harmful chemical concentrations, and biological interactions such as competition and predation. Characterizing biological integrity in such systems is difficult; however, year 1 ALA findings do provide a foundation for understanding basic conditions in Resley Creek. The results, probably reflecting slightly more favorable instream conditions than normal judging from rainfall patterns, showed that biological integrity exceeded a presumed minimal ALU when instream flows were >1.5 cfs. By late August, habitat sufficient for supporting significant aquatic life had been eliminated by drying, which may occur earlier in the summer during most years since June and July 2010 were wetter than normal. Year 1 results shed light on biological integrity during hydrological extremes, *i.e.,* substantial flow present versus essentially dry. Biological integrity was not characterized during intermediate hydrological conditions - when flows were extremely low or in isolated pools during intermittency - or during the critical portion of the index period to allow an evaluation of seasonal variability. Obviously, much remains to be learned. However, information to date suggests that a seasonal or flow-dependent ALU designation and DO criteria may ultimately be needed to descriptively account for conditions in Resley Creek.

Also in segment **1221**, Coryell Creek is schedule for a biological assessment in FY2012. Station 11804 is located 51 meters downstream of FM 107, approximately 1.9 KM upstream of the confluence of the Leon River.

Table 3.3.6.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria Impairment	Nearly 54% of the mainstem and tributary sites of the Leon River watershed	• Small rural tributaries, highly influenced by grazing pastures and very little flow. • WWTPs in urbanized and rural areas • Storm water runoff from CAFOs	• WPP in the process of being approved by the EPA for the Leon River Watershed. • RUAAs have been completed for many of the tributaries in the watershed, and are under review for publication. • Continue to conduct RUAAs to address all impairments in the system
DO Impairment	Resley Creek sub-watershed, and Leon River below Leon Reservior	• Agricultural land in sub-watershed • Runoff from permitted CAFOs • Municipal point source discharges	• ALA underway for Resley Creek • Additional 25-hr DO data for Leon below Leon Reservoir

Lampasas River Watershed



3.3.7 Lampasas Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
1,502 mi^2	17	BRA, TCEQ	6	Cities of Lampasas, Salado, Florence, Copperas Cove; Central Texas WSC	1215, 1216, 1217, 1243

Description of Segments:

1215: Lampasas River Below Stillhouse Hollow Lake – From the confluence with Leon River in Bell County to Stillhouse Hollow Lake Dam in Bell County.

Segment Length: 17 miles
Assessment Units (Stations): 1215_01 (11893, 13547)

1216: Stillhouse Hollow Lake – From Stillhouse Hollow Lake Dam in Bell County to a point immediately upstream of the confluence of Rock Creek in Bell county, up to normal pool elevation of 622 feet msl. (impounds Lampasas River)

Segment Area: 6,430 acres at top of conservation pool
Assessment Units (Stations): 1216_01 (11894, 14058, 18752, 18753, 18756, 18757, 18758, 20049), 1216_02 (20046, 20047, 20048), 1216_03 (None), 1216_SA1 (20051, 20052)

Unclassified Segments: **1216A**: Trimmier Creek, **1216B**: Onion Creek
Assessment Units (Stations): 1216A_01 (18754, 20050), 1216B_01 (18755)

1217: Lampasas River Above Stillhouse Hollow Lake – From point immediately upstream of the confluence of Rock Creek in Bell County to FM 2005 in Hamilton County

Segment Length: 94 miles
Assessment Units (Stations): 1217_01 (11895, 11896, 18761), 1217_02 (11897), 1217_03 (16404), 1217_04 (15770), 1217_05 (15762)

Unclassified Segments: **1217A**: Rocky Creek, **1217B**: Sulphur Creek, **1217C**: Simms Creek, **1217D**: North Rocky Creek, **1217E**: South Rocky Creek, **1217F**: Reese Creek

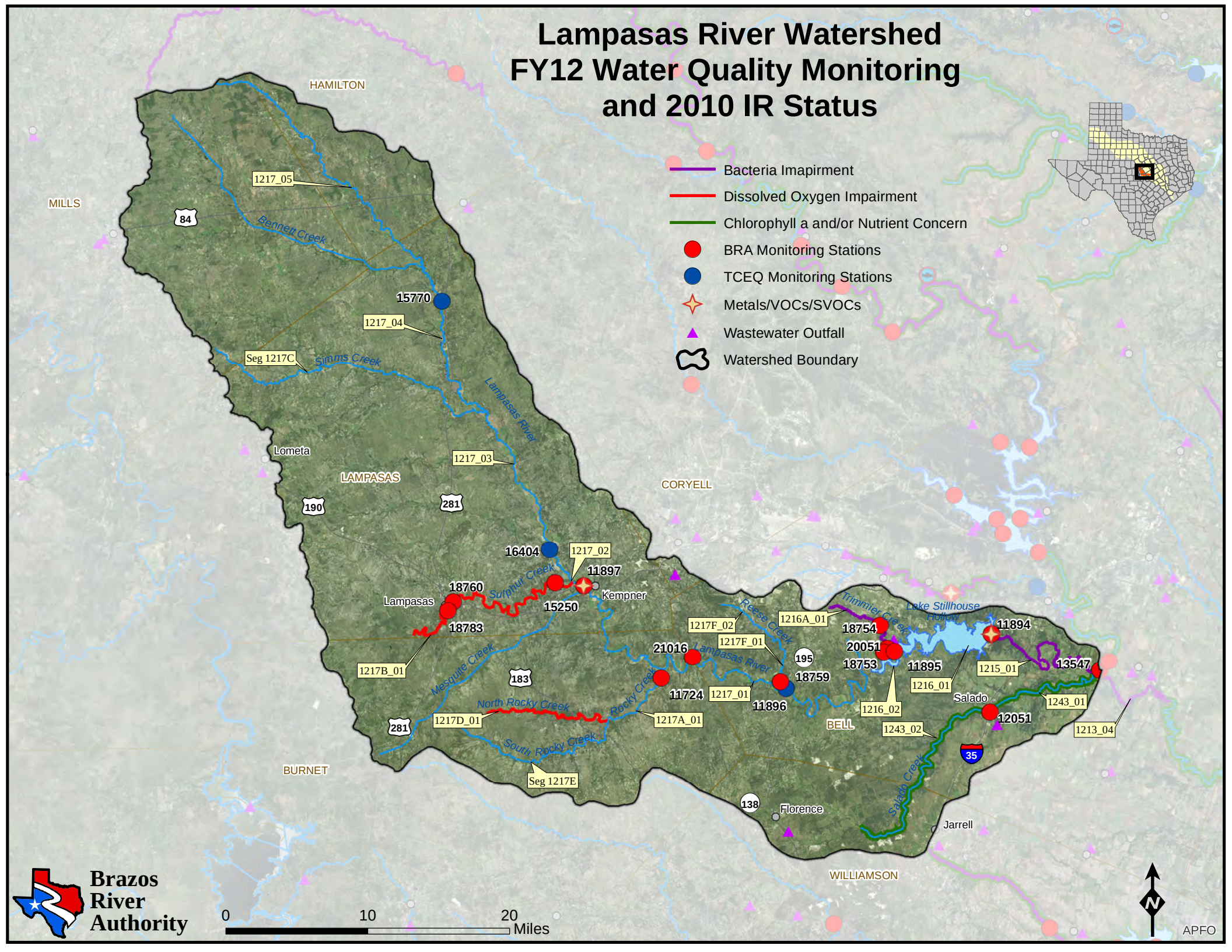
Assessment Units (Stations): 1217A_01 (11724, 18330, 18331, 18332), 1217B_01 (15250, 15781, 15782, 16358), 1217B _02 (15766, 15780, 18760, 18782, 18783, 18787), 1217C_01 (None), 1217D_01 (18334, 18656), 1217E_01 (11725, 18333, 18657), 1217F_01 (18759, 18850)

1243: Salado Creek – From the confluence with the Lampasas River in Bell County to the confluence of North/South Fork Salado Creek in Williamson County

Segment Length: 27 miles

Assessment Units (Stations): 1243_01 (12045, 12047, 12049, 12050, 12051), 1243_02 (11760, 12052, 12053, 20306)

Lampasas River Watershed FY12 Water Quality Monitoring and 2010 IR Status



Brazos River Authority

Table 3.3.7.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Lampasas Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1215	**Lampasas River below Stillhouse Hollow Dam**	**PCR**	**H**	**100↓**	**60**	**400**	**5.0/3.0**	**6.5-9.0**	**126**	**91**		**0.33↓**	**1.95↑**	**0.37**	**0.69**	**14.1↑**
1216	**Stillhouse Hollow Lake**	**PCR**	**E**	**100**	**75**	**500**	**6.0/4.0**	**6.5-9.0**	**126↓**	**93**	**26.70↑**	**0.11↓**	**0.37**	**0.05**	**0.20**	
1216A	Trimmier Creek	PCR	H	100	75	500	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.41
1216B	Onion Creek	PCR	M	100	75	500	2.0/1.5	6.5-9.0	126	93		0.11	0.37	0.05	0.20	14.14
1217	**Lampasas River Above Stillhouse Hollow Lake**	**PCR**	**H**	**500**	**100**	**1200↓**	**5.0/3.0↑**	**6.5-9.0**	**126**	**91**		**0.11↓**	**0.37↑**	**0.05↓**	**0.69**	**14.1**
1217A	Rocky Creek	PCR	L	500	100	1200	3.0/2.0	6.5-9.0	126	91		0.11	0.37↑	0.05	0.69	14.1
1217B	Sulphur Creek	PCR	H	500	100	1200	5.0/3.0	6.5-9.0↓	126	91		0.11	0.37	0.05	0.69	14.1
1217C	Simms Creek	PCR		500	100	1200	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.69	14.1
1217D	North Rocky Creek	PCR	L	500	100	1200	3.0/2.0	6.5-9.0	126	91		0.11	0.37	0.05	0.69	14.1
1217E	South Rocky Creek	PCR	L	500	100↓	1200	3.0/2.0	6.5-9.0	126	91↑		0.11	0.37	0.05	0.69	14.1
1217F	Reese Creek	PCR	H	500	100	1200	5.0/3.0	6.5-9.0	126	91		0.11	0.37	0.05	0.69	14.1
1243	**Salado Creek**	**PCR**	**H**	**50**	**50**	**400**	**5.0/3.0**	**6.5-9.0**	**126**	**90**		**0.11**	**0.37**	**0.05**	**0.69**	**14.1**

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

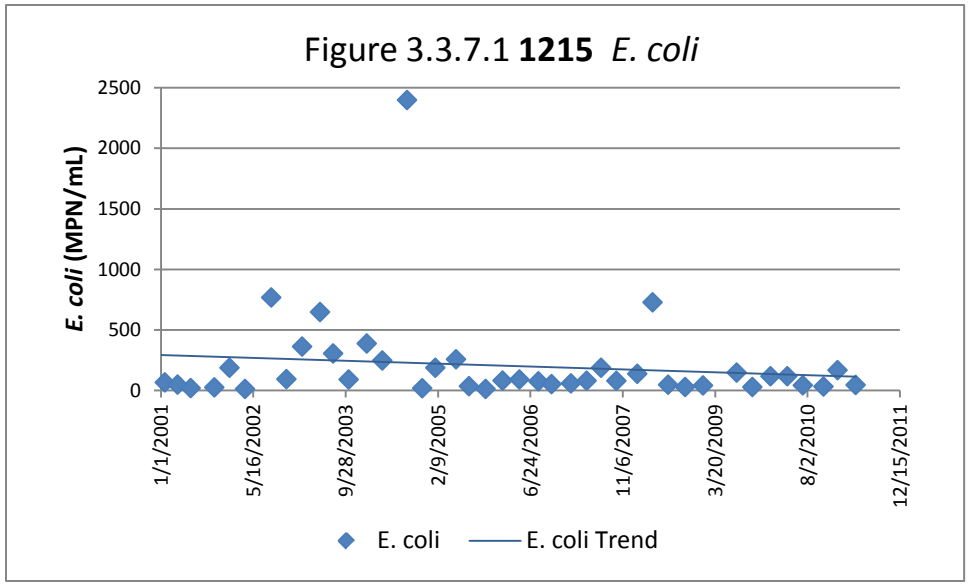
↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Lampasas Watershed

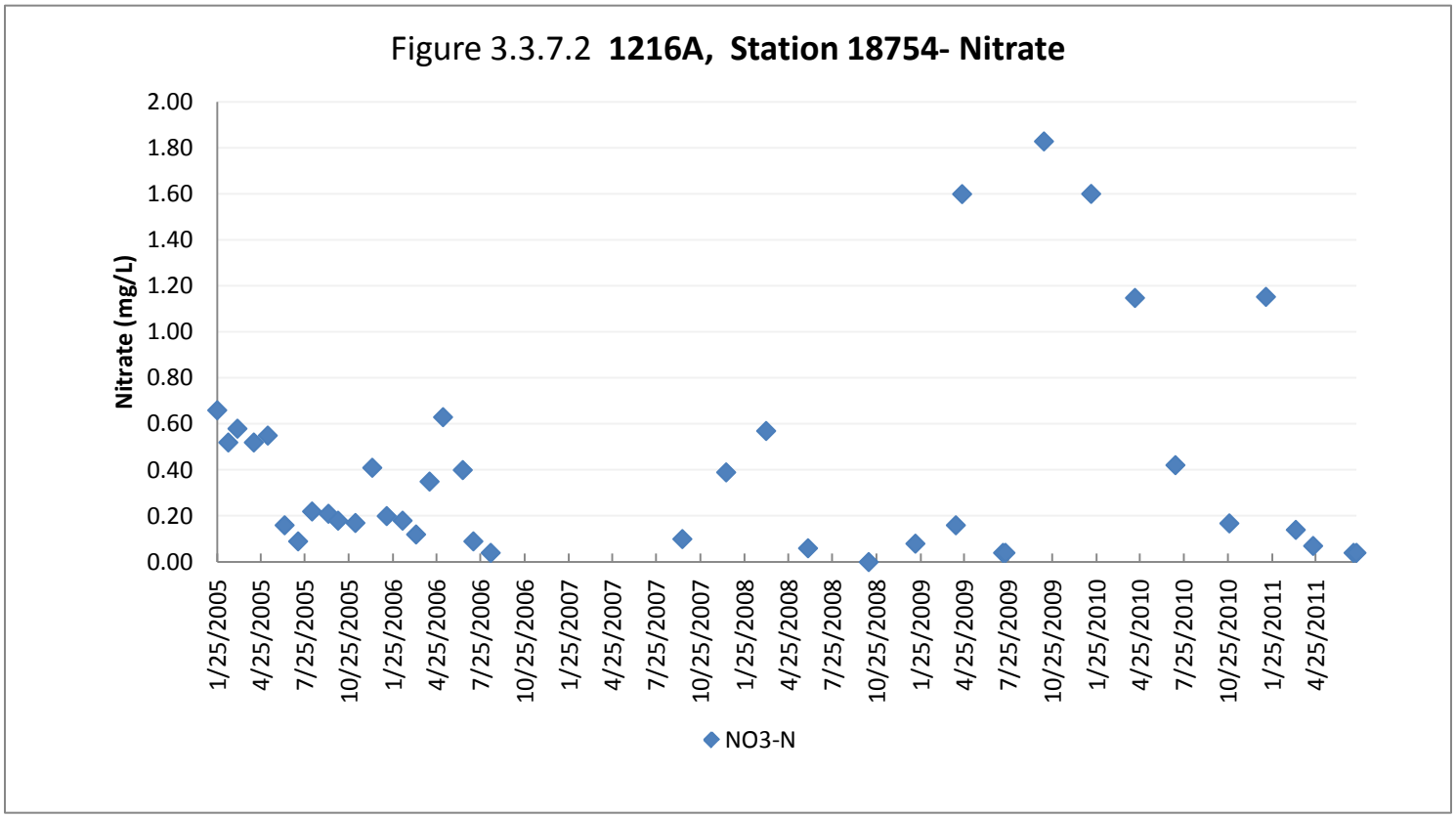
The headwaters of the Lampasas River are west of the City of Hamilton. The river courses through Lampasas, Burnett, and Bell counties before being impounded by Stillhouse Hollow Dam. Salado Creek drains into the Lampasas below the dam, and then confluences with the Leon River to form the Little River. The Land use in the Lampasas River watershed is predominantly agricultural, although rapid development continues around Kempner, Coppers Cove, Killeen, and Harker Heights. Much of the Lampasas River has heavily vegetated banks and is characterized by low-flow conditions much of the time.

Segment **1215,** the Lampasas River below Stillhouse Hollow Reservoir was assessed in 2010 as not supporting for bacteria. The bacteria geomean assessed was 126.7, 0.7 above the standard. Station 13574 which is used to assess segment **1215** has been monitored since 2001. Figure 3.3.7.1 shows bacteria at this site trending down and will likely be fully supporting as more data is collected.



The 2010 assessment identified concerns for elevated bacteria levels and an impaired macrobenthic community for Trimmier Creek (**1216A**). Routine water quality monitoring at Trimmier Creek revealed excessive sedimentation beginning in April 2005. Aquatic life monitoring was implemented in 2006 to determine if biological impacts were occurring, and to provide data for the 305(b) assessment. Physical habitat and macrobenthic assemblage impairments were observed in 2006-07, and were attributed to excessive sedimentation resulting from wide scale land clearing in the watershed. All components of aquatic life monitoring events, conducted in 2009 and 2011, met or exceeded high ALU criteria. A degree of recovery from sediment related impacts was supported by updated analysis of TSS and transparency data, but routine monitoring indicates that recovery is incomplete. Recent development in the watershed may be increasing nutrient input through urban runoff, as indicated by nitrate levels (Figure 3.3.7.2). Increased nutrient levels stimulate attached algae growth, which was minimal in 2006

(Figure 3.3.7.3) but much more prevalent in 2011 (Figure 3.3.7.4). There are no point source wastewater discharges to the creek, implying that urban runoff from rapid development in the watershed is the probable source of nutrients and may become a concern in the future. Downstream transport of contaminants could cause degradation of water quality in Stillhouse Hollow Reservoir.

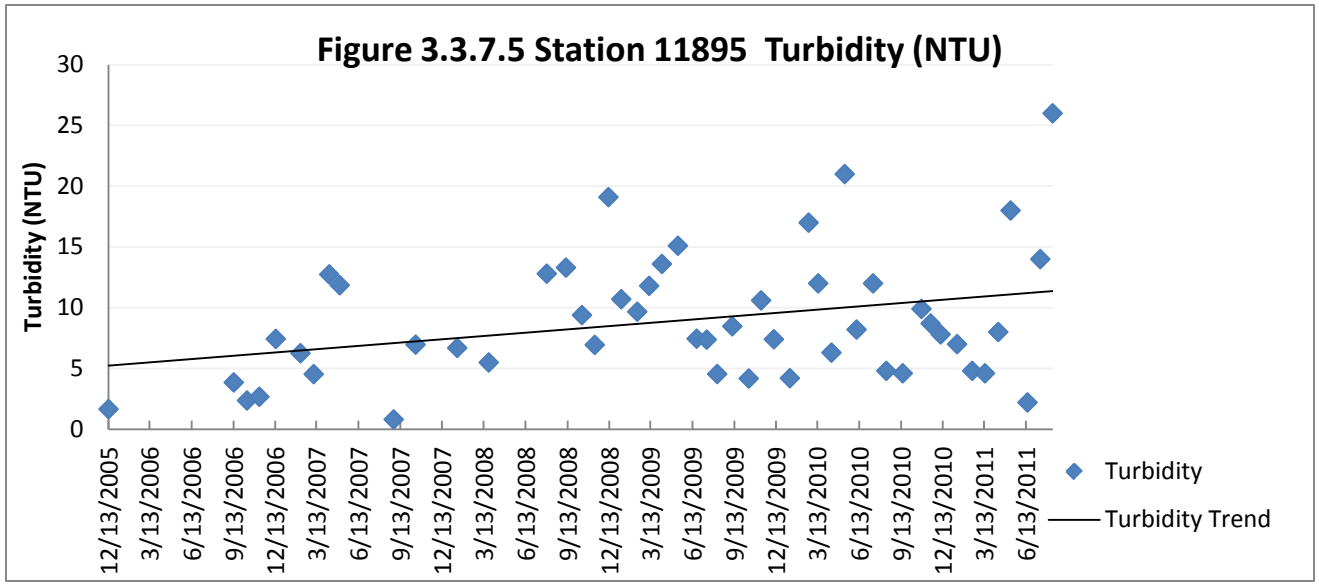


Of 100 reservoirs TCEQ evaluated in the 2010 305(b) assessment, Stillhouse Hollow Reservoir (Segment **1216**) ranked as the clearest lake in the state based on Secchi transparency. An analysis of turbidity data from Station 11895, the first monitoring site down lake from the mouth of Trimmier Creek, shows a significant increase since 2005 (Figure 3.3.7.5). Regression analysis indicating decreased transparency and increased chlorophyll *a* may be representing a rise in primary production of the reservoir. This is likely attributed to a combination of nutrient inputs from development around the lake and natural eutrophication. Revision of the 2010 Water Quality Standards decreased Stillhouse Hollow Reservoir

chlorophyll *a* standard from 26.70 µg/L to 5.0 µg/L. Data suggest that even at the more stringent levels this segment will still be below the criteria.

Figure 3.3.7.3 Transect 3 looking downstream, Trimmier Creek at Chaparral Road, April 2006.

Figure 3.3.7.4 Transect 1 looking upstream, Trimmier Creek at Chaparral Road, March 2011.



Sulphur Creek (**1217B**) is newly listed in the 2010 IR as being impaired for depressed dissolved oxygen. The impairment is specific to Sulphur Creek from the confluence with Burleson Creek upstream to the confluences with Donalson Creek and Espy Branch west of Lampasas in Lampasas County. Low dissolved oxygen may be a result of anoxic groundwater influx from the many springs that feed in to the stream.

Segment **1217D** North Rocky Creek was listed as impaired on the 2004 303(d) list for depressed dissolved oxygen levels. The 2010 TCEQ Water Quality Standards assigned North Rocky Creek site specific criteria for 24-hr dissolved oxygen. Data suggest that in the 2012 assessment this segment may meet the site specific criteria and be delisted.

Segment **1243**, Salado Creek, exceeds nitrate screening levels in 89 percent of samples between 2004 and 2010. Nitrate levels have not increased over time, suggesting that this system is stable. All components of aquatic life monitoring conducted in 2008 met or exceeded high ALU criteria.

Special Studies:

The Lampasas River Watershed Protection Plan process has begun to address bacteria issues in the watershed as segment **1217** had previously been listed as impaired for bacteria. For more information visit the web site at www.lampasasriver.org .

Biological Assessments:

Segment **1217**, the Lampasas River above Stillhouse Hollow Lake, has a designated high aquatic life use (ALU), and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). The stream was assessed at US 190 near Kempner, Station 11897, on June 16-17 and August 26-27, 2010. The objective was to evaluate ALU attainment, in light of potential threats indicated by concerns for bacteria in portions of the segment, and excessive algal growth below Sulphur Creek, which enters 1.7 km above the site.

In the first event, during the non-critical portion of the index period, dissolved oxygen concentrations and fish achieved an exceptional ALU, and physical habitat and benthic macroinvertebrates a high ALU.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 6/16/10 physical habitat data, which reflected achievement of

a high ALU, were re-utilized. Dissolved oxygen concentrations, fish, and benthic macroinvertebrates achieved an exceptional ALU.

Whereas all components of the assessments met or exceeded high ALU expectations, nutrient enrichment was indicated by dense filamentous algae growth. However, associated effects were not severe, as diel dissolved oxygen fluctuations were relatively narrow and fish and benthic macroinvertebrate assemblages were not impaired.

An abnormality occurred in August, when a benthic macroinvertebrate disease outbreak was observed. Nineteen of the 29 taxa, and 30.9% of the specimens, had dark-colored tissue necrosis on parts of the body. The disorder is believed to be a fungal infection, caused by some type of sediment-related stressor which compromises benthic organisms' immunity. Similar outbreaks were observed in the North Bosque River and Trimmier Creek in 2009. The condition evidently is episodic rather than chronic, but is virulent and ultimately results in substantial mortality. Although benthic integrity in the Lampasas wasn't perceptibly degraded at the time of sampling, severe impairment may have eventually occurred before the outbreak ran its course. Research is needed to characterize the disease and identify environmental stressors that trigger it.

Segment **1243**, Salado Creek, has a designated high aquatic life use, and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). Biological assessments were conducted at a site located 418 m upstream of IH 35 near Salado, Station 20306, on 4/15-16/08 and 8/11-12/08. The purpose was to evaluate the current condition of aquatic life in the river, in relation to public concern over the expansion of rock quarry operations in the watershed and the potential for instream impacts.

In the initial event, during the non-critical portion of the index period, dissolved oxygen concentrations, fish, and benthic macroinvertebrates achieved an exceptional aquatic life use, and physical habitat a high aquatic life use.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 4/15/08 physical habitat data, which reflected achievement of a high aquatic life use, were re-utilized. Dissolved oxygen concentrations, fish, and benthic macroinvertebrates again achieved an exceptional aquatic life use.

All biological components of the assessments exceeded expectations for the stream, and indicated healthy environmental conditions and lack of discernible impacts from rock quarry operations or any other sources. The data will provide a

baseline for assessing future water quality conditions. The findings suggest that upgrading of the designated aquatic life use from high to exceptional should be considered.

Segment **1216A**, Trimmier Creek has been monitored for aquatic life biennially since 2007 to identify impacts of excessive sedimentation. Aquatic life assessment conduced in 2006-07 showed impairments to physical habitat and macrobenthic assemblage. An analysis of water quality monitoring data verified excessive sediment inputs. The fish assemblage wasn't noticeably affected, so adverse effects evidently were restricted to the streambed, in relation to deposition of large amounts of fine solids. All components met or exceeded high ALU expectations during follow-up assessments in 2009. A degree of recovery from sediment-related impacts was further reflected by an updated analysis of TSS and Secchi transparency data. Results of current assessments in March and July 2011 parallel 2009 findings in that all components met or exceeded high ALU expectations. Cumulative data show that sedimentation and associated instream impacts peaked around September 2007, and have diminished to some extent since then.

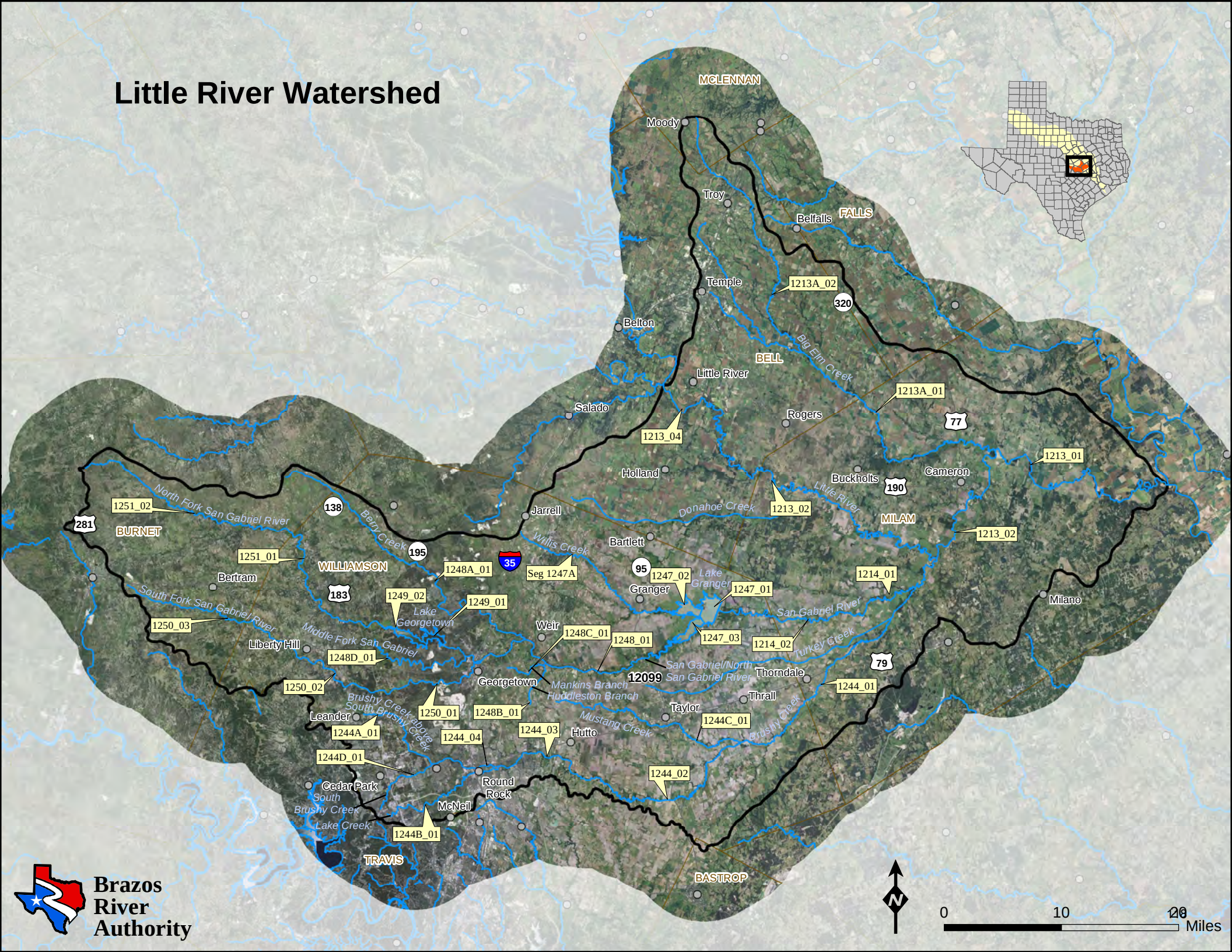
Additional concerns have been identified. One is the occurrence of macrobenthic disease outbreaks observed on two occasions. The disease, thought to be a type of fungal infection, produces dark-colored lesions and severe tissue necrosis, and affects most taxa. Nineteen percent of the individuals were infected in April 2009, and 44% in July 2011. Although episodic rather than chronic, the infection is virulent and appears to cause significant mortality. The probable cause is compromised immunity resulting from an unidentified environmental stressor, which appears to be associated with bottom sediments since fish haven't been affected. Although macrobenthic integrity was not significantly impaired in either sample, a potential for periodic recurrence and severe impact exists. The dynamics are not presently understood, and research is needed to characterize the disease, identify environmental stressors that trigger it, and determine assemblage-level effects. BRA currently is collaborating with an invertebrate disease specialist at the University of Texas at Arlington in an attempt to identify the pathogen, a first step toward understanding the problem.

A second concern involves downstream transport of contaminants and potential water quality degradation in Stillhouse Hollow Lake. Further increases in nutrient loading may also impact the reservoir by stimulating excessive primary production, which could affect recreational use, aquatic life integrity, and palatability of domestic raw water supplies.

Table 3.3.7.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria	Lampasas River below Stillhouse Hollow and Trimmier Creek	• Storm water runoff from rural sources	• More data collection.
Depressed Dissolved Oxygen	Sulphur Creek and North Rocky Creek	• Ground water, spring influence	• Site specific criteria set for North Rocky Creek. • Determine if DO Criteria for Sulphur Creek is appropriate

Little River Watershed



Brazos River Authority

3.3.8 Little River Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
2,351 mi^2	28	BRA, TCEQ	36	City of Round Rock, City of Georgetown, City of Hutto, City of Liberty Hill, City of Temple, City of Cameron	1213. 1214, 1244, 1247, 1248, 1249, 1250, 1251

Description of Segments:

1213: **Little River** – from the confluence with the Brazos River in Milam County to the confluence of the Leon River and the Lampasas River in Bell County

Segment Length: 108 miles
Assessment Units (Stations): 1213_01 (11888, 20526), 1213_02 (17499), 1213_03 (13544), 1213_04 (16409)

Unclassified Segment: **1213A**: Big Elm Creek, **1213B**: Little Elm Creek, **1213C**: Unnamed tributary of Little Elm Creek
Assessment Units (Stations): 1213A_01 (16385), 1213A_02 (None), 1213B_01 (13537, 13538), 1213B_02 (None), 1213C_01 (13536, 13539, 13540)

1214: **San Gabriel River** – from the confluence with the Little River in Milam County to Granger Lake Dam in Williamson County

Segment Length: 33 miles
Assessment Units (Stations): 1214_01 (11892), 1214_02 (13648, 17652)

1244: **Brushy Creek** – from the confluence with the San Gabriel River in Milam County to the confluence of South Brushy Creek in Williamson County

Segment Length: 68 miles
Assessment Units (Stations): 1244_01 (12056), 1244_02 (12058), 1244_03 (12060), 1244_04 (12067, 12068)

Unclassified Segments: **1244A**: Brushy Creek above South Brushy Creek, **1244B**: Lake Creek, **1244C**: Mustang Creek, **1244D**: South Brushy Creek

Assessment Units (Stations): 1244A_01 (11731, 17374, 18659), 1244B_01 (17375), 1244C_01 (None), 1222D_01 (11735)

1247 **Granger Lake**– from Granger Dam in Williamson County to a point 1.9 kilometers (1.2 miles) downstream of SH 95 in Williamson County to North San Gabriel Dam in Williamson County

Segment Area: 4,525 acres
Assessment Units (Stations): 1247_01 (12095, 13868), 1247_02 (12097), 1247_03 (12096, 13872)

Unclassified Segments: **1247A**: Willis Creek
Assessment Units (Stations): 1247A_01 (11573, 20305)

1248 **San Gabriel/North Fork San Gabriel River**– from a point 1.9 kilometers (1.2 miles) downstream of SH 95 in Williamson County to North Fork San Gabriel Dam in Williamson County

Segment Length: 24miles
Assessment Units (Stations): 1248_01 (12099, 12102, 12106, 12108, 13692)

Unclassified Segments: **1248A**: Berry Creek, **1248B**: Huddleston Branch, **1248C**: Mankins Branch, **1248D**: Middle Fork San Gabriel River
Assessment Units (Stations): 1248A_01 (11572, 13496), 1248B_01 (17052), 1248C_01 (13497, 17051), 1248D_01 (15754, 18734)

1249 **Lake Georgetown**– from North San Gabriel Dam in Williamson County to a point 6.6 kilometers (4.1 miles) downstream of US 183 in Williamson County, up to the normal pool elevation of 791 feet (impounds North Fork San Gabriel River)

Segment Area: 1,668 acres
Assessment Units (Stations): 1249_01 (12111), 1249_02 (12113)

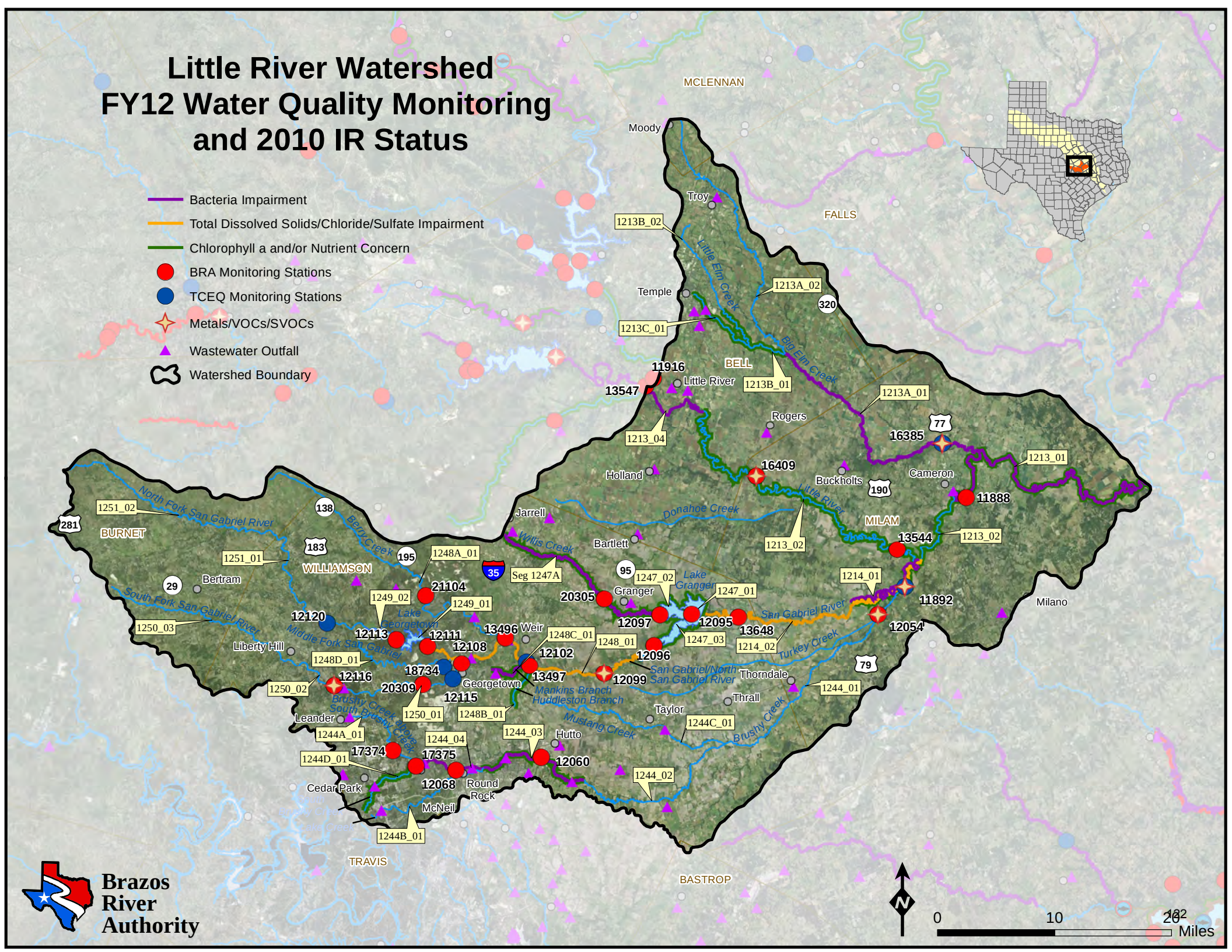
1250 **South Fork San Gabriel River**– from the confluence with the North Fork San Gabriel River in Williamson County to the most upstream crossing of SH 29 in Burnet County

Segment Length: 41 miles
Assessment Units (Stations): 1250_01 (12114; 12115; 20309), 1250_02 (12116), 1250_03 (12117)

1251 **North Fork San Gabriel River**– from a point 6.6 kilometers (4.1 miles) downstream of US 183 in Williamson County to the confluence of Allen Branch in Burnet County

Segment Length: 42 miles
Assessment Units (Stations): 1251_01 (12120, 13676), 1251_02 (12122)

Little River Watershed FY12 Water Quality Monitoring and 2010 IR Status



Brazos River Authority

Table 3.3.8.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Little River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1213	**Little River**	**PCR**	**H**	**75**	**75**	**400**	**5.0/3.0**	**6.5-9.0**	**126**	**90**		**0.33↓**	**1.95**	**0.37↓**	**0.69↓**	**14.1↑**
1213A	Big Elm Creek	PCR	H	75	75	400	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37	0.69	14.1
1213B	Little Elm Creek	PCR	H	75	75	400	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37	0.69	14.1
1213C	Unnamed Tributary	PCR	H	75	75	400	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37	0.69	14.1
1214	**San Gabriel River**	**PCR**	**H**	**50↑**	**45**	**500↑**	**5.0/3.0**	**6.5-9.0↑**	**126**	**91**		**0.33**	**1.95↑**	**0.37↑**	**0.69↑**	**14.1**
1244	**Brushy Creek**	**PCR**	**H**	**200↓**	**150↓**	**800↓**	**5.0/3.0**	**6.5-9.0**	**126↑**	**91**		**0.33**	**1.95↑**	**0.37**	**0.69↑**	**14.1**
1244A	Brushy Creek above South Brushy Creek	PCR	H	200↑	150↑	800	5.0/3.0↓	6.5-9.0	126	91		0.33	1.95↑	0.37	0.69	14.1
1244B	Lake Creek	PCR	H	200	150	800	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1244D	South Brushy Creek	PCR	H	200↑	150↑	800↑	5.0/3.0	6.5-9.0	126	91		0.33	1.95	0.37	0.69	14.1
1247	**Granger Lake**	**PCR**	**H**	**50↑**	**50↑**	**400**	**5.0/3.0**	**6.5-9.0↑**	**126**	**90↓**	**11.72↑**	**0.11↑**	**0.37**	**0.05**	**0.20**	**26.7↑**
1247A	Willis Creek	PCR	H	50	50↓	400	5.0/3.0	6.5-9.0	126	90		0.11	0.37↓	0.05	0.20	26.7
1248	**San Gabriel/North Fork San Gabriel**	**PCR**	**H**	**50↑**	**50↑**	**350**	**5.0/3.0**	**6.5-9.0**	**126**	**95**		**0.33**	**1.95↑**	**0.37**	**0.69**	**14.1↑**
1248A	Berry Creek	PCR	H	50	50	350	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1248B	Huddleston Branch	PCR	H	50	50	350	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1248C	Mankins Branch	PCR	H	50↑	50↑	350	5.0/3.0	6.5-9.0↑	126	95		0.33	1.95↑	0.37	0.69	14.1↑
1248D	Middle Fork San Gabriel River	PCR	H	50	50	350	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1249	**Lake Georgetown**	**PCR**	**H**	**50↑**	**50**	**350**	**5.0/3.0**	**6.5-9.0**	**126**	**90**	**5.00↑**	**0.11↑**	**0.37**	**0.05↓**	**0.20**	**26.7↑**

Little River Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1250	**South Fork San Gabriel**	**PCR**	**H**	**50↑**	**50↑**	**350↑**	**5.0/3.0**	**6.5-9.0**	**126**	**95**		**0.33↓**	**1.95**	**0.37**	**0.69**	**14.1**
1251	**North Fork San Gabriel**	**PCR**	**H**	**50↑**	**50**	**400**	**5.0/3.0**	**6.5-9.0**	**126**	**91**		**0.33↓**	**1.95**	**0.37**	**0.69**	**14.1**

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Little River Watershed

The Little River watershed drains approximately 2,349 square miles, includes Lake Georgetown and Lake Granger and crosses three ecoregions, the Central Texas Plateau, the Texas Blackland Prairie, and the East Central Texas Plains. The western portion of this watershed is experiencing rapid urban development while the eastern portion of the watershed remains fairly rural. Rapid urban development can bring additional land application of fertilizers, pesticides, pet waste, septic systems, and new sewage outfalls can result in increased concentrations of nutrients, bacteria, and organic constituents in the waterbody. Data collected recently indicated that the water quality in the watershed overall is good and that most segments support their designated use classifications.

The 2010 IR identified two recreational use impairments, three nutrient concerns and four improvements to the assessed level of support for the assessment units of Segment **1213**, Little River (Figure 3.3.8.1). Two assessment units, 1213_01 and 1213_04, are listed as impaired for non-supporting of recreational uses. This is a new impairment for 1213_04 and a repeat impairment for 1213_01, which was also identified as impaired on 2008 303(d) List. Both AUs are categorized as 5c waterbodies indicating that they do not support their designated recreational use and require additional data collection to confirm the impairment before a TMDL will be scheduled. Evaluation of more recent data confirms the non-supporting classification for both 1213_01 and 1213_04, with geomeans of 151 and 147, respectively.

Figure 3.3.8.1. Little River at FM

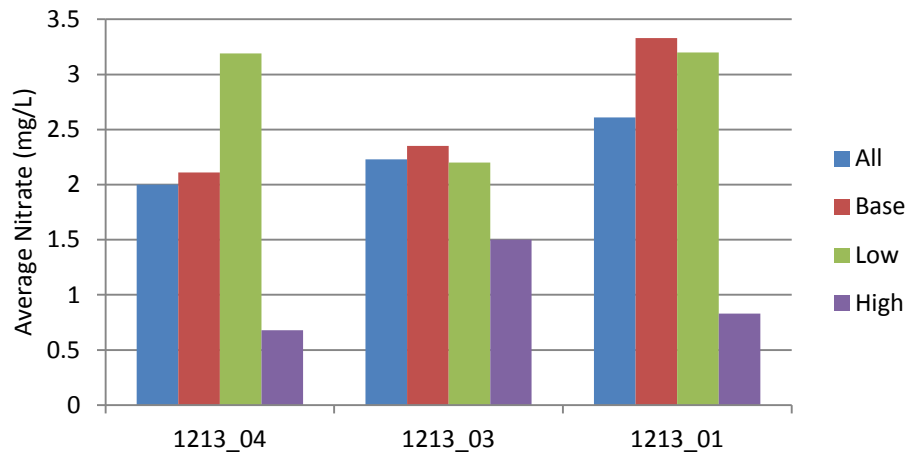
Recreational use support showed improvement from 2008 to 2010 in the middle two assessment units, 1213_02 and 1213_03, with 1213_02 status being revised from non-supporting to fully supporting and 1213_03 being revised from a concern for near non-attainment to fully supporting. Analysis of more recent data continues to support these noted improvements and it is anticipated that will continue to be categorized as fully supporting.

Segment **1213** also has concerns for nutrient enrichment. AUs 1213_01, 1213_02 and 1213_03 were all identified in the 2010 IR as having concerns for nitrate nitrogen. Analysis of more recent data confirms these concerns still exist for AUs 01-03 and indicates that a concern for 1213_04 is likely to be identified in the 2012 IR. Additionally, long-term data analysis indicates a statistically significant increasing trend in nitrates ($p<0.005$, $\alpha = 0.05$).

The actual source of the nutrients (whether of wildlife, livestock or human origin) is difficult to determine based on the wide use of nutrient containing compounds and their presence in municipal discharges. To identify potential sources for each AU, nutrient concentrations were compared to daily mean discharge values at each monitoring location. When nutrient values are compared to the flow regime components (base flow – 25th-75th percentile of all flow data from the period of record for the site, high flow - >75th percentile, and low flow - <25th percentile).

In all AUs, nitrate concentrations are highest at base and low flows and are decline at high flows indicating that the primary source of nitrates is most likely point source discharges (Figure 3.3.8.2). Despite agriculture being the dominant land use in the watershed, nonpoint source inputs of nitrate from stormwater runoff appear to be a small contributor to the segments nitrate concerns.

Figure 3.3.8.2 **1213 Nitrate by Flow Regime Component**



Trend analysis of other nutrient parameters indicates statistically significant decreasing trends in total phosphorus ($p = 0.002$, $\alpha = 0.05$), orthophosphate ($p = 0.002$, $\alpha = 0.05$) and ammonia ($p = 0.0005$, $\alpha = 0.05$) and no identifiable change in TKN concentration was identified over time. The decreasing trends in phosphorus compounds and ammonia are most likely a result of improved wastewater treatment practices.

Three unclassified streams have been assessed in Segment 1213, 1213A – Big Elm Creek, 1213B – Little Elm Creek and 1213C – Unnamed tributary of Little Elm Creek. Big Elm Creek was assessed from 2004 through 2008, is impaired for bacteria and is categorized as 5b waterbody, a review of the recreational use standard for this waterbody will be conducted before a TMDL is scheduled. Potential sources of bacteria include nonpoint source runoff from agricultural lands and wastewater discharges. Little Elm Creek currently has no impairments or concerns. The unnamed tributary of Little Elm Creek is identified as having a concern for impaired habitat in the 2010 IR, but no additional information regarding this determination is provided in the IR and a review of water quality data does not indicate any concerns.

Segment **1214**, San Gabriel River is separated into two assessment units. Both assessment units are non-supporting of general uses for elevated levels of chloride and sulfates. On the 2010 303(d) List, the chloride and sulfate impairment is categorized as a 5c waterbody, indicating additional data and information are needed regarding the impairment before a TMDL can be scheduled.

Evaluation of more recent data confirms the non-supporting general use classifications for 1214_01 but does not confirm the non-supporting general use criteria for 1214_02. The listing for 1214_02 appears to be erroneous, data used assess the AU was data from 1214_01, there is insufficient data currently available on 1214_02 to perform an assessment and it is anticipated that 1214_02 will be removed from the 303(d) List during the 2012 assessment (Table 3.3.8.2). There is a statistically significant difference between the two AUs for all mineral-related analyses, including chloride, sulfate and total dissolved solids, with concentrations of all three being significantly higher in AU 1214_01. There are no naturally occurring sources in this watershed nor are there permitted discharges that may be contributing to the chloride and sulfate concentrations in the AU. These elevated values are a result of the influence of from Brushy Creek (Segment 1244) which flows into 1214_01. Brushy Creek is a perennial, effluent dominated stream with TSWQSs for the three parameters being significantly greater than the TSWQSs assigned to Segment 1214. Another indicator, supporting a constant source into AU 1214_01 is the strong inverse relationship between flow and both chlorides and sulfates ($p<0.0001$, $\alpha = 0.05$). As flows increase chloride and sulfate decline dramatically, indicating that runoff and/or releases from Lake Granger are diluting the inflows from Brushy Creek.

Table 3.3.8.2 Segment 1214 Chloride, Sulfate, and Total Dissolved Solids

AU	Chloride		Sulfate		Total Dissolved Solids	
	TSWQS	Average (mg/L)	TSWQS	Average (mg/L)	TSWQS	Average (mg/L)
1214_01	50	60.4	45	45.2	500	399
1214_02	50	20.7	45	28.1	500	271
F (α=0.05)		54.301		14.496		34.812

Further analysis of Segment 1214 mineral data identified some interesting relationships. While neither AU appears to individually, be experiencing a significant increase in chloride, sulfate or total dissolved solids over time, the segment as a whole is experiencing a significant increase in chlorides ($p = 0.0005$, $\alpha = 0.05$) and total dissolved solids ($p = 0.0005$, $\alpha = 0.05$).

AU 1214_01 is impaired for bacteria and has been listed on the 303(d) List since 2006. No bacteria data is currently available for AU 1214_02. However, AU 1214_01 classified as a 5a waterbody, meaning that at some point in time, the

TCEQ will perform a TMDL on the segment. No significant change over time in bacteria concentrations was identified for AU 1214_01.

AU 1214_01 also has concerns for elevated nitrate and orthophosphate. These concerns are not observed upstream in AU 1214_02. The watershed surrounding segment 1214 is principally rural with agriculture being the dominant land use and there are no permanent discharges into the segment. However, the absence of nutrient concerns in 1214_02 indicates that nutrient inputs from agricultural runoff are not the source primary source of the concern; otherwise both AUs would express similar data. While there may be some agricultural nutrient contributions into 1214_01, the most likely source of elevated nutrients is inflows from Brushy Creek (Table 3.3.8.3).

Table 3.3.8.3 Segment 1214 Average Nutrients

AU	Nitrate (mg/L)	Phosphate (mg/L)	Total Phosphorus
Screening Level	1.95	0.37	0.69
1214_01	2.67	0.46	0.59
1244	6.06	0.71	0.87
1214_02	1.28	NA	0.05

Trend analysis further supports that Brushy Creek inflow is the source of elevated nutrients in 1214_01. Trend analysis reveals no significant change in nutrient concentrations over time in 1214_02, but a significant increase over time is occurring in 1214_01 for nitrate ($p = 0.0005$, $\alpha = 0.05$), phosphate ($p = 0.015$, $\alpha = 0.05$) and total phosphorus($p = 0.011$, $\alpha = 0.05$). Additionally, no significant relationship exists between flow and any of the nutrient parameters further supporting a point source input (Brushy Creek), not nonpoint source pollution.

Segment **1244**, Brushy Creek, flows through one of the fastest developing areas of Williamson County and has experienced rapid urbanization over the last 20 years. Flows in Brushy Creek are effluent dominant with twelve permitted wastewater discharges totaling a combined permitted discharge of 38.44 million gallons per day. The total permitted discharge converts to a flow measurement of 59.48 cubic feet/second (cfs), assuming all of the permitted facilities are discharging at their permitted maximum flow. The range of flows across segment (8.2 – 32.5 cfs) with a median flow value of 21.6 cfs indicates that the flows in the stream are effluent dominated but that not all facilities are operating at their maximum permitted discharge rate. Water quality in this segment is typical of what is expected of effluent dominated streams, including elevated nutrient levels in some AUs, and low suspended solids.

Currently, 1244_03 is listed in the 2010 IR as having concerns for elevated levels of nitrate, total phosphorus and orthophosphate phosphorus. Analysis of more recent data confirms the concern in 1244_03 and indicates a previously unidentified nutrient concern also exists in 1244_01. There are no current monitoring locations in 1244_02 but it can be

assumed the same concern exists in this AU. Unfortunately there is not an USGS flow gauging station on Brushy Creek so it is difficult to determine how much of the elevated nutrient concentrations are a result of point source discharges versus nonpoint source urban runoff.

Additionally, the unclassified segment **1244D**, South Brushy Creek (Figure 3.3.8.3), is listed in the 2010 IR as having a concern for nitrate. However, more recent data from the stream indicates that the concern is no longer warranted. It is anticipated that the concern for nutrients 1244D will be removed from the list of concerns in the 2012 IR.

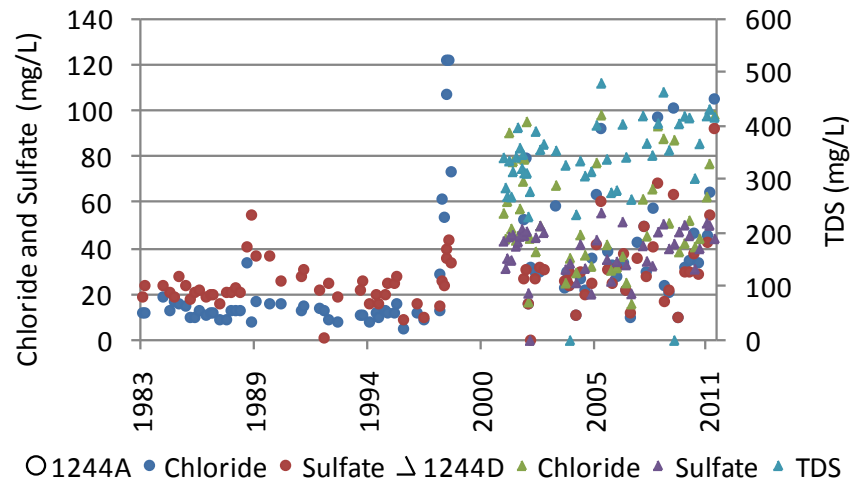
Trend analysis of **1244** indicates statistically significant increasing trends in nitrates ($p=0.003$, $\alpha = 0.05$) and total phosphorus ($p=0.0005$, $\alpha = 0.05$). However, several municipalities are pursuing or currently implement direct reuse of their effluent to water vegetation in parks, roadway medians, and golf courses, reducing the amount of nutrient laden water discharged directly into Brushy Creek. Additionally, all of the wastewater facilities in the subwatershed are currently subjected to maximum allowable ammonia concentrations in their discharge permits and recently several of the larger facilities have been required to monitor additional nutrient parameters. Overtime, increased reuse and nutrient limits in permits will most likely reduce nutrient impacts from point source discharges in the watershed and lead to a reversal of the increasing trend.

Figure 3.3.8.3. South Brushy Creek

Several bacteria impairments exist in segment **1244** with 1244_03 and 1244_04 currently listed on the 2012 303(d) List. Analysis of more recent data confirms these impairments and indicates that 1244_01 will most likely be impaired during the 2012 assessment. Unfortunately, there is no flow data associated with the data so determining whether the source of bacteria is point or nonpoint source is difficult for this stream. TCEQ is currently performing a recreational use attainability assessment on segment **1244** (see Special Projects Section for more information).

TDS, chloride and sulfate are supporting of general use in all AUs and unclassified streams in the Brushy Creek watershed. However, there are some interesting trends when long-term data from some of the unclassified streams are evaluated. Brushy Creek Above South Brushy Creek, **1244A**, displays increasing trends in TDS, chlorides and sulfates and South Brushy Creek, **1244D**, displays increasing trends chlorides and sulfates (Figure 3.3.8.4). The source of the increasing minerals in **1244A** and **1244D** is currently unknown but may be a result of an increased reliance on water softeners by residential landowners as the watershed has transitioned from rural to suburban over the last 20 years. Most wastewater treatment systems in the state are not equipped to remove the high levels of salts and dissolved solids generated by water softeners. When elevated mineral levels enter the treatment facility from residential properties they are passed through the treatment system and discharged into lakes and streams. In addition to increased loading from water softener use, drought conditions, which have persisted over much of the last decade, may also be contributing to the elevated mineral levels in the water. As water evaporates from a stream during drought the minerals remain in the stream which leads mineral concentration in the remaining water, a phenomena observed across the basin during drought.

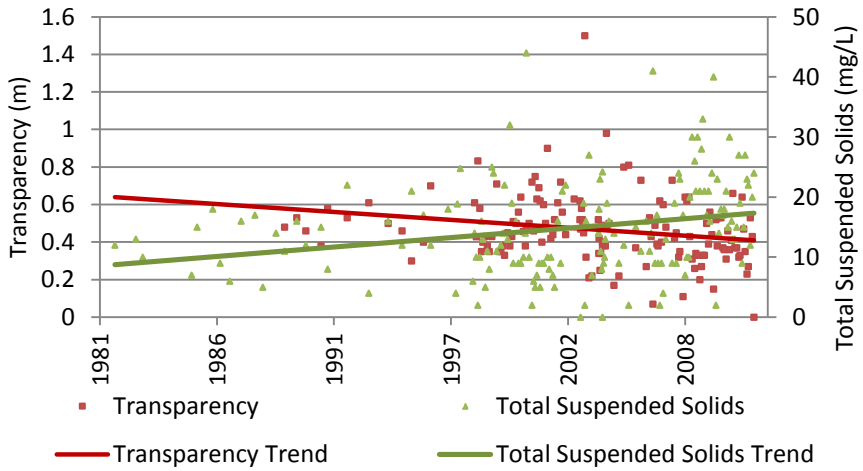
Figure 3.3.8.4 **1244A and 1244D Minerals**



Segment **1247,** Lake Granger has had a long history of concern for excessive sedimentation that is reducing the storage capacity of the reservoir at rate much greater than anticipated by design engineers. Volumetric surveys of the reservoir indicate that the rate of sedimentation has slowed. However, analysis of long-term total suspended solids and transparency data indicates an increasing trend in total suspended solids ($p=0.001$, concentrations and decreasing trend in transparency ($p=0.019$, $\alpha = 0.05$) at the Lake Granger Dam (Figure 3.3.8.5).

Lake Granger and one of its tributary streams, Willis Creek, unclassified segment **1247A**, have possessed long standing concerns of elevated nitrates. Analysis of more recent data for **1247** and **1247A** confirm the concerns are still valid.

Figure 3.3.8.5 **Lake Granger Dam Total Suspended Solids and Transparency**



Historically, there has been no concern for chlorophyll *a* when compared to the screening level. Assessment of data using the newly implemented, segment-specific, water quality standard for chlorophyll *a*, it is not anticipated that Lake Granger will be listed as impaired for chlorophyll *a*. The elevated nitrate concentration in Lake Granger does not appear to be resulting in increased eutrophication in the lake. There is a significant relationship between chlorophyll *a* and total suspended solids ($p=0.013$, $\alpha = 0.05$). The total suspended solids concentrations in the reservoir are inhibiting algal growth by reducing transparency and light penetration thus limiting eutrophication of the reservoir.

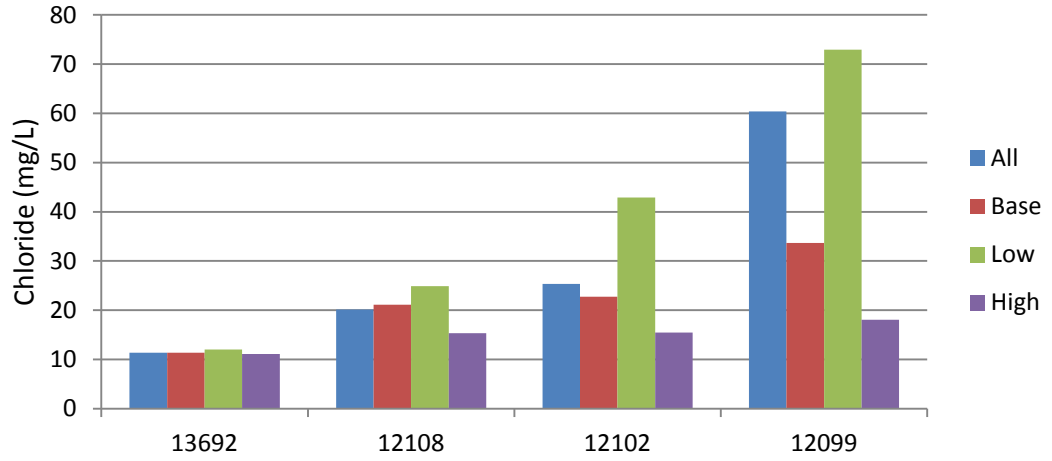
Despite its concerns, Lake Granger remains an invaluable refuge for wildlife. For the first time in many years, in the winter of 2011, two families of whopping cranes wintered at Lake Granger. The birds have been observed by local residents feeding in fields that abut the reservoir and in the reservoir itself. Why the federally endangered birds did not winter at Aransas National Wildlife Refuge on the coast, the usual winter grounds for whopping cranes, is not known.

Willis Creek, unclassified tributary **1247A**, has a long standing impairment for non-support of contact recreation use. Analysis of more recent data confirms the impairment and it is anticipated that **1247A** will remain classified as impaired in the 2012 IR. TCEQ is currently performing a recreational use attainability assessment on segment **1247A** (see Special Projects Section for more information).

The San Gabriel River, part of segment **1248**, is listed on the 2010 303(d) list as non-supporting of general use due to elevated chloride levels. Analysis of more recent data indicates that elevated chlorides are no longer of concern in the San Gabriel River. While further impairment does not appear to be necessary, analysis of long-term chloride data indicates an increasing trend in chlorides in the river ($p = 0.0005$, $\alpha = 0.05$). The source of the increasing chlorides in **1248** is currently unknown but, like in Brushy Creek, the chlorides may be result of an increased reliance on water softeners by residential landowners.

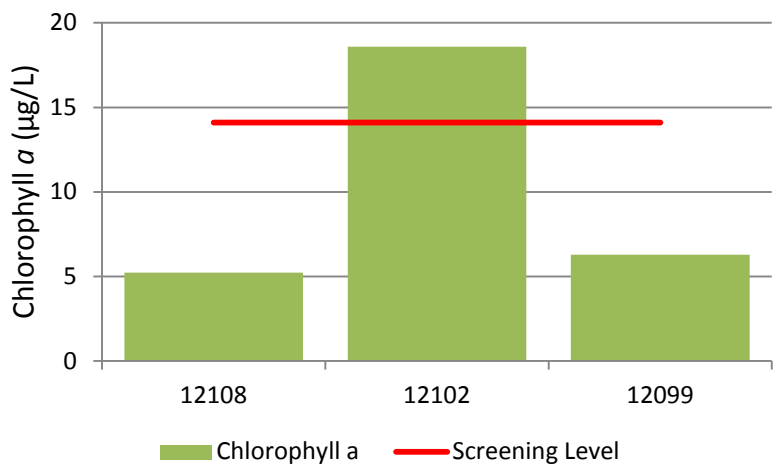
Comparing the long-term chloride data to different components of the flow regime in Segment **1248** reveal that the increasing chloride levels and historical impairment are driven by drought conditions and potentially, point source contributions (Figure 3.3.8.6). Average chloride concentrations are elevated during low flow periods in the stream. The difference in chloride levels across flow regime components with the highest levels being observed at low flows indicates that during drought chlorides concentrate in the segment as water evaporates from the stream leaving. However, given no natural source of chlorides (e.g. brine springs) in the watershed, and the dramatic increase in chloride concentrations during low flow periods, the potential for point source discharges (water softening chemical disposal) to being influencing and increasing chloride concentrations is likely.

Figure3.3.8.6 **1248 - Chloride by Flow Regime Component**



While currently Segment **1248** does not currently have any concerns for nutrients or chlorophyll *a*, it is anticipated that the segment will be listed as having a concerns for both nitrate and chlorophyll *a* in the 2012 IR. The anticipated concern for chlorophyll *a* is the result of data from one monitoring location on segment 1248. Two sites of the three active monitoring sites in the segment, 12099 and 12108, do not pose any concern for chlorophyll *a*; 12102, which is between the other two sites, displays a concern for elevated chlorophyll *a* concentrations (Figure 3.3.8.7). The rise in chlorophyll *a* concentrations at 12102 appear to be driven by TKN ($p=0.0005$, $\alpha = 0.05$). No other significant nutrient-chlorophyll relationships could be identified. There are three wastewater

Figure 3.3.8.7 **1248 - Average Chlorophyll *a* Concentrations by Monitoring Location**

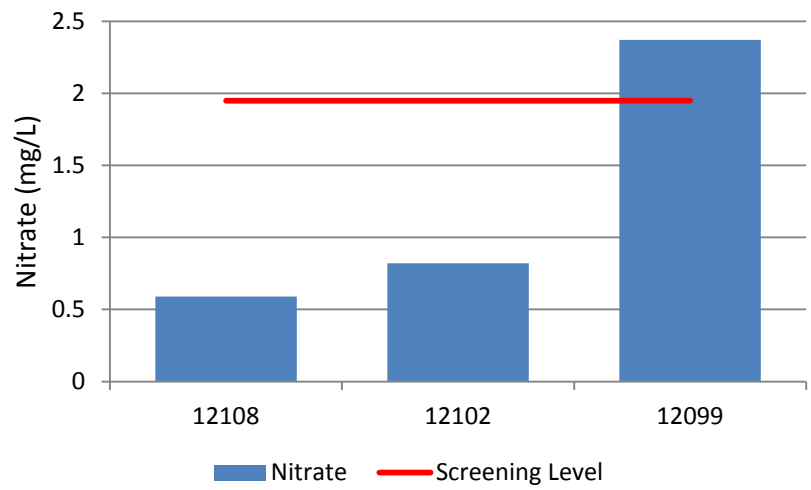


treatment facilities whose discharges enters the stream below 12108 but upstream of site 12102, that may be contributing nutrients to the stream but it is unlikely that they are discharging high levels of organic nitrogen. Traditionally, in well-run wastewater treatment facilities organic nitrogen (TKN) is removed during the treatment process, the primary nitrogen compound of concern in wastewater treatment discharge is inorganic nitrate. Land use in the vicinity of 12102 is dominated by row crop agriculture with crops being cultivated immediately adjacent to the stream. Depending on the type of fertilizers used in these fields, agricultural nonpoint source runoff may be the largest source of TKN at this location.

Long-term trend analysis on segment **1248** reveals two unrelated trends in nutrients. Chlorophyll *a* and nitrate are both increasing over time, however; no significant relationship was identified between chlorophyll a and nitrate levels ($p=0.596$, $\alpha = 0.05$). Like chlorophyll *a*, it appears that the increasing nitrate trend appears to be driven solely by data from one site, 12099, and is not actually a trend across the entire segment.

Nitrate levels appear to increase longitudinally in the stream, from low to higher levels, as the stream flows from the Lake Georgetown Dam to the headwaters of Lake Granger (Figure 3.3.8.8). The trend for nitrate appears to be similar to the trend for chlorophyll *a* with only data from site 12102 displaying a significant increase over time; however, unlike chlorophyll *a*, nitrate concentrations do increase as the stream flows from the Lake Georgetown Dam to the headwaters of Lake Granger. The watershed transitions from urban in the vicinity of sites 12108 to rural by the time it reaches site 12102, the nitrates are most likely a result of a combination of point source discharges, urban runoff, and agricultural runoff.

Figure 3.3.8.8 **1248 - Average Nitrate by Monitoring Location**



Mankins Branch (Figure 3.3.8.9), unclassified segment **1248C**, is currently listed as not supporting of recreational uses and concerns for nitrate, total phosphorus and orthophosphate. Analysis of more recent data confirms the impairments and concerns. Two sites are currently monitored on Mankins Branch. Site 17501 is the most upstream site and site 13497 is just above the confluence of the San Gabriel River. While both sites have nutrient concerns there are marked differences in nutrient concentrations between the two sites, with 13497 being significantly higher that 17501(Table 3.3.8.4). There is a municipal discharge in an unnamed tributary upstream of

Figure 3.3.8.9 **1248C Mankins Branch**

site 17501; however, this discharge is small and rarely reaches Mankins Branch, unless there is a rain event. It does not appear to be the primary source of the nutrients in Mankins Branch, if the discharge were the primary source of the nutrients; site 17501 would have concentrations higher than site 13497. While the municipal discharge undoubtedly contributes some nutrients to the stream, the largest contributor is from nonpoint sources. In the immediate vicinity of site 17501 is a housing development that relies on on-site sewage systems for waste treatment, the development pre-dates 1989 when the first comprehensive on-site sewage system regulations were implemented. Lot sizes are significantly smaller than current regulations permit, potentially rendering the system drain fields ineffective. Between 17501 and 13497, land use is dominated by row crop agriculture. These two sources are most likely the sources leading to the concerns for Mankins Branch.

Berry Creek, unclassified segment **1248A**, in a relatively undeveloped part of the watershed, currently has no impairments or concerns. Analysis of more recent date confirms that no impairments or concerns are warranted. Unclassified segment **1248D**, the Middle Fork of the San Gabriel River, also has not impairments or concerns.

Table 3.3.8.4 **1248C Average Nutrients**

Nutrient Parameter	**17051**	**13497**
Nitrate (mg/L)	7.23	11.06
Total Phosphorus (mg/L)	0.75	1.33
Othophosphate (mg/L)	0.84	1.42

Segment **1250**, the South Fork San Gabriel River (Figure 3.3.8.10), is not currently listed on the 303(d) List for any impairment or concern. More recent data analysis continues to indicate that there are no impairments or concerns in this segment.

Historically, the segment **1250** has been considered perennial, as implied by TSWQS Appendix A and TCEQ's 305(b) assessment approach. However, monitoring data reveals that the segment is intermittent with perennial pools from the headwaters to a point approximately 3.2 km upstream from IH 35, and perennial from that point to the confluence with the Segment 1248, San Gabriel/North Fork San Gabriel River. This assessment is based on five years of field observations and flow severity data from multiple locations throughout the segment, and USGS flow records from IH 35. Intermittency, no flow with pools, has occurred during three different years of the five-year period of record. However, this intermittent nature has not appeared to have a negative impact on instream biota. Two years of aquatic life monitoring reveals high

aquatic life use. The intermittent nature of the stream dictates that its Aquatic Life Use Characterization should be reduced from high to intermediate; but the aquatic life monitoring data indicates that the designated high ALU is appropriate for the segment.

The segment does have several identified trends. Nitrate ($p=0.008$, $\alpha = 0.05$) is on the decline in this segment while chloride ($p=0.001$, $\alpha = 0.05$), TDS ($p=0.005$, $\alpha = 0.05$), sulfate ($p=0.029$, $\alpha = 0.05$), and TKN ($p<0.005$, $\alpha = 0.05$) are all increasing.

Why TKN is on the rise is unknown but it may be a result of increased urban development and the associated increase in sediment runoff from new development and from fertilizers containing organic nitrogen being used on newly developed residential properties. These fertilizers are most likely entering the segment via stormwater runoff.

Figure 3.3.8.10 **South Fork San Gabriel**

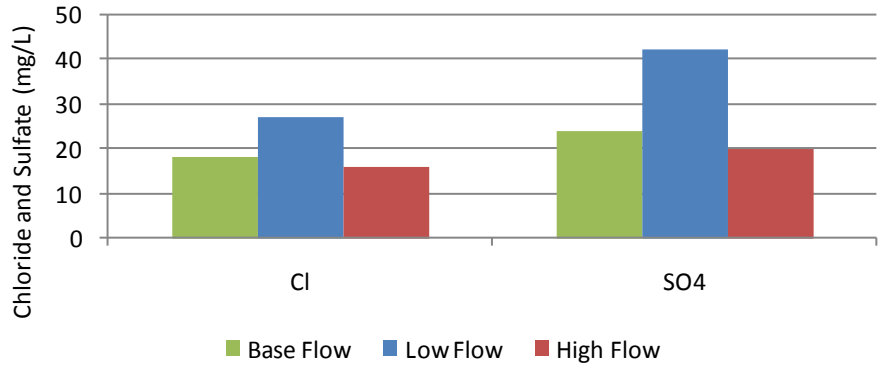
The decline in nitrates is most likely a result of the development of wastewater treatment facilities, the removal of OSSFs as the primary waste treatment methodology, implementation of tighter discharge permit requirements and improved wastewater treatment technologies. There are currently two municipal discharges to the segment. The newest facility came on-line in 2006, implements advanced treatment technologies for the removal of nutrients, and has discharge limits for ammonia, nitrate, total nitrogen, and total phosphorus.

The increase in chlorides and sulfates are both inversely related to flow ($p<0.005$, $\alpha = 0.05$, and $p=0.001$, $\alpha = 0.05$, respectively). Comparing chloride and sulfate data to different components of the flow regime in Segment **1250** reveals that the increasing concentrations are driven by low flow conditions and potentially, point source contributions (Figure 3.3.8 11). The difference in chloride and sulfate concentrations across flow regime components indicates that during drought chloride and sulfate concentrate in the stream as water evaporates from the stream leaving. However, given no natural source of chlorides (e.g. brine springs) in the watershed, and the dramatic increase in chlorides and sulfates during low flow periods, indicates that the source of the minerals may be from municipal discharges impacted by the reliance of residential properties on water softening technology to reduce calcium and magnesium.

The increase in TDS concentration is directly related to the increases in chloride and sulfate ($p<0.005$ $\alpha = 0.05$) (Figure 3.3.8.12).

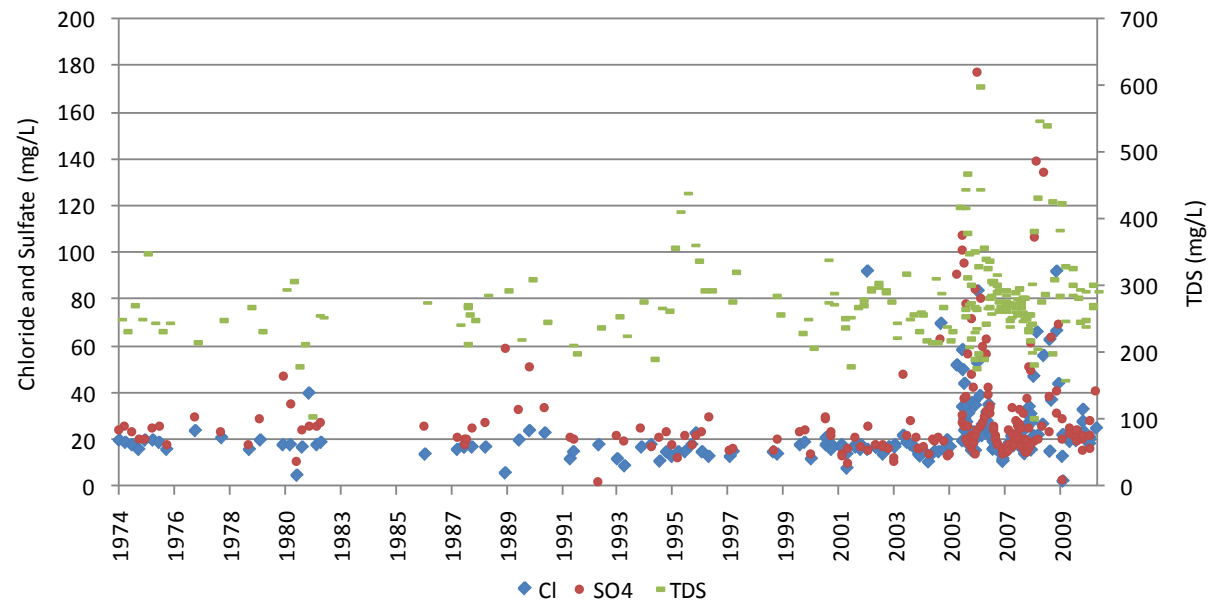
Lake Georgetown, segment **1249**, currently has no impairments or concerns and analysis of recent data confirms the lack of water quality issues. Historically, Lake Georgetown has had difficulty supporting a robust and diverse fishery due to poor habitat and low primary productivity (TPWD). However, there are some interesting trends have been identified as the lake ages that may slowly lead to the lake being able to sustain a robust fishery.

Figure 3.3.8.11 **1250 - Chloride and Sulfate by Flow Regime Component**



There has been a significant decline in suspended solids and transparency; however, the only trends that are correlated with other parameters are suspended solids and transparency ($p<0.005$, $\alpha = 0.05$). The decline in transparency appears to be a result of chlorophyll *a* ($p<0.005$, $\alpha = 0.05$) and not suspended solids (Figures 3.3.8.13 and 3.3.8.14); however, there is no statistically significant increase in chlorophyll *a* at the dam monitoring site. With no municipal or industrial discharges and minimal agricultural activity in the Lake

Figure 3.3.8.12 **1250 - Chloride, Sulfate and Total Dissolved Solids**



Georgetown, the slight rise in chlorophyll *a* levels since 2007 maybe a result of flooding that began in March 2007 and lasted throughout the year. This flood event affected most of the Brazos basin and led to unprecedented flooding and reservoir retention times. This flood event most likely flushed the watershed of any surface nutrients, and then the stormwater was held in Lake Georgetown for an extended period of time, instead of being passed downstream, to reduce downstream flooding impacts. These nonpoint source nutrients did not create an observable increase in nutrient concentrations, but may have been enough to spur primary production in the reservoir. Median chlorophyll a levels in the reservoir prior to March 2007 was 4.7 µg/L and 5.1 µg/L after March 2007. It remains to be seen if this rise in primary productivity will continue long-term and support much needed fishery development or if over time primary productivity will fall back to pre-March 2007 levels remains to be seen.

Figure 3.3.8.13 **1249 - Transparency and Total Suspended Solids**

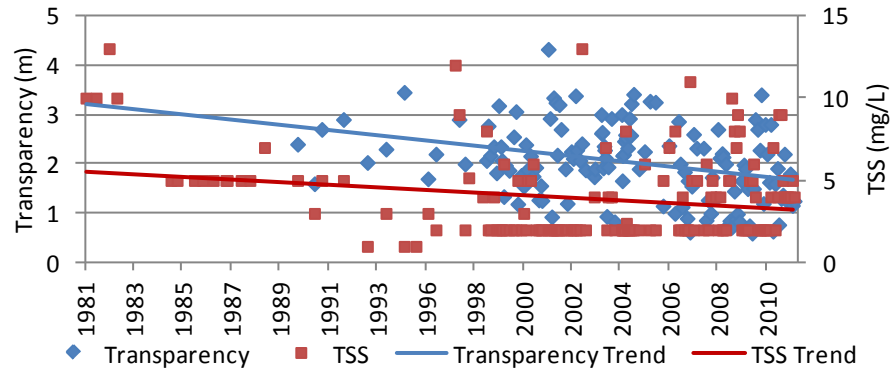
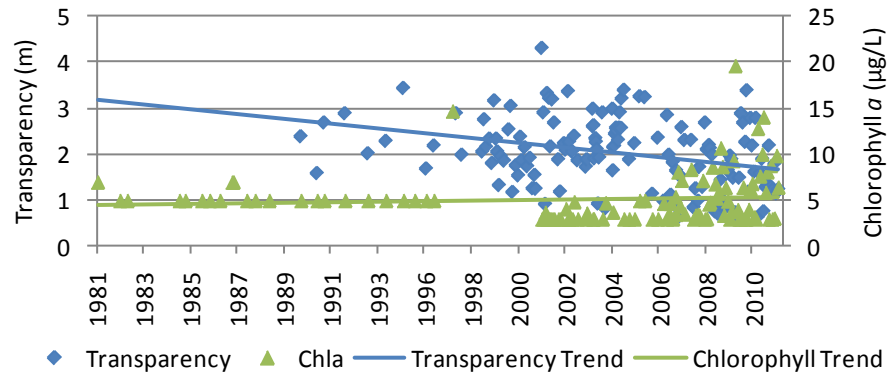
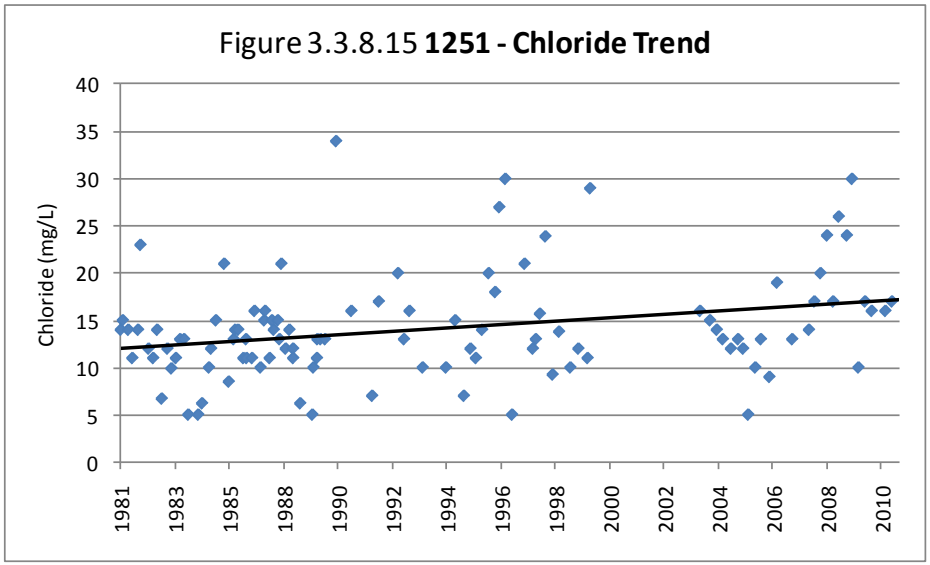


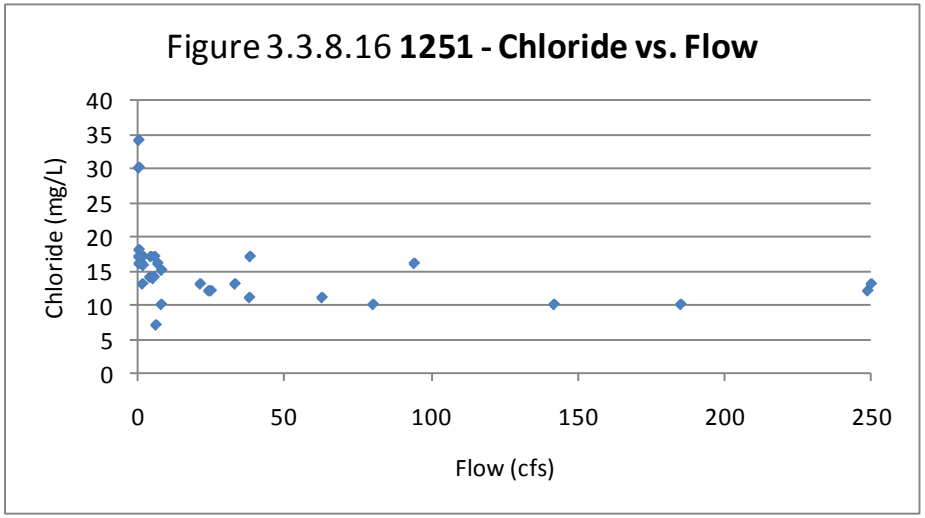
Figure 3.3.8.14 **1249 - Transparency and Chlorophyll *a***



The North Fork San Gabriel River, Segment **1251**, currently has no impairments or concerns. The segments watershed has limited agricultural activity but is currently experiencing rapid residential development. This change in land use has prompted three significant trends. There have been significant declines in TKN ($p<0.005$, $\alpha = 0.05$) and ammonia ($p<0.005$, $\alpha = 0.05$) and a significant increase in chlorides ($p=0.001$, $\alpha = 0.05$). The nutrient declines are somewhat puzzling, usually as a watershed moves from undeveloped to a more urban land use footprint there is a strong potential for nutrients to increase from urban stormwater runoff. This does not appear to be the case in the North Fork San Gabriel River.

Like most of the western portion of the watershed, chloride levels are on the rise despite there being no natural source of chlorides in the watershed (Figure 3.3.8.15). While there is limited paired chloride and flow data on the segment it does appear that the more elevated chloride levels occur during periods of low flow (Figure 3.3.8.16). With no natural sources or point source discharges in the watershed, these rising levels are most likely a result of drought conditions concentrating chlorides in the steam





Special Studies:

*2010 Brushy Creek (Segment **1244**) Comprehensive RUAA* – Texas Commission on Environmental Quality In September 2009, a recreational use attainability analyses (RUAA) was initiated on Brushy Creek, Segment **1244**. The completed Recreational Survey Report for Segment **1244** was submitted to TCEQ in September 2010. The Recreational Survey Report provides the TCEQ's Standards Team with information relevant to recreational uses and physical stream characteristics. This information will help TCEQ determine the most appropriate recreational use classification for the segment. Evidence of recreational use, availability of public access to the stream and general stream characteristics (e.g. stream depth) are documented in the report.

The Recreational Survey Report was posted for Public Review on the TCEQ's website in January 2012; the report can be located at: http://www.tceq.texas.gov/waterquality/standards/ruaas/brushycreek1244 . Once the public comment period is over, the TCEQ Standards Team will make its final determination regarding the appropriate recreation use for the segment. If a change to the Recreational Use classification is recommended for Segment **1244**, the

recommended change will be include in the next revision of the Texas Surface Water Quality Standards (TSWQS) which is anticipated to occur in 2013.

2011 Brazos Basin Recreational Use Attainability Analysis, Part 1 - Texas Commission on Environmental Quality
Recreational use surveys are currently being conducted on Willis Creek **1247A** and Mankins Branch **1248C** as part of a larger 31 stream assessment project. Like with Segment **1244**, at the conclusion of the assessment, the TCEQ Standard's Team will determine the most appropriate recreational use classification for the streams and recommend any warranted changes to the stream's recreational use classifications in the next TSWQS revision.

http://www.tceq.texas.gov/waterquality/standards/ruaas/brazos-basin-recreational-use-attainability-analysis-part-1#project-summary

2010 Lake Granger Watershed Assessment and Implementation Project– Texas State Soil and Water Conservation Board
Completed in 2010, this project developed a watershed protection plan to address elevated sediment loading into the San Gabriel River and in to Lake Granger. This project provided the Little River-San Gabriel Soil and Water Conservation District (LR-SGSWCD) and the Taylor Soil and Water Conservation District (TSWCD) with funding for technical assistance and financial assistance to implement best management practices (BMPs) through conservation planning. BMPs were installed on select properties for the purpose of reducing erosion within the watershed and reducing TSS concentrations in the reservoir. An additional, anticipated benefit from installation of BMPs is reduced nutrient loadings from agricultural lands.

*2010 Georgetown Reservoir Performance Re*port – Texas Parks and Wildlife Department
This study evaluated the status of game fish populations in Lake Georgetown and determined that fishery development is restricted due to poor habitat conditions. TPWD noted steep banks, rocky shoreline, no substantial establishment of aquatic vegetation and low primary productivity as factors limiting the development of a self-sustaining fishery. To counter the natural habitat limitations and provide cover for fish in Lake Georgetown, TPWD has installed twenty-eight fish attractors since 2007. However, it is not yet clear if the attractors will result in a long-term improvement in the reservoir's fishery.

*2009 Granger Reservoir Performance Re*port – Texas Parks and Wildlife Department
This study evaluated the status of game fish populations in Granger Reservoir (Figure 3.3.8.17). Catch rates for threadfin shad, bluegill, blue catfish, largemouth bass, and white bass white bass all increased from previous surveys. White

crappie, gizzard shad, longear sunfish, warmouth and redear sunfish populations appear stable with little change from previous surveys. On a positive note, TPWD staff noted that water hyacinth; an exotic, highly invasive aquatic plant that had been previously documented in the upper San Gabriel arm of the reservoir appears to have been eradicated.

Figure 3.3.8.17 **Lake Granger**

2008 Watershed Steward Training – Texas State Soil and Water Conservation Board and Texas AgriLIfe Extension Service
The Texas Watershed Steward program was delivered in the Granger Reservoir watershed. It is an educational program for anyone interested in water quality issues. The workshops is a one-day training event that addresses the fundamentals of watershed systems, water quality regulation and monitoring, watershed improvement methods, enhancing watershed functions, and community-driven water resource management. TPWD cited one hindrance to the development of a more robust fishery in Granger Reservoir is the low amount of shoreline habitat and the lack of a stable aquatic vegetation community. TPWD recommends the establishment of emergent aquatic vegetation to provide additional fish habitat.

2007 Reducing Atrazine Loss in Central Texas – Texas Cooperative Extension and Texas Agricultural Experiment Station
This project conducted in the Willis Creek watershed, included a demonstration of best management practices (BMPs) related to the application of atrazine in corn production, and evaluated the success of alternative application methods, evaluated model predictions associated with atrazine movement.
The study concluded that by employing the techniques of pre-plant incorporation and banding for atrazine treatments, instead of the traditional broadcast technique, corn and sorghum producers can reduce off-target losses of atrazine in surface runoff, reduce the risk of atrazine contamination of the surface waters of Texas and maintain acceptable production yields.

Biological Assessments:
The streams of the Little River watershed support a diverse and healthy community of fish. Overall the riverine fish community is dominated by generalist taxa and reservoir type fish; however, the lower reaches of the Little River do

support several “big river” fish. Additionally, the watershed supports a variety of fluvial specialists including shoal chubs, orangethroat darters, dusky darters, blackspot shiners, and silverband shiners.

Extensive aquatic life monitoring (ALM) has occurred in the San Gabriel watershed over the last five years, and the lower segment of the Little River has been sampled using aquatic life monitoring protocols and Texas Instream Flow Program (TIFP) Protocols. Data collected using ALM protocols is used to provide baseline data on environmental conditions and determine if aquatic life use (ALU) designations and dissolve oxygen criteria are being obtained. Data collected using TIFP protocols will be used to determine what flow conditions are needed maintain biological diversity in riverine ecosystems. A summary of events is presented in Table 3.3.8.5.

Segment **1248** – San Gabriel North Fork San Gabriel
This segment has a designated high aquatic life use, and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). Biological assessments were conducted in 2008 at two San Gabriel River sites which bracket inflow from a tributary, Mankins Branch. The purpose was to generate baseline data prior to possible construction of a regional wastewater treatment plant which would discharge to Mankins Branch, and to provide baseline data to facilitate future assessments of instream conditions.

The upstream site at SH 29 east of Georgetown, Station 12102, was assessed on 4/8-9/08 and 7/21-22/08. In the initial event, during the non-critical portion of the index period, dissolved oxygen concentrations achieved an exceptional ALU rating, fish and benthic macroinvertebrates a high ALU rating, and physical habitat an intermediate ALU rating.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 4/8/08 physical habitat data, which reflected achievement of an intermediate ALU rating, were re-utilized. Dissolved oxygen concentrations achieved an exceptional ALU rating based on the 24-hr. mean, and a high ALU rating based on the 24-hr. minimum. Fish (Figure 3.3.8.18) and benthic macroinvertebrates achieved a high ALU rating.

Figure 3.3.8.18 Channel Catfish Collected During ALM on San Gabriel River

Table 3.3.8.5. Summary of Aquatic Life Monitoring Results by Segment

Site	Date	**Invertebrates** ALU rating	**Fish** ALU rating	**Habitat** ALU rating	**D.O. 24-hr mean** ALU rating	**D.O. 24-hr min** ALU rating
1248						
San Gabriel R. at SH 29 east of Georgetown (12102)	Apr 2010	high	high	intermediate	exceptional	exceptional
San Gabriel R. at SH 29 east of Georgetown (12102)	Jul 2008	high	high	intermediate	exceptional	high
San Gabriel R. at SH 29 east of Georgetown (12102)	May 2008	exceptional	high	high	exceptional	exceptional
San Gabriel R. at SH 29 east of Georgetown (12102)	Jul 2008	exceptional	high	high	exceptional	exceptional
1248C						
Mankins Branch at CR 100 east of Georgetown (13497)	Mar 2008	high	high	intermediate	exceptional	exceptional
Mankins Branch at CR 100 east of Georgetown (13497)	Jul 2008	exceptional	high	intermediate	exceptional	exceptional
1250						
South Fork San Gabriel R. at Weir Pit west of Georgetown (20309)	Mar 2008	exceptional	high	high	exceptional	exceptional
South Fork San Gabriel R. at Weir Pit west of Georgetown (20309)	Jul 2008	exceptional	high	intermediate	high	exceptional
South Fork San Gabriel R. at Weir Pit west of Georgetown (20309)	Apr 2010	intermediate	high	high	exceptional	exceptional
South Fork San Gabriel R. at Weir Pit west of Georgetown (20309)	Jul 2010	high	high	high	exceptional	exceptional

Whereas physical habitat characteristics were less-than-optimal, due mainly to a predominantly bedrock substrate, limited amount of instream cover, and low channel sinuosity, all other components met expectations, reflecting favorable environmental conditions. A degree of nutrient enrichment was indicated by dense periphyton and filamentous algae growth, and fairly wide diel dissolved oxygen swings (6.1-15.3 mg/L and 3.3-12.1 mg/L). However, nutrient-associated effects were not of a severity that significantly degraded fish or benthic macroinvertebrate communities.

The initial assessment, during the non-critical portion of the index period, at the downstream site (San Gabriel River at CR 366 east of Jonah, Station 12099) revealed exceptional ALU ratings for dissolved oxygen concentrations and benthic macroinvertebrates, and high ALU ratings for fish and physical habitat.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the non-critical period habitat data, which reflected achievement of a high ALU rating, were re-utilized. Findings were the same as during the first event, with dissolved oxygen concentrations and benthic macroinvertebrates achieving an exceptional ALU rating, and fish a high ALU rating. Thus, all components of the assessments met or exceeded expectations, indicating favorable environmental conditions.

Whereas all biological components attained the designated aquatic life use at both sites, in every instance IBI scores were higher at CR 366 than at SH 29. Factors contributing to greater biological integrity at the downstream site included: (1) greater habitat suitability, as instream cover was more abundant and substrate conditions were much more favorable due to predominance of gravel and cobble (versus bedrock); (2) flow augmentation from intervening springs and tributaries; and (3) diminished nutrient effects with increased distance from primary sources in the Georgetown area, through dilution and assimilation.

Segment **1248C** – Mankins Branch
Mankins Branch is an unclassified tributary of the San Gabriel River (Segment **1248**). The creek has not been assigned an aquatic life use or dissolved oxygen criteria by TCEQ. Following TCEQ guidelines, a high aquatic life use and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) are presumed to apply, since flow is perennial. The creek was assessed at CR 100 east of Georgetown, Station 13497, on 3/24-25/08 and 7/14-15/08. The purpose was to generate background biological data prior to possible construction of a regional wastewater treatment plant which would discharge to the creek. The San Gabriel River (Segment **1248**) would be the secondary receiving stream.

In the initial event, during the non-critical portion of the index period, dissolved oxygen concentrations achieved an exceptional ALU rating, fish (Figure 3.3.8.19) and benthic macroinvertebrates a high ALU rating, and physical habitat an intermediate ALU rating.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the non-critical period habitat data, which reflected achievement of an intermediate ALU rating, were re-utilized. Dissolved oxygen concentrations and benthic macroinvertebrates achieved an exceptional ALU rating, and fish a high ALU rating.

Despite less-than-optimal physical habitat characteristics, due mainly to limited instream cover and low channel sinuosity, all biological components met or exceeded expectations, which reflected favorable water quality conditions during the study period.

Figure 3.3.8.19 **Large Mouth Bass from Mankins Branch**

Segment **1250** – South Fork San Gabriel River

Segment **1250**, the South Fork San Gabriel River, has a designated high aquatic life use, and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, 30TAC§307.10(1)). Biological assessments were conducted at the Weir Pit west of Georgetown in 2008 and 2010. The original objective was to assess instream effects of rapid development in the watershed. However, developments during the course of the ALM project shifted the focus to impacts of major sewer line installation activities along the streambed in the study area and investigating whether a change to the segments ALU classification and associated dissolved oxygen criteria was warranted.

Sampling during the non-critical portion of the index period in 2008 revealed that dissolved oxygen concentrations and benthic macroinvertebrates achieved an exceptional rating using aquatic life use subcategories (30TAC§307.7(b)(3)(A)(i)), and fish and physical habitat rated high.

In the second event of 2008, during the critical portion of the index period, dissolved oxygen concentrations achieved an exceptional aquatic life use based on the 24-hr. minimum, and a high rating based on the 24-hr. mean. Benthic

macroinvertebrates achieved an exceptional rating; fish achieved a high rating, but the physical habitat rating fell to intermediate.

The decline in the habitat rating between the non-critical and critical portions of the index period sampling events is the result of the initiation of a sewer line installation project in the vicinity. The project extended from IH 35 in Georgetown about nine miles upstream, involved clearing of riparian vegetation, and trenching in and immediately adjacent to the stream channel. Additionally, direct instream disturbances occurred in nine locations where the line crossed the streambed. Environmental effects included destruction of large amounts of riparian vegetation, increased turbidity, deposition of large amounts of silt on the streambed, direct physical damage to the stream channel due to trenching and maneuvering of heavy machinery in and immediately adjacent to the river, and alteration to flow patterns from the construction of temporary low water dams drained by culverts (Figure 3.3.8.20).

Figure 3.3.8.20. Construction Impacting the South Fork San Gabriel River in 2008

While all biological components achieved or exceeded the designated ALU criteria for the stream indicating that the sewer line installation did not immediately impact the biota. The physical habitat rating, however, declined from the first to the second event, falling from high to intermediate. Monthly observations through the end of September 2008 revealed progressive deterioration of instream habitat and water quality conditions during construction which did have an impact on aquatic life as evidenced by subsequent assessments.

In an attempt to quantify if the habitat disturbance observed in 2008 resulted in long-term degradation to the biota in the segment, additional assessments were conducted in 2010. Sampling during the non-critical portion of the index period, dissolved oxygen concentrations achieved an exceptional ALU rating, physical habitat and fish a high ALU rating, and benthic macroinvertebrates an intermediate ALU rating.

In the second event, during the critical portion of the index period, dissolved oxygen concentrations achieved an exceptional ALU rating, and habitat, benthic macroinvertebrates and fish all achieved a high ALU rating.

Failure of the benthic assemblage to meet high ALU expectations in April was due to adverse impacts to benthic habitat from the construction activities and its resultant, residual, excessive silt deposits in the streambed. A prevalence of organisms tolerant to disturbance, including *Cheumatopsyche* and Chironomidae, and an absence of intolerant organisms led to the downgraded ALU ranking. While a high benthic ALU rating was attained in the second event, indicating some improvement, both 2010 benthic IBI scores were depressed compared to 2008 scores. Fortunately, the water column appears to have returned to pre-construction conditions and the fish assemblage does not appear to have experienced long-term negative impacts (Figure 3.3.8.21). However, the impact from the residual silt may not be truly evident for several years as it may interfere with the reproductive strategies of some fish species.

In conclusion, evidence exists that the lower South Fork San Gabriel River hasn't completely recovered from stream channel disturbance caused by sewer line installation in 2008. Additional aquatic life monitoring is recommended within the next five years to further evaluate recovery from that incident, and to assess ongoing environmental threats as development continues in the watershed.

Figure 3.3.8.21 **South Fork San Gabriel River 2010**

The Little River, segment **1213**, is designated high aquatic life use stream, with 24-hour dissolved oxygen (DO) criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum). Biological assessments were conducted 6.31 km upstream of the confluence with the Brazos River north of Gause, Station 20526, in 2009. This site integrates effects of most water quality influences in the watershed. Fisheries surveys were performed at the site by TPWD/BRA in 2006-07 for the Texas Instream Flow Program, providing a starting point for understanding existing biological conditions. The 2008 ALM effort was conducted to generate more comprehensive information. In 2008, Segment **1213** was included on the 2008 303(d) List for bacteria impairment and was noted in the Texas Water Quality Inventory Regarding as having concerns for atrazine and elevated nitrates. The 2008 study

was conducted to evaluate ALU attainment and determine if impacts are occurring from water quality concerns.

In the initial event, during the non-critical portion of the index period, DO concentrations achieved an exceptional ALU rating, physical habitat and benthic macroinvertebrates a high ALU rating, and fish (Figure 3.3.8.22) an intermediate ALU rating.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the non-critical period habitat data, which reflected achievement of a high ALU, were re-utilized. DO attained an exceptional ALU rating, and benthic macroinvertebrates and fish a high ALU rating.

Figure 3.3.8.22. Blue Catfish from the Little River

The only instance of nonattainment of the ALU for the segment was for fish during the non-critical period event, when the IBI score (40) was two points below a high ALU rating. Reason for the low rating included a scarcity of benthic invertivore species, an absence of intolerant species, a high percentage of tolerant individuals, and a low percentage of piscivores.

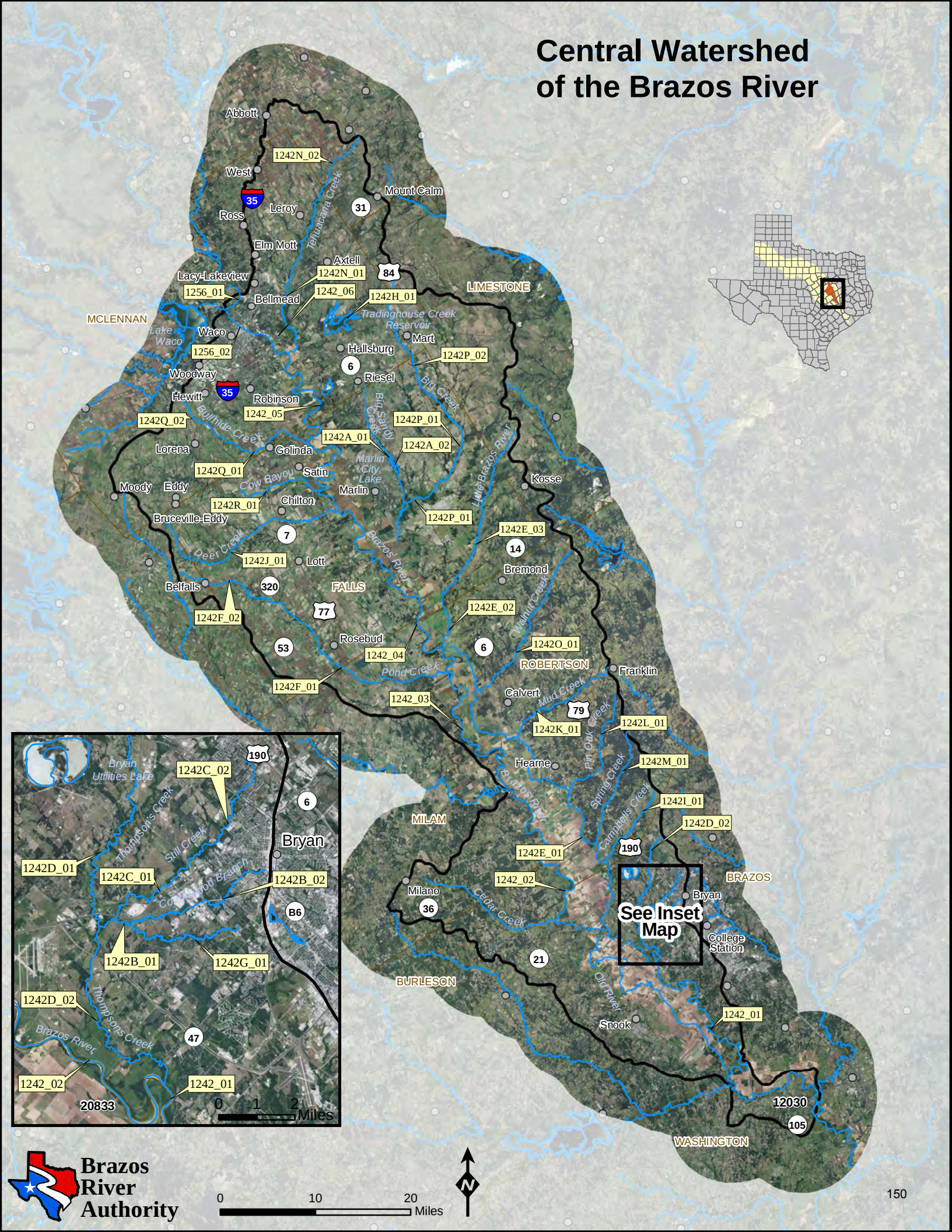
No obvious environmental factors have been identified that would explain the depressed fish IBI score in the first sampling event. . Instream flows and water quality were comparable during the two events and physical habitat was favorable. Nevertheless, a degree of instream stress was clearly indicated by the lack of intolerant species and overwhelming dominance by red shiners. The process of elimination implies that an unidentified, ephemeral stressor was responsible for less-than-optimal fish assemblage integrity. Overall, the segment attained or exceeded high ALU expectations, indicating a general prevalence of favorable environmental conditions.

Table 3.3.8.6 Water Quality Issues Summary

Water Quality Issue	Affected Area	Possible Influences/Concerns	Possible Actions Taken/to be Taken
Bacteria	1213_01, 1213_04, 1213A, 1214_01, 1244_03, 1244_04, 1247A, 1248C,	• Small, rural streams with little assimilative capacity having with no to low flow for most of the year, when water is present it is a result of storm event and associated runoff • Municipal Discharge • Aging, poorly-maintained OSSFs • Urban Stormwater Runoff • Rural Stormwater Runoff	• Upgrade/Rehabilitate WWTPs and associated wastewater collection systems in segments where anthropogenic bacteria inputs are indicated • Consider routine maintenance and repair requirements for OSSFs in small, unclassified, perennial waterbodies where anthropogenic inputs are indicated • Consiider standards revisions for small, unclassified intermittent streams where nonpoint source inputs are indicated • RUAAs in-progress in many of the affected areas • Education • Implement BMPs to reduce runoff from agricultural lands
Sedimentation	1247_01, 1247_02, 1247_03	• Urban Stormwater Runoff • Rural Stormwater Runoff	• Education • Stormwater Construction Control • Implement BMPs to reduce runoff from agricultural lands
Chloride, Sulfate	1214_01, 1214_02	• Residential use of ion-exchange, and/or advanced filtrations water softening systems	• Reduce use of water softening systems • Require alternate disposal,

		• Drought	other than through municipal WWTPs or direct discharges to streams and lakes, of brine generated by water softening systems

Central Watershed of the Brazos River



3.3.9 Central Watershed of the Brazos River

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
2706 mi^2	17	BRA, TCEQ	51	Cities of Bryan, College Station, Snook, Hearne, Calvert, Franklin, Rosebud, Bremond, Lott, Matlin, Kosse, Lorena, Woodway, Belmeade, Robinson, Mart, Mount Calm, West, Abbott; Sanderson Farms, Altura Power, KT Mining, Luminant Generation, Tradinghouse Power	1242

Description of Segments:

1242: Central Brazos River – Brazos River above Navasota River – From a point immediately upstream of the confluence of the Navasota River in Brazos/Grimes/Washington County to the low water dam forming Lake Brazos in McLennan County.

Segment Length: 185.35 mi

Assessment Units (Stations): 1242_01 (12030, 13666), 1242_02 (12031, 15767), 1242_03 (None), 1242_04 (12032, 12033), 1242_05 (12034, 12035, 12036, 12037), 1242_06 (12038)

Unclassified Segment: **1242A**: Marlin City Lake System; **1242B**: Cottonwood Branch; **1242C**: Still Creek; **1242D**: Thompsons Creek; **1242E**: Little Brazos River; **1242F**: Pond Creek; **1242G**: Unnamed tributary of Cottonwood Branch; **1242H**: Tradinghouse Reservoir; **1242I**: Campbells Creek; **1242J**: Deer Creek; **1242K**: Mud Creek; **1242L**: Pin Oak Creek; **1242M**: Spring Creek; **1242N**: Tehuacana Creek; **1242O**: Walnut Creek; **1242P**: Big Creek; **1242Q**: Bull Hide Creek; **1242R**: Cow Bayou

Assessment Units (Stations): 1242A_01 (16783), 1242A_02 (16781), 1242B_01 (17598), 1242B_02 (17597), 1242C_01 (16882), 1242C_02 (17378), 1242D_01 (16396, 20530), 1242D_02 (16397), 1242E_01 (11581, 11591), 1242E_02 (None), 1242E_03 (None), 1242F_01 (16406), 1242F_02 (None), 1242G_01 (None), 1242H_01 (18457), 1242I_01 (16395), 1242J_01 (11723, 16407, 18644), 1242K_01 (16402), 1242L_01 (16401), 1242M_01 (16394), 1242N_01 (11609; 11610; 15771; 18812; 18870; 18871), 1242N_02 (None), 1242O_01 (16403), 1242P_01 (16400), 1242P_02 (None), 1242Q_01 (11604, 20128), 1242Q_02 (None), 1242R_01 (None)

Central Watershed of the Brazos River FY12 Water Quality Monitoring and 2010 IR Status

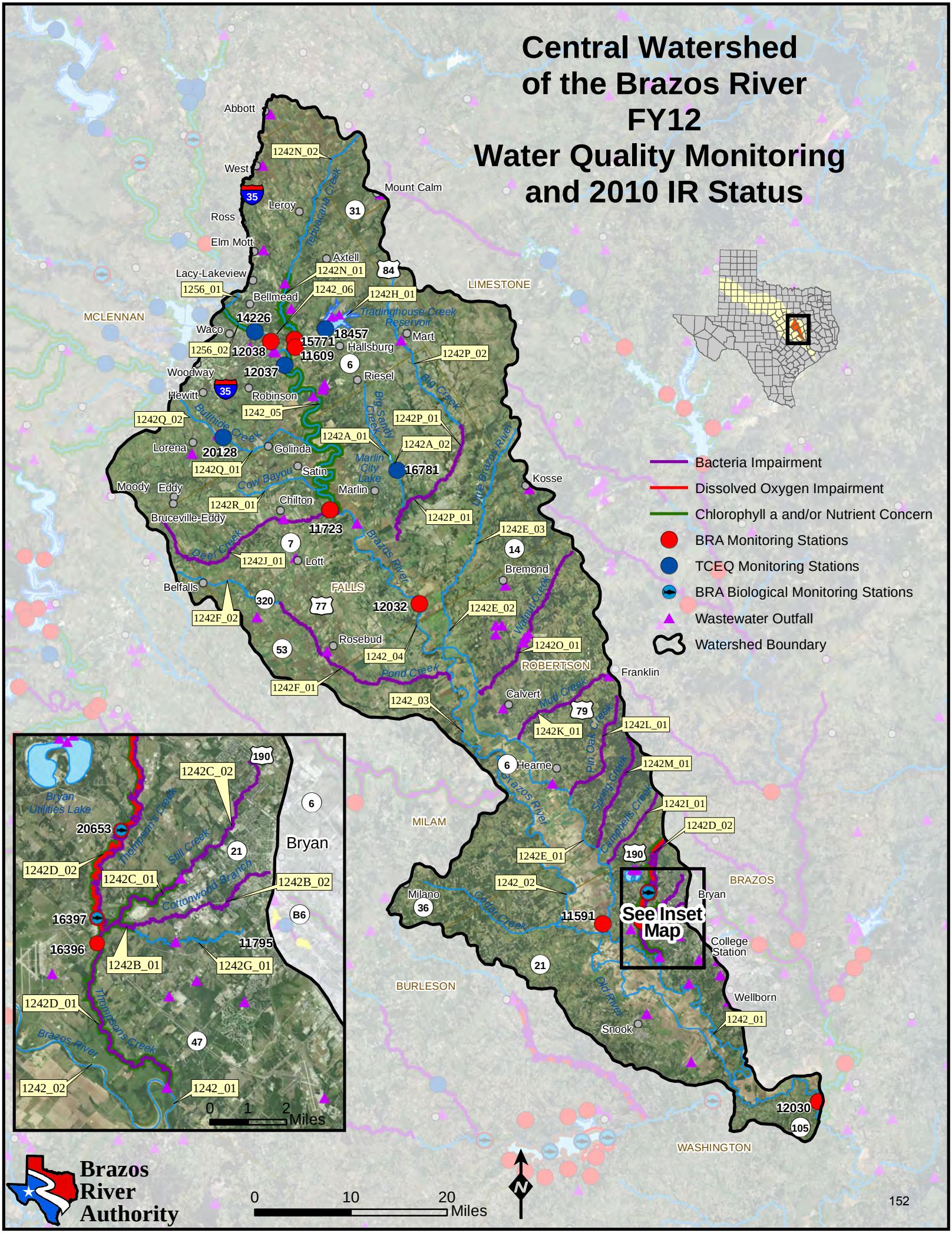


Table 3.3.9.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Central Watershed of the Brazos River		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[4] (MPN/100mL)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1242	**Brazos River above Navasota River**	**PCR**	H	**350**	**200 ↓**	**1000 ↓**	**5.0/3.0 ↑**	**6.5-9.0**	**126**	**95**		**0.33**	**1.95 ↑**	**0.37 ↓**	**0.69**	**14.1**
1242A	Marlin City Lake System	PCR	H	350	200	1000	5.0/3.0	6.5-9.0	126	95		0.11	0.37	0.05	0.2	26.7
1242B	Cottonwood Branch	PCR	I	350	200	1000	4.0/3.0	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242C	Still Creek	PCR	H	350	200	1000	5.0/3.0	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242D	Thompsons Creek	PCR	I	350	200	1000 ↑	4.0/3.0	6.5-9.0 ↑	126	95	14.1 ↑	0.33	1.95 ↑	0.37 ↑	0.69	14.1 ↑
1242E	Little Brazos River	PCR	H	350	200	1000	5.0/3.0	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242F	Pond Creek	PCR	L	350	200	1000	3.0/2.0	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242H	Tradinghouse Reservoir	PCR	H	350	200	1000	5.0/3.0	6.5-9.0	126	95	26.7	0.11	0.37	0.05	0.2	26.7
1242I	Campbells Creek	PCR	M	350	200	1000	2.0/1.5	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242J	Deer Creek	PCR	I	350 ↓	200 ↑	1000	4.0/3.0	6.5-9.0	126	95	14.1	0.33	1.95	0.37 ↓	0.69	14.1
1242K	Mud Creek	PCR	L	350	200	1000 ↓	3.0/2.0	6.5-9.0 ↓	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242L	Pin Oak Creek	PCR	L	350	200	1000 ↓	2.0/1.5	6.5-9.0 ↓	126 ↓	95	14.1	0.33	1.95	0.37	0.69	14.1
1242M	Spring Creek	PCR	L	350	200	1000 ↓	3.0/2.0	6.5-9.0 ↓	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242N	Tehuacana Creek	PCR	H	350	200 ↑	1000	5.0/3.0 ↑	6.5-9.0 ↑	126	95	14.1	0.33	1.95 ↑	0.37 ↑	0.69	14.1
1242O	Walnut Creek	PCR	H	350	200 ↑	1000 ↓	2.0/1.5	6.5-9.0 ↓	126	95 ↓	14.1	0.33	1.95 ↓	0.37	0.69	14.1
1242P	Big Creek	PCR	M	350	200	1000	2.0/1.5	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1
1242Q	Bull Hide Creek	PCR	H	350	200	1000	5.0/3.0	6.5-9.0	126	95	14.1	0.33	1.95	0.37	0.69	14.1

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation

[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

↑ Statistically significant increasing trend

Segment or portion of segment has a concern for the standard or screening level

↓ Statistically significant decreasing trend

Central Watershed of the Brazos River

The Central Watershed of the Brazos River extends from Lake Brazos Dam in Waco to the mouth of the Navasota River southeast of College Station, and drains approximately 2,706 square miles. Land usage is primarily agricultural, with two sizeable urban areas, Waco and Bryan/College Station. One classified waterbody, the Brazos River above Navasota River, segment **1242**, and 18 unclassified water bodies on tributary systems, have adequate water quality data for the period of record and were included in the present assessment.

In the 2010 assessment, segment **1242** has no impairments and only the portion of the segment from the confluence with Deer Creek upstream to the confluence with Tehuacana Creek had a concern for chlorophyll *a*.

For the Marlin City Lake System (**1242A**), orthophosphate phosphorus and elevated chlorophyll *a* pose concerns. Currently, the source of phosphorus is unknown; however, the elevated phosphorous levels are likely influencing chlorophyll *a* concentrations. Tradinghouse Reservoir (**1242H**) has a concern for harmful algal bloom/golden algae.

Eleven tributaries to the Brazos above Navasota possess bacterial impairments, including: Cottonwood Branch (**1242B**), Still Creek (**1242C**), Thompson Creek (**1242D**) (also with depressed DO impairment), Pond Creek (**1242F**), Campbell's Creek (**1242I**), Deer Creek (**1242J**), Mud Creek (**1242K**), Pin Oak Creek (**1242L**), Spring Creek (**1242M**), Walnut Creek (**1242O**) and Big Creek (**1242P**). Nutrient enrichment is a concern for Cottonwood Branch, Still Creek, Thompson Creek, and Pond Creek. In the 2010 assessment Tehuacana Creek (**1242N**) has concerns for bacteria, chlorophyll *a*, and fish kill report.

As in the case of the unclassified tributary streams in the Bosque and Leon Watersheds, many of the impaired or concern sub-segments in **1242** are small, rural streams with little to no flow for most of the year whose water is primarily generated by storm events and the associated runoff.

Special Studies:

There are two project in progress intended to address many of the issues in these unclassified streams. Please click here for more information on the Little Brazos River Tributaries project that is addressing the bacterial impairment in the Campbell's (**1242I**), Mud (**1242K**), Pin Oak (**1242L**), Spring (**1242M**), and Walnut Creeks (**1242O**). This study involved completing RUAAs for the aforementioned streams as well as bacterial source tracking and land use modeling of the watershed. The Two Data Collection Initiatives project is addressing issues in Thompson's, Deer and Tehuacana Creeks.

Two Data Collection Initiatives
Tehuacana Creek (**1242N**) and Deer Creek (**1242J**) are on the 303(d) List for bacteria impairment. Because these unclassified streams are small, ephemeral streams where recreational potential is low to non-existent, the efficacy of applying water quality standards meant for large, recreational river segments has come into question. Typically these streams have low flow to no flow for most of the year and if water is present, it is a result of storm events. Stormwater is known to accumulate high levels of both bacteria and nutrients as it travels over land. These pollutants are then deposited in the small streams where they can accumulate possibly causing impairment. Data will be collected to verify the impairment, a land use assessment for the watershed will be prepared, and intensive watershed surveys will be performed. This data will allow TCEQ to determine if existing bacteria criterion applied to these creeks are appropriate and, if not, to develop information necessary to adjust the criterion. Collection of this data began in 2010.

Thompsons Creek (**1242D**) is on the 303(d) List for depressed dissolved oxygen (DO). This stream is characterized by highly intermittent flow and frequent low water levels. The DO impairment is caused in part by the frequent low water levels which hinder the ability of the water to buffer against high ambient air temperatures in the summer and fall reducing the water's capacity to maintain dissolved oxygen levels. BRA will conduct a series of biological and 24-hour DO data collections. A Use attainability analysis (UAA) will be conducted on Thompsons Creek (**1242D**) to determine if existing aquatic life use/dissolved oxygen criterion are appropriate and, if not, to develop information necessary to adjust the aquatic life use/dissolved oxygen criterion. Year 1 of the UAA was conducted on Thompsons Creek (**1242D**) in 2010. Preliminary data indicate several generalities that held true during year 1, independent of hydrology and DO concentrations: (1) all habitat quality index scores rated intermediate; (2) all benthic IBI scores rated limited; (3) three of the four fish IBI scores rated high, with the March score for Sandy Point Road falling only slightly below the high ALU range. Interestingly, biological integrity did not decrease proportionally to DO through the gradient to intermittency. In fact, all July IBI scores for benthics and fish, under conditions of no flow and extremely low oxygen levels, were higher than corresponding scores for March, when the creek was flowing and oxygen concentrations were much greater. Due to

the drought in 2011, Year 2 data could not be collected; however collection is scheduled for 2012, and will help refine initial indications.

Biological Assessments:

Tehuacana Creek is an unclassified tributary of Brazos River Segment **1242**. The creek has not been assigned an aquatic life use (ALU) or dissolved oxygen (DO) criteria by TCEQ. Following TCEQ guidelines, a high ALU and 24-hour DO criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) are presumed to apply, since flow in the lower portion of the creek is perennial. These presumptions are supported by a January 2006 receiving water assessment conducted by TCEQ Region 9, which found the lower assessment unit to be attaining a high ALU, based on the fish assemblage.

The creek was assessed at SH 6 southeast of Waco, Station 15771, on June 1-4 and August 24-25, 2009. The site, due to its location in the lower reach, integrates effects of most water quality influences in the watershed. The purposes were to assess the current condition of aquatic life in the creek, in light of potential water quality degradation from upstream wastewater discharges, and to provide biological data for future 305(b) assessments.

In the initial event, during the non-critical portion of the index period, DO concentrations achieved an exceptional ALU, fish a high ALU, and physical habitat and benthic macroinvertebrates an intermediate ALU.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 6/1/09 physical habitat data, which corresponded to an intermediate ALU, were re-utilized. DO concentrations and fish achieved an exceptional ALU, and benthic macroinvertebrates a limited ALU.

Whereas fish met or exceeded high ALU expectations, benthic macroinvertebrate integrity was depressed. Low benthic IBI scores resulted mainly from dominance by relatively tolerant taxa, including *Cheumatopsyche*, Chironomidae, and *Stenelmis*. The particularly low August score reflected a decrease in the total number of taxa, from 18 to 11; disappearance of certain, relatively sensitive taxa such as *Baetis*, *Labiobaetis*, and *Erpetogomphus*; and increased dominance by *Stenelmis*.

Two environmental variables may have negatively affected benthic macroinvertebrate integrity. The first was physical habitat, which was not particularly favorable for aquatic life, due mainly to steep, erodible stream banks

and scarce instream cover. However, high fish IBI scores imply that physical habitat limitations were not the main determinant. Water quality appeared to be the more important factor. Physicochemical conditions were fair in June, but harsh in August. Although some water quality deterioration might have been expected in relation to seasonal effects during the critical period of the year, natural factors alone could not explain what was observed in August. Flow was less than half that in June (1.6 versus 3.8 cfs), so less dilution was available for wastewater effluents. Nitrate (71 mg/L), orthophosphate (5.40 mg/L), total phosphorus (5.68 mg/L), and chlorophyll *a* (157 µg/L) were extremely high. Information from TCEQ's SWQMIS data base for a nearby monitoring site (11609) indicates other instances where concentrations were elevated during 2008-09, including nitrate, 42 mg/L; orthophosphate, 2.55 and 5.98 mg/L; and chlorophyll *a*, 50, 56, and 93 µg/L. Twenty-four hour maxima for temperature, conductivity, and pH were at levels that might be expected to stress sensitive aquatic organisms. Although the DO minimum was not low, diel fluctuations were extremely wide, with a 162% difference between maximum and minimum saturation values, a degree of variation that might also be expected to induce stress.

In conclusion, the results showed that physicochemical conditions were harsh in the lower reaches of Tehuacana Creek, particularly during the critical period when instream flows were minimal. Nutrients contributed by wastewater discharges were stimulating excessive primary production, which promoted exaggerated algal photosynthesis/respiration, disruption of normal DO and pH dynamics, and autochthonous generation of inordinate amounts of organic matter in the form of decaying phytoplankton and filamentous algae cells. Allochthonous inputs of organic solids from point source discharges may also have been influential, but the significance is unknown. Differential impacts on benthic macroinvertebrates versus fish indicate that at the present time, adverse effects are primarily associated with the streambed rather than the water column, in relation to buildups of fine particulate organic matter (FPOM) on the substrate. Excessive deposition of FPOM can have an array of detrimental effects on benthic macroinvertebrate assemblages, including physical smothering, DO depletion at the water/sediment interface, and functional feeding group imbalance.

There are two biological assessments scheduled for 2012: one at station 12032 - Brazos River downstream of FM 413 northeast of Rosebud, and 15767 - Brazos River at SH 21 northeast of Caldwell.

Table 3.3.9.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria	Small rural tributaries throughout the watershed	• Small rural tributaries, highly influenced by nonpoint sources and very little flow. • Storm water runoff	• RUAAs have been completed for many of the tributaries in the watershed, and are under review • Continue to conduct RUAAs to address all impairments in the system • Special studies are underway
Nutrient and Chlorophyll *a* enrichment	Lake Brazos portion to confluence with Deer Creek of the Brazos River	• Industrial permitted discharges • Storm water runoff	• Permit review

Navasota River Watershed
HILL
NAVARRO
Coolidge
Mount Calm
Navasota River
1210A_01
1210_01
Lake Mexia
1210_02
Mexia
FREESTONE
Teague
MCLENNAN
Springfield Lake
1253A_01
1253_03
1253_02
Groesbeck
1253_01
LIMESTONE
1252_04
1252_05
Thornton
1252_02
1252_03
Lake Limestone
Lewiss Creek
1209K_02
1252_01
Lawlit
FALLS
Marlin
1209_05
LEON
Marquez
Lyon Creek Reservoir
1209K_01
1209H_02
1209_05
1209H_01
Camp Creek Lake
1209O_01
Franklin
ROBERTSON
Normangee Lake
Normangee
MADISON
1209J_01
1209_04
North Zulch
1209G_01
Sag 1209J
BRAZOS
1209E_01
Wixon Valley
Wickson Creek
1209I_03
Gibbons Creek Reservoir
See Inset Map
1209_03
1209N_01
1209N_04
1209N_03
1209N_02
1209_02
1209C_01
Wellborn
1209I_01
GRIMES
BURLESON
1209_02
Anderson
Millican
1209_01
Navasota
1242C_02
BRAZOS
1209C_01
Bryan
1242B_02
1209L_01
Bryan Lake
1209B_01
1209D_01
1209A_01
College Station
Country Club Branch
1209F_01
Miles
Brazos River Authority
0
10
20
Miles

3.3.10 Navasota Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
2235 sq. m	19	BRA, TCEQ	50	Cities of Bryan, College Station, Thornton, Groesbeck, Teague, Mexia; Atofina Chemicals, Sanderson Frams, US Silica Company, NRG Texas	1209, 1210, 1252, 1253

Description of Segments:

1209: **Navasota River Below Lake Limestone** – From the confluence with the Brazos River in Grimes County to Sterling C. Robertson Dam in Leon/Robertson County.

Segment Length: 120 miles

Assessment Units (Stations): 1209 _01 (11872, 11873), 1209_02 (11875, 20528), 1209_03 (16398), 1209_04 (18341), 1209_05 (11877), 1209_06 (None)

Unclassified Segment: **1209A**: Country Club Lake; **1209B**: Fin Feather Lake; **1209C**: Carter's Creek; **1209D:** Country Club Branch; **1209E**: Wickson Creek; **1209F**: Wolfpen Creek; **1209G**: Cedar Creek; **1209H**: Duck Creek; **1209I**: Gibbon's Creek; **1209J**: Sheperd Creek; **1209K**: Steele Creek; **1209L**: Burton Creek; **1209N**: Gibbon's Creek Reservoir; **1209O**: Normangee Lake; **1209P**: Clear Creek

Assessment Units (Stations)*: 1209A_01 (11792, 11793, 11794, 20262, 20264, 20265, 20266, 20267, 20268, 20270), 1209B_01 (11798, 11799, 11800, 20253, 20254, 20255, 20256, 20257, 20258, 20259, 20260, 20261), 1209C_01 (11784, 11785), 1209D_01 (11795), 1209E_01 (11789, 15033), 1209F_01 (None), 1209G_01 (11787, 20529), 1209H_01 (16389), 1209H_02 (16390), 1209I_01 (11756), 1209I_02 (17904, 18800), 1209I_03 (None), 1209J_01 (11790), 1209K_01 (None), 1209K_02 (16384), 1209L_01 (11783), 1209L_02 (None), 1209N_01 (11749), 1209N_02 (11747, 11750, 11752, 11753), 1209N_03 (11746), 1209N_04 (11751), 1209O_01 (20271, 20272, 20273, 20274, 20275, 20276, 20277, 20278), 1209P_01 (20019)*

1210: **Lake Mexia** – From Bistone Dam in Limestone County up to the normal pool elevation of 448.3 feet (impounds Navasota River).

Segment Area: 1001.19 acres

Assessment Units (Stations): 1210_01 (11878, 14238, 17586, 17587), 1210_02 (17588, 18444)

Unclassified Segments: **1210A**: Navasota River above Lake Mexia
Assessment Units (Stations): 1210A_01 (16391)

1252: **Lake Limestone** – From Sterling C. Robertson Dam in Leon/Robertson County to a point 2.3 km (1.4 miles) downstream of SH 164 in Limestone County, up to normal pool elevation of 363 feet (impounds Navasota River).

Segment Area: 15960.74 acres
Assessment Units (Stations): 1252_01 (12123), 1252_02 (12125), 1252_03 (12124), 1252_04 (13971), 1252_05 (13970)

1253: **Navasota River Below Lake Mexia** – From a point 2.3 km (1.4 miles) downstream of SH 164 in Limestone County to Bistone Dam in Limestone County.

Segment Length: 19 miles
Assessment Units (Stations): 1253_01 (12126), 1253_02 (13650, 16393), 1253_03 (17039)

Unclassified Segments: **1253A**: Springfield Lake
Assessment Units (Stations): 1253A_01 (16247, 18799)

Navasota River Watershed FY12 Water Quality Monitoring and 2010 IR Status

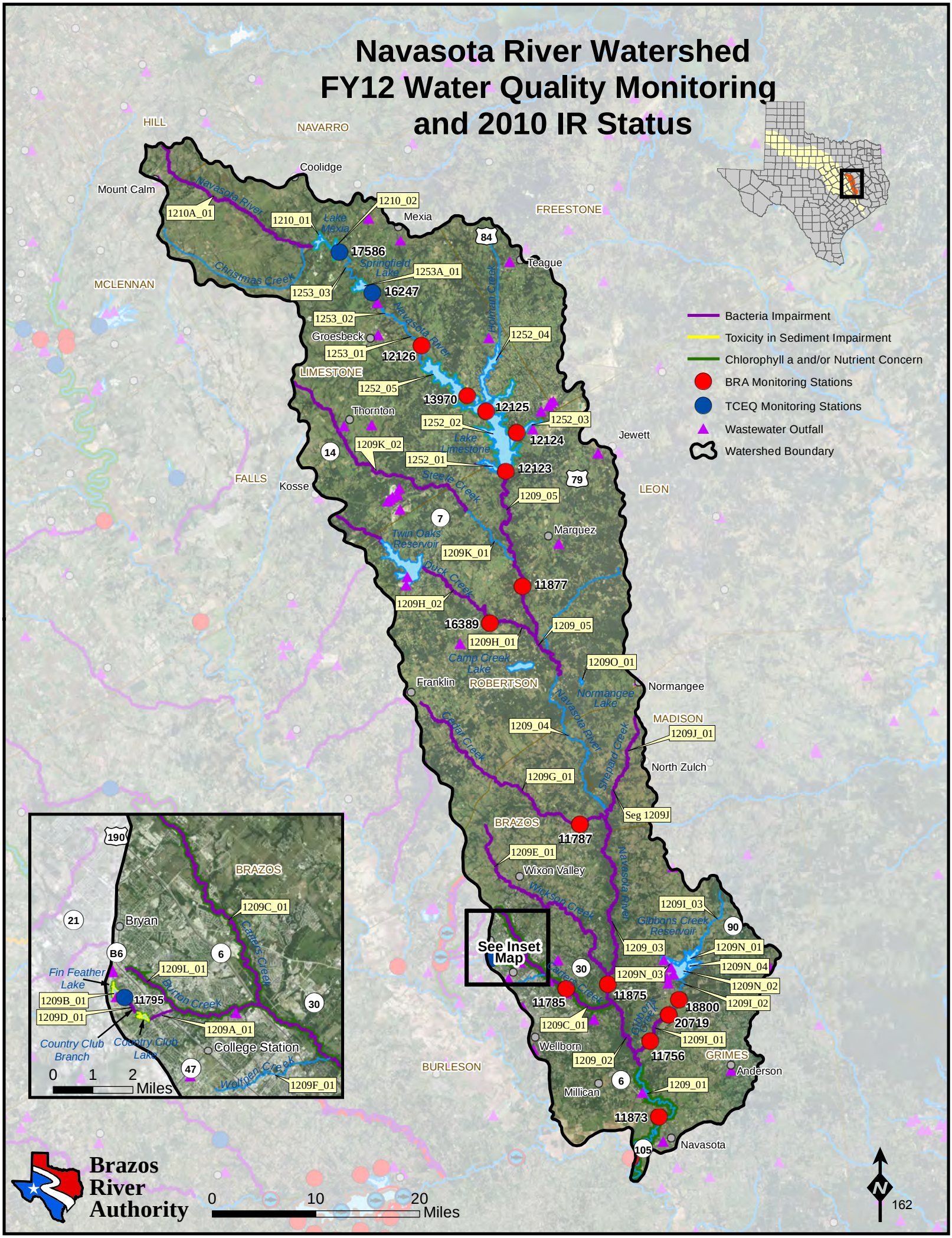


Table 3.3.10.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Navasota Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1209	**Navasota River below Lake Limestone**	**PCR**	**H**	**140↓**	**100↓**	**600↓**	**5.0/3.0**	**6.5-9.0↓**	**126**	**93**		**0.33**	**1.95**	**0.37↓**	**0.69**	**14.1**
1209A	Country Club Lake	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.11	0.37	0.05	0.20	26.7
1209B	Fin Feather Lake	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.11	0.37	0.05	0.20	26.7
1209C	Carter's Creek	PCR	H	140	100	600	4.0/3.0↑	6.5-9.0	126	93		0.33	1.95	0.37↓	0.69↓	14.1
1209D	Country Club Branch	PCR	H	140	100	600	3.0/2.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209E	Wickson Creek	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209F	Wolfpen Creek	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209G	Cedar Creek	PCR	H	140	100↓	600	5.0/3.0	6.5-9.0↑	126↓	93		0.33	1.95	0.37	0.69	14.1
1209H	Duck Creek	PCR	H	140	100	600↑	5.0/3.0↓	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209I	Gibbon's Creek	PCR	H	140	100	600	3.0/2.0↑	6.5-9.0↑	126	93		0.33	1.95↓	0.37	0.69	14.1
1209J	Sheperd Creek	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209K	Steele Creek	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209L	Burton Creek	PCR	H	140	100	600	3.0/2.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1209N	Gibbon's Creek Reservoir	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.11	0.37	0.05	0.20	26.7
1209O	Normangee Lake	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.11	0.37	0.05	0.20	26.7
1209P	Clear Creek	PCR	H	140	100	600	5.0/3.0	6.5-9.0	126	93		0.33	1.95	0.37	0.69	14.1
1210	**Lake Mexia**	**PCR**	**H**	**100↓**	**50↓**	**400**	**5.0/3.0**	**6.5-9.0**	**126**	**90**	**26.7↑**	**0.11**	**0.37**	**0.05↑**	**0.20**	**26.7↑**
1210A	Navasota River above lake Mexia	PCR	H	100	50	400	5.0/3.0	6.5-9.0	126	90		0.33	1.95	0.37	0.69	14.1
1252	**Lake Limestone**	**PCR**	**H**	**50↓**	**50**	**300↓**	**5.0/3.0**	**6.5-9.0↑**	**126**	**90**	**19.26↑**	**0.11**	**0.37↓**	**0.05**	**0.20↑**	
1253	**Navasota River below Lake Mexia**	**PCR**	**H**	**440↓**	**150**	**1350↓**	**5.0/3.0**	**6.5-9.0**	**126**	**93**		**0.33**	**1.95**	**0.37**	**0.69**	**14.1**
1253A	Springfield Lake	PCR	H	440	150	1350	5.0/3.0	6.5-9.0	126	93		0.11	0.37	0.05	0.20	26.7

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Navasota River Watershed

The Navasota River Watershed drains approximately 2,235 square miles, originating in southeast Hill County and flows 125 miles south to its confluence with the Brazos River. The main stem of the river is impounded in three places in Limestone County creating Lake Mexia, Lake Springfield and Lake Limestone. Land use in this watershed is primarily agricultural land with one growing urban area, Bryan/College Station. The Navasota River runs through two eco-regions: the Texas Blackland Prairies in the northern portion and the East Central Texas Plains in the southern portion of the watershed. In most of the area water quality is good, though there are segments within the watershed that exceed the state standards for fecal coliform, E. coli and dissolved oxygen. This is not an unexpected result for waterbodies in this area due to sluggish flow, warm temperatures and an abundance of organic matter.

Potential sources of nonpoint source pollution in the Navasota Rive below Lake Limestone include municipal point source discharges, on-site sewage facilities, and runoff from agricultural lands (particularly chicken farms in the upstream extent of the river). For any urban collection and treatment system, sanitary sewer overflows and WWTF bypasses are possible sources of bacteria loadings to receiving waters. The Navasota River below Lake Limestone (segment **1209**) watershed can be described as relatively rural with few permitted WWTF relative to area. This fact suggests that there are potentially a high number of on- site sewage facilities (OSSF or septic systems) in use in the watershed. OSSF require routine repairs and maintenance to avoid failures causing potential leaks or overflows. Poorly maintained OSSF are a potential source of bacteria loadings into the Navasota River below Lake Limestone.

Directly adjacent to the Navasota River below Lake Limestone are agriculture grazing tracts. These tracts potentially provide livestock with direct access to the River. Evidence of direct access was witnessed at the reconnaissance for field survey site 14 when cattle tracks were documented on the right bank along the river bank. Direct contact with agriculture grazing is a potential nonpoint source for the Navasota River below Lake Limestone.

Segment **1209** consists of the Navasota River below Lake Limestone downstream to its confluence with the Brazos River. This segment contains several small tributary creeks and two off-channel city lakes in Bryan/College Station, Country Club Lake and Fin Feather Lake. Several water quality impairments exist in this segment, mostly due to high concentrations of E. coli bacteria.

Country Club Lake (**1209A**) and Fin Feather Lake (**1209B**) are two small municipal lakes located in the cities of Bryan/College Station. From 1988 to 1990 a study conducted by the Texas Parks and Wildlife Department found that sediment from both lakes toxic to aquatic organisms. Researchers found arsenic, copper and zinc, among other metals in sediment samples from both lakes. These pollutants have been attributed to long-term discharge from an old nearby pesticide formulating facility. Periodic monitoring of sediment toxicity and eventual development of a more extensive long-term monitoring plan, a legacy TMDL, and the possibility of future remediation recommendations for copper and zinc are needed to restore aquatic life use in these two lakes.

Carters Creek (**1209C**) is a perennial stream from the confluence with the Navasota River southeast of College Station upstream to its confluence with an unnamed tributary creek upstream of FM 158 in Brazos County. The entire stream is impaired due to elevated concentrations of *E. coli* bacteria that do not meet the State's criteria for contact recreational use. Additionally, municipal discharges, stormwater runoff from agricultural lands and livestock and wildlife waste may be contributing to the bacterial impairments in Carters Creek.

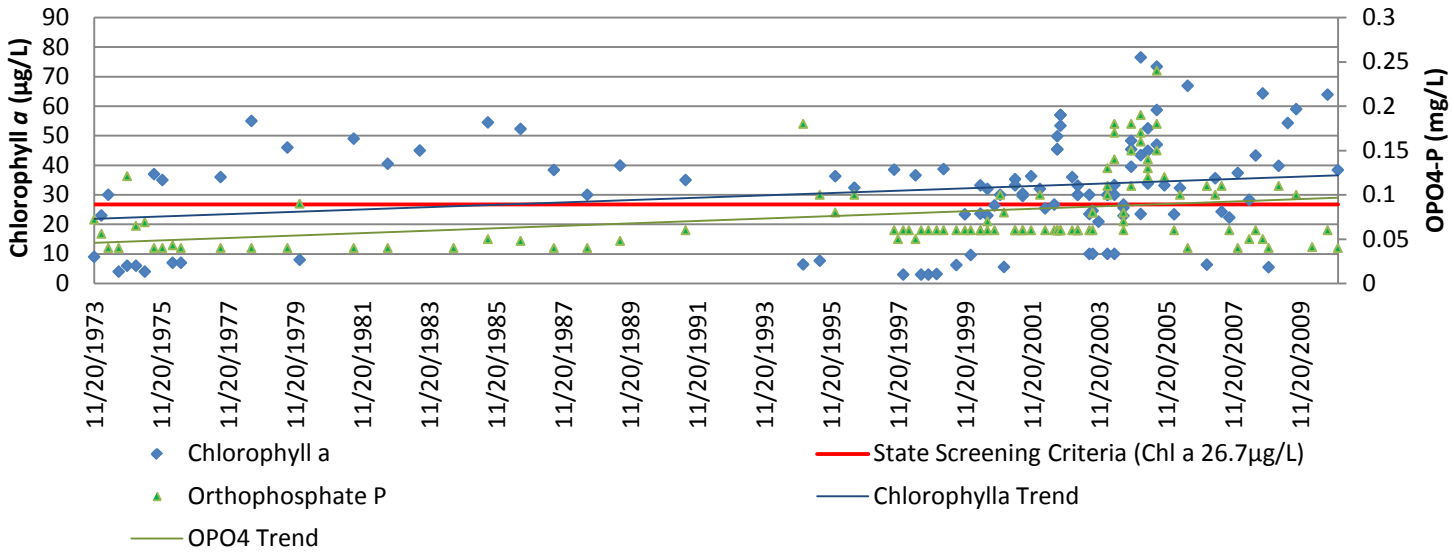
Data from water quality samples collected by Authority staff indicate a concern for elevated nutrients, specifically, nitrite+nitrate and Orthophosphate Phosphorus. Excessive nutrient levels increase algal growth which can potentially decrease dissolved oxygen when algae and aquatic plant material decompose. There are a permitted domestic outfalls, row crops, and pastureland within the watershed. Any or all of these could contribute to the bacteria and nutrients load in Carters Creek. Nutrient levels commonly exceed concern levels downstream from wastewater plants and most municipal discharges which do not have designated permit limits for nitrate and phosphorus and are not required by the state to perform nutrient reduction of their effluent prior to discharge.

Bacteria impairments also exist in four other small creeks in this watershed: Cedar Creek (**1209G**), Duck Creek (**1209H**), Shepherd Creek (**1209J**), and Steele Creek (**1209K**). They are typically small sluggish or stagnant creeks in lowland areas and have little flow or mixing of water often resulting in water quality that is not suitable for supporting general uses. Additionally, municipal discharges, stormwater runoff from agricultural lands and livestock and wildlife waste may be contributing to the bacterial impairments.

Segment **1210A** includes the Navasota River above Lake Mexia and it is impaired for elevated levels of bacteria.

Segment **1210**, Lake Mexia, is impaired for Chlorophyll *a*. 60% of the samples are higher than the 26.7 mg/L criteria. The average is 36 mg/L and the median is 32 mg/L with an increasing trend. The increase in orthophosphates may be encouraging this upward trend in Chlorophyll *a* (Figure 3.3.10.1).

Figure 3.3.10.1 **1210 - Chlorophyll *a* and Orthophosphate**



Special Studies:

RUAAs on segments 1209 and 1210A have been completed are under review.

A TMDL was initiated for Carter's (**1209C**) and Burton Creek (**1209L**) in August 2007. A draft implementation plan has been developed and published for public comment.

Biological Assessments:

Segment **1209**, the Navasota River below Lake Limestone, has a designated high aquatic life use (ALU), and 24-hour dissolved oxygen criteria of 5.0 mg/L (average) and 3.0 mg/L (minimum) (Texas Surface Water Quality Standards, Appendix A). Assessments were conducted 3.5 km upstream from the mouth of Gibbons Creek southeast of College Station, Station 20529, on May 10-11 and August 16-17, 2010. The site integrates effects of most water quality influences in the watershed, due to its location in the lower portion of the river. Fisheries surveys were performed at the site by TPWD/BRA in 2006 for the Texas Instream Flow Program. The present effort was conducted to generate more comprehensive information on existing ecological conditions. Past 305(b) assessments have identified impairments for bacteria and concerns for nitrate and orthophosphorus in portions of the segment. Biological data were collected to determine if any water quality-related impacts are occurring, and to help elucidate the effectiveness of the recently completed Brazos/Navasota Watershed Protection Plan.

In the first event, during the non-critical portion of the index period, physical habitat, benthic macroinvertebrates, and fish achieved a high ALU. No dissolved oxygen data were collected due to equipment failure.

In the second event, during the critical portion of the index period, reassessment of one habitat transect showed that characteristics had not changed appreciably; therefore, the 5/5/10 physical habitat data, which reflected achievement of a high ALU, were re-utilized. Dissolved oxygen concentrations achieved a high ALU based on the 24-hr. mean, and an exceptional ALU based on the 24-hr. minimum. Fish and benthic macroinvertebrates achieved a high ALU.

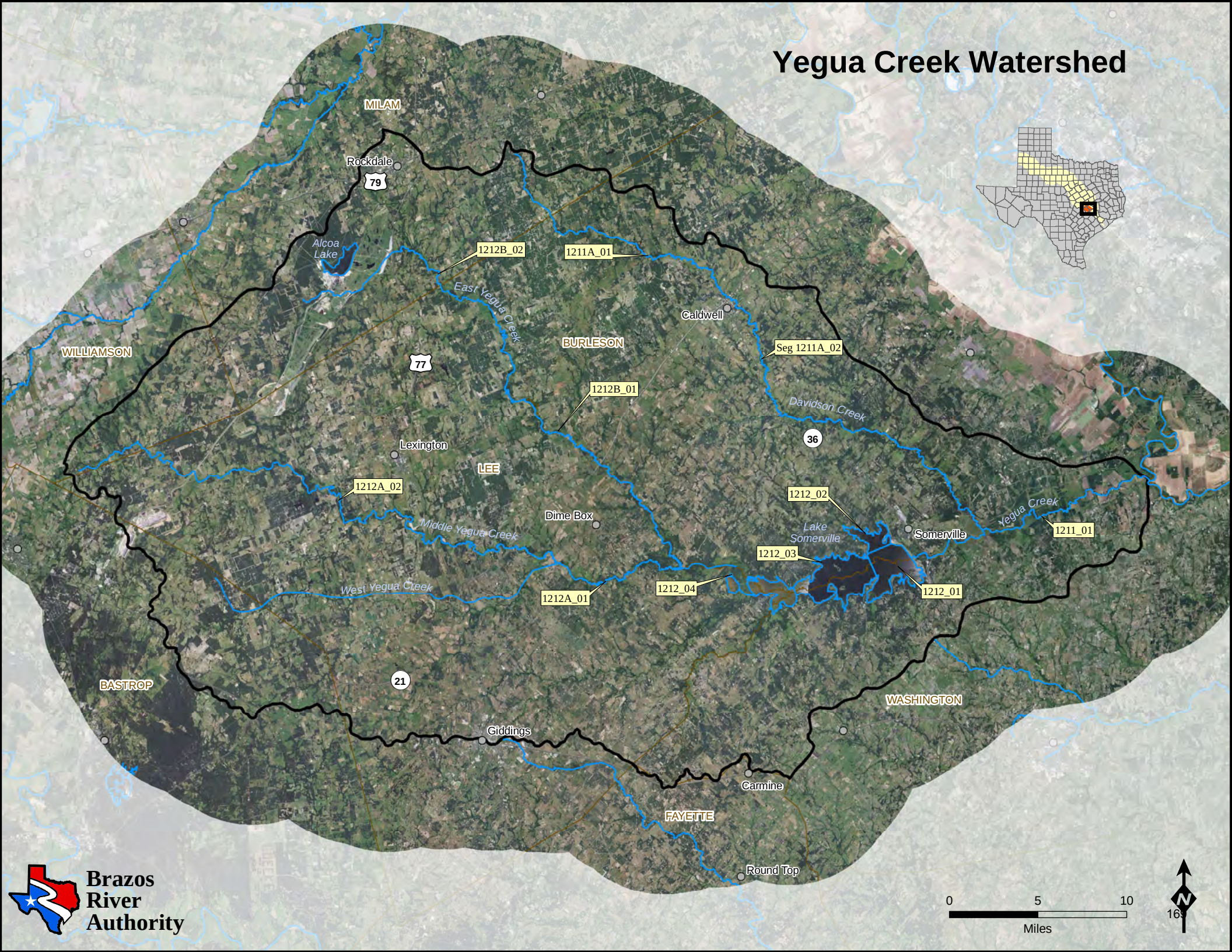
Nutrient enrichment was indicated by water chemistry data. Nitrate, orthophosphorus, and total phosphorus exceeded TCEQ screening levels during both events, along with chlorophyll *a* during the August event. However, no adverse effects on dissolved oxygen concentrations or aquatic life were evident.

Fish species richness was noteworthy for Brazos River Basin streams – 26 in May and 30 in August – indicating a rich and diverse assemblage. This, together with the fact that all aquatic life monitoring components met high ALU expectations, reflected favorable environmental conditions.

Table 3.3.10.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria	• Small rural tributaries throughout the watershed • Urban areas	• Small rural tributaries, highly influenced by nonpoint sources and very little flow. • Storm and municipal water runoff	• RUAAs have been completed for many of the tributaries in the watershed, and are under review • Continue to conduct RUAAs to address all impairments in the system • TMDL is underway for Carter's Creek

Yegua Creek Watershed



Brazos River Authority

3.3.11 Yegua Creek Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
XX	15	BRA, TCEQ	20	Cities of Brenham, Somerville, Giddings, Lexington, Caldwell, Rockdale; Aqua WSC, Luminant Mining, Alcoa, Inc.	1211, 1212

Description of Segments:

1211: Yegua Creek – From the confluence with the Brazos River in Burleson/Washington County to Somerville Dam in Burleson/Washington County

Segment Length: 20.5 miles
Assessment Units (Stations): 1211_01 (11880)

Unclassified Segments: **1211A**: Davidson Creek 58.5 miles
Assessment Units (Stations): 1211A_01 (18349), 1211A_02 (11729)

1212: Somerville Lake – From Somerville Dam in Burleson/Washington County up to normal pool elevation of 238 feet

Segment Area: 11968 acres
Assessment Units (Stations): 1212_01 (11881), 1212_02 (11883), 1212_03 (11885, 16879, 18445, 20532), 1212_04 (11882)

Unclassified Segment: ***1212A***: Middle Yegua Creek 61.9 miles
Assessment Units (Stations): 1212A_01 (11838), 1212A_02 (18750, 18751)

Unclassified Segment: ***1212B***: East Yegua Creek 48.8 miles
Assessment Units (Stations): 1212B_01 (11594), 1212B_02 (16887)

Yegua Creek Watershed
FY12 Water Quality Monitoring and 2010 IR Status

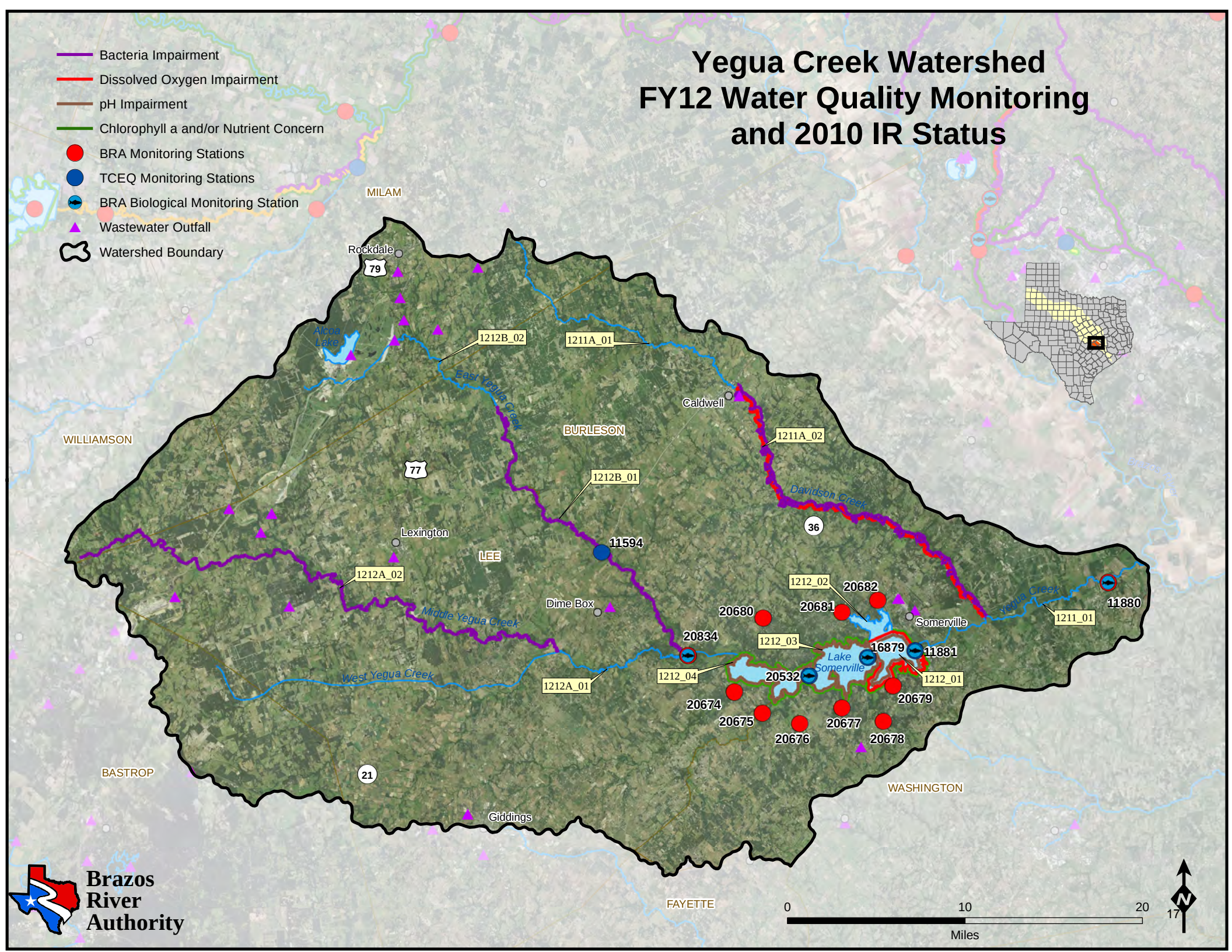


Table 3.3.11.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Yegua Creek Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[4] (MPN/100ml)	Temperature (°F)	Chlorophyll a (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (µg/l)
1211	**Yegua Creek**	**PCR**	**H**	**140.0**	**130.0**	**640.0**	**5.0/3.0**	**9.0**	**126**	**91**			**1.95**	**0.37**		**14.1**
1211A	Davidson Creek	PCR	I	140.0	130.0	640.0	4.0/3.0	9.0	126	91		0.33	1.95	0.37	0.69	14.1
1212	**Somerville Lake**	**PCR**	**H**	**100.0↑**	**100.0**	**400.0**	**5.0/3.0↑**	**9.0↑**	**126↑**	**93**	**53.05**	**0.11↓**	**0.37**	**0.05↑**	**0.20↓**	
1212A	Middle Yegua	PCR	H	100.0	100.0	400.0	5.0/3.0	9.0	126	93		0.33	1.95	0.37	0.69	14.1
1212B	East Yegua	PCR	H	100.0	100.0↓	400.0	5.0/3.0↓	9.0	126	93		0.33	1.95↓	0.37	0.69	14.1

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Yegua Creek Watershed

Land use in the Yegua Creek watershed is mainly rural and cattle production intensive with small urban areas and limited crop production areas. The main channel is impounded for flood control, municipal water supply and recreation to create Lake Somerville. Lake Somerville's holdings are the main water supply for The City of Brenham.

The uppermost portions of East and Middle Yegua creek reside on former Sandow lignite mine and Alcoa aluminum foundry. As of 2005, dewatering permits have concluded, and base flows have dropped. New mining operations opened

to the south, splitting the Colorado and Brazos basins, have lower outputs placing water mainly into Middle Yegua. The effects of this and further development of groundwater assets from the Carrizo-Wilcox aquifer on stream health will be interesting to watch in the future. If groundwater influence drops, major shifts in water quality may occur as the perennial nature of the streams will come into question. Current high aquatic life use ratings may need to be revisited.

Middle Yegua Creek (**1212A_01**) was placed on the 2010 303(d) List for both geomean and single sample bacteria exceeding standards. East Yegua was placed in the 303(d) List in 2002 for the same reasons (Figure 3.3.11.1). Middle Yegua is also listed for concerns for impaired habitat, impaired macrobenthic community, and depressed dissolved oxygen. The area is predominantly rural with pasture land with scattered mixed forest and minimal vegetative buffer area (Figure 3.3.11.2). Wild hogs tend to be a problem as well, defecating and further destabilizing stream banks.

Figure 3.3.11.1 **Middle and East Yegua - *E.coli***

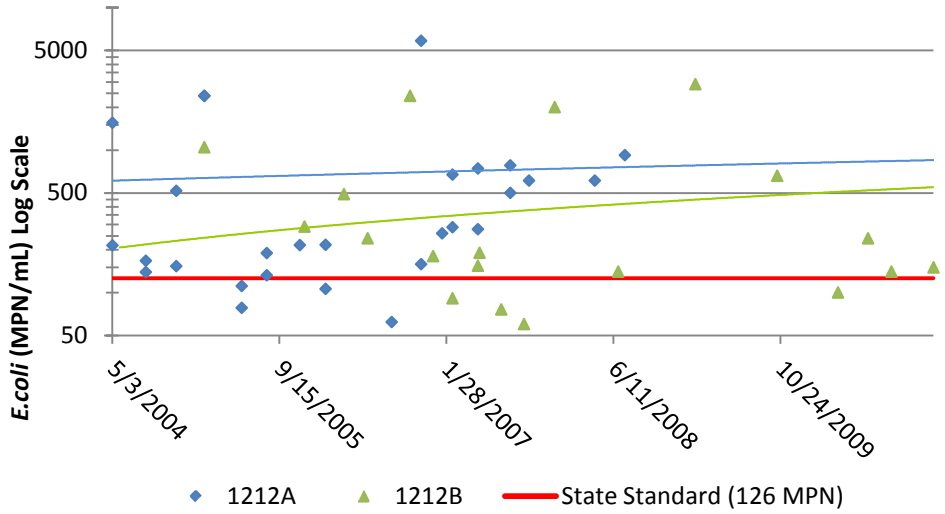
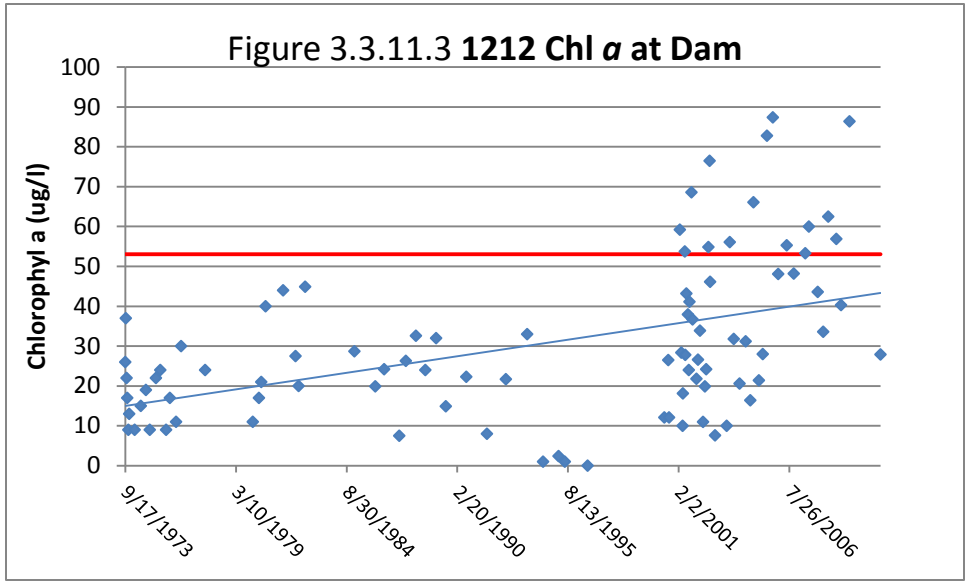
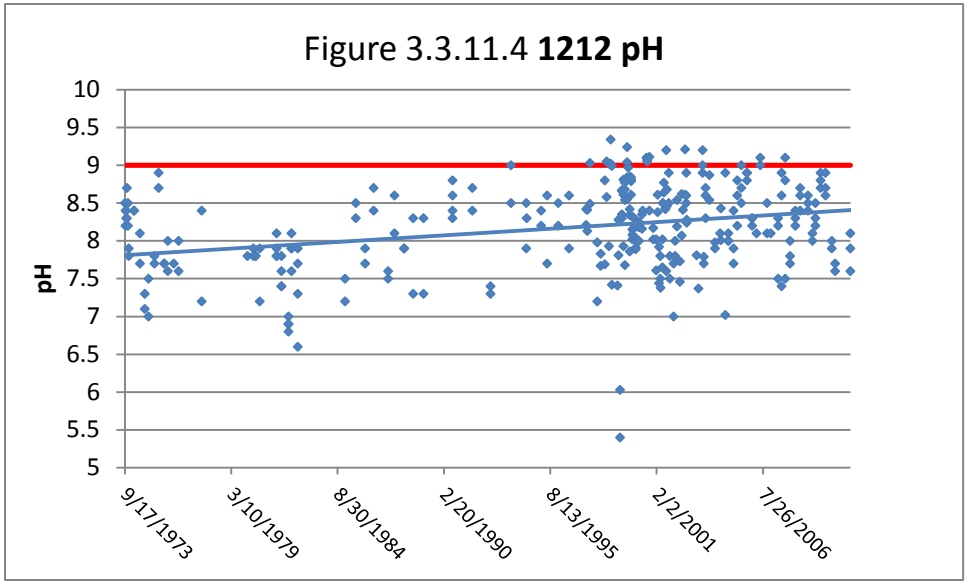


Figure 3.3.11.2
Middle and East Yegua Land Use

Lake Somerville is currently on the 303(d) list for both depressed dissolved oxygen (1212_01), and pH (1212_01, 1212_03, 1212_04). These parameters are commonly linked to eutrophication. Over production by planktonic algae (Figure 3.3.11.3) produces diel swings in dissolved oxygen causing super-saturation during the day while respiration can cause night time oxygen levels to crash. As photosynthesis ramps up in the daylight hours, CO_2 is removed from the water causing more alkaline conditions (Figure 3.3.11.4). However, there is not sufficient data to determine that cyanobacteria are the only organism causing this oscillation in pH and DO. Additionally, historical data collection indicates

that nutrient concentrations in Lake Somerville and its major tributary, Yegua Creek, are low. The low nutrient level brings into question the cause of cyanobacteria blooms. The limiting factor leading to algal blooms in the lake is not currently known making regulation of inflows to control blooms virtually impossible. The lake is also listed for concerns in regards to chlorophyll levels, and several harmful algal blooms that have prompted fish kill events.





Somerville's shallow and open surroundings are conducive to strong mixing pressures. This can lead to resuspension of sediments laden with nutrients, in combination with allochthonous material, fuels excessive algal growth. Revisions to the 2010 Texas Surface Water Quality Standards have increased the chlorophyll a standard to 53.05µg/l making it the second highest in the state. Habitual dumping is also a large problem in the watershed with every waterbody having some amount of household garbage, or animal carcass at some time during recent project sampling.

Davidson creek (1211A) is listed for depressed DO, and bacterial impairments. 24 hour DO measurements have concluded that the segments do not meet standards for average dissolved oxygen concentrations on 4 of the 10 deployments.

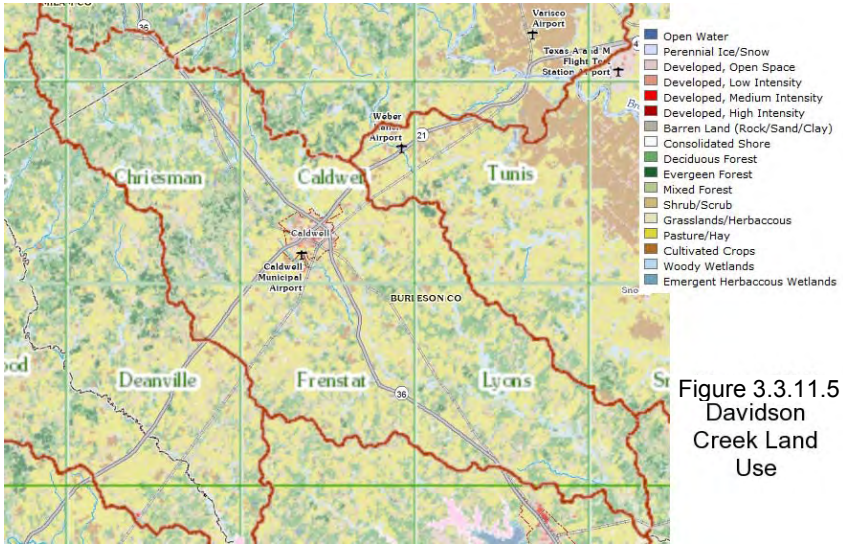
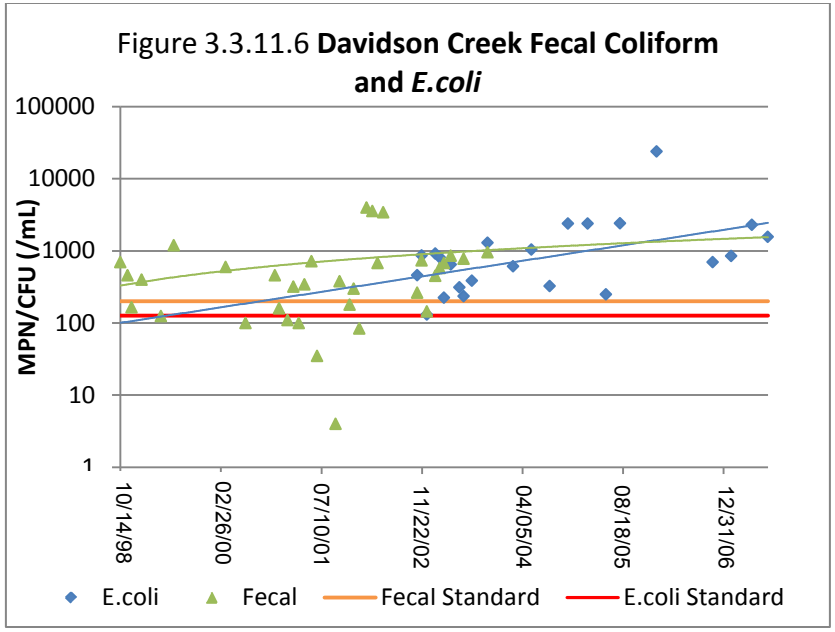


Figure 3.3.11.5 Davidson Creek Land Use



Land use in the top portion of the watershed, bisected by highway 21, primarily consists of pockets of mixed forest interspersed with cleared pasture land. The lower section includes most of the city of Caldwell, and cleared pasture land with small riparian corridors. Bacteria loads are high as demonstrated in figure 12.6 above with the geomean being almost six times the standard. The assessment is based on data collected from a station above the Caldwell WWTP and any densely populated areas so wildlife and livestock are the most likely sources.

Yegua Creek below the dam to the confluence with the Brazos (**1211**) is currently not listed for any parameters, and there are no statistically relevant trends. It appears to be stable at this time.

Special Studies:

Davidson Creek (**1211A**) has undergone an RUAA to establish its use level as a recreational waterbody and is currently under review.
http://www.tceq.texas.gov/waterquality/standards/ruaas/brazos-basin-recreational-use-attainability-analysis-part-1

A UAA and further study has been recommended to address Davidson's DO issues.

An RUAA was completed in 2010 for East Yegua Creek (**1212B**) by Texas A&M University. The full report can be viewed here: http://www.tceq.texas.gov/waterquality/standards/ruaas/multibrazos12part2

The BRA in conjunction with TIAER are in the finishing stages of a multiyear data collection effort to track nutrient sources for Lake Somerville (**1212**), and observe in lake nutrient, sediment and algal community conditions. This project will collect the additional data necessary for TCEQ to determine what course of action is most appropriate to address the impairment; again, whether it is a standards amendment, a TMDL, development of at Watershed Protection Plan, etc. This project will conclude in 2013.

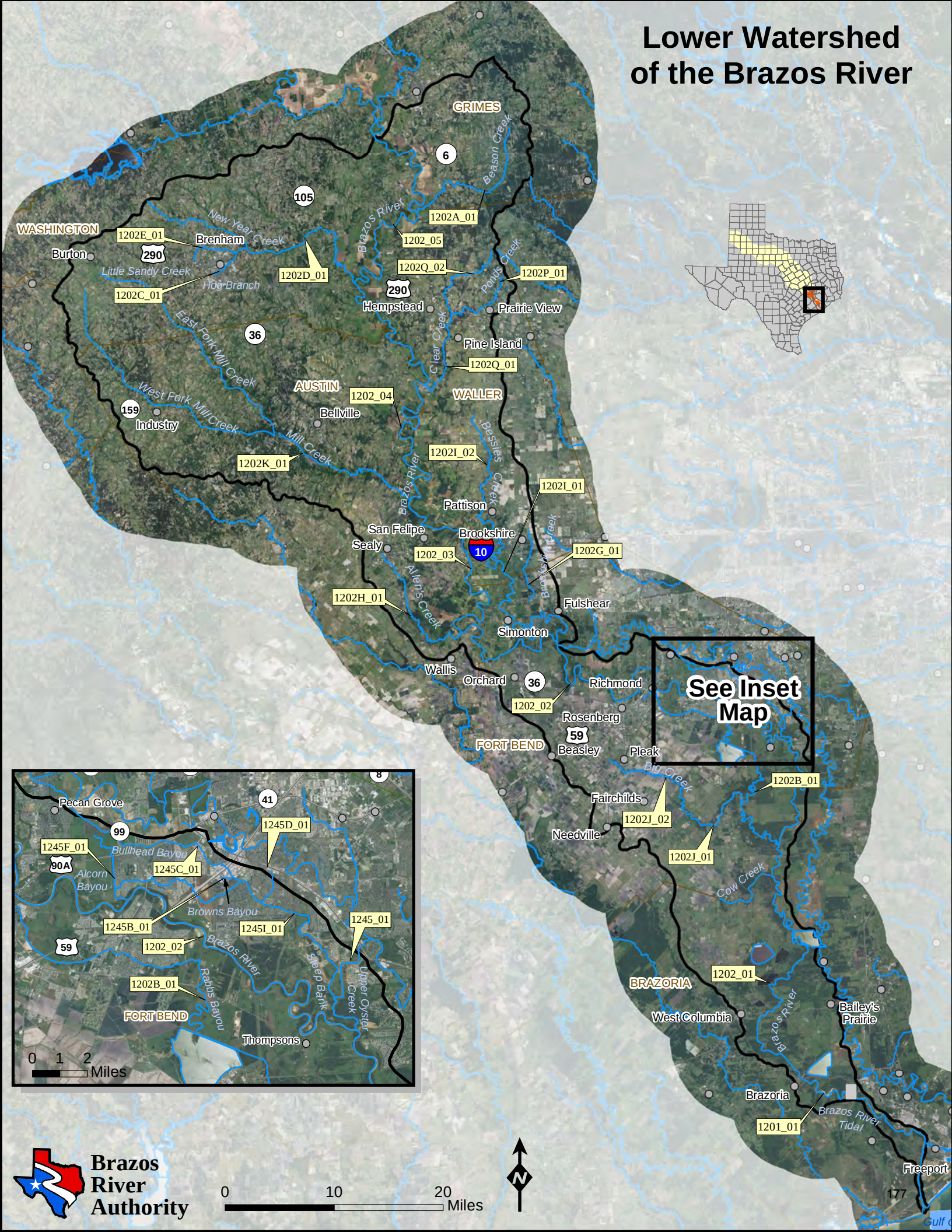
Biological Assessments:

Biological assessments are planned for the 2012 index and critical periods for Yegua creek below the confluence of Middle and East Yegua creeks, and for Yegua Creek below the dam at FM 50. This will include, habitat, macroinvertebrate, fish community, and 24-hour water quality monitoring.

Table 3.3.11.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria	1211A, 1212A, 1212B	• Wildlife and livestock.	• RUAA, runoff controls
Depressed DO	1211A, 1212	• Unknown	• Special study is in progress
Chlorophyll *a*	1212	• Excessive cyanobacteria growth	• Special study is in progress
pH	1212	• Unknown	• Special study is in progress
Impaired habitat and macrobenthic community	1212A	• Stream bank degradation and lack of healthy riparian vegetation	• Promotion of riparian restoration

Lower Watershed of the Brazos River



3.3.12 Lower Watershed of the Brazos River

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
2,077	9	BRA, TCEQ	94	Cities of Richmond, Rosenberg, Freeport, Lake Jackson, West Columbia, Needville, Missouri City, Sugar Land, Sealy, Hempstead, Brenham, Bellville, Burton, NRG Texas, Dow Chemical	1201, 1202

Description of Segments:

1201: Brazos River Tidal – From the confluence with the Gulf of Mexico in Brazoria County to a point 100 meters (110 miles) upstream of SH 332 in Brazoria County

Segment Area: 25 miles

Assessment Units (Stations): 1201_01 (11843, 16878)

1202: Brazos River Below Navasota River – From a point 100 meters (110 yards) upstream of SH 332 in Brazoria County to the confluence of the Navasota River in Grimes County

Segment Length: 199 miles

Assessment Units (Stations): 1202_01 (16355), 1202_02 (11846), 1202_03 (16387), 1202_04 (16386), 1202_05 (11850)

Unclassified Segments: **1202A**: Beason Creek, **1202B**: Rabbs Bayou, **1202C**: Hog Branch, **1202D**: New Year Creek, **1202E**: Little Sandy Creek, **1202F**: Unnamed Oxbow Slough, **1202G**: Brookshire Creek, **1202H**: Allen's Creek, **1202I**: Bessie's Creek, **1202J**: Big Creek, **1202K**: Mill Creek, **1202P**: Pond Creek, **1202Q**: Clear Creek, **1245B**: Brown's Bayou, **1245C**: Bullhead Bayou, **1245D**: Unnamed tributary of Bullhead Bayou, **1245F**: Alcorn Bayou, **1245I**: Steep Bank Creek

Assessment Units (Stations): 1202A_01 (None), 1202B_01 (None), 1202C_01 (20651), 1202D_01 (None), 1202E_01 (None), 1202F_01 (None), 1202G_01 (None), 1202H_01 (11577), 1202I_01 (None), 1202I _02 (18589), 1202J_01 (16353, 16354, 17932), 1202J _02 (11518, 17551, 18393), 1202K_01 (11576), 1202P_01 (11579), 1202Q_01 (None), 1202Q _02 (18335), 1245B_01 (17380), 1245C_01 (17371), 1245D_01 (17382), 1245F_01 (17381), 1245I_01 (11507, 17689)

Lower Watershed of the Brazos River FY12 Water Quality Monitoring and 2010 IR Status

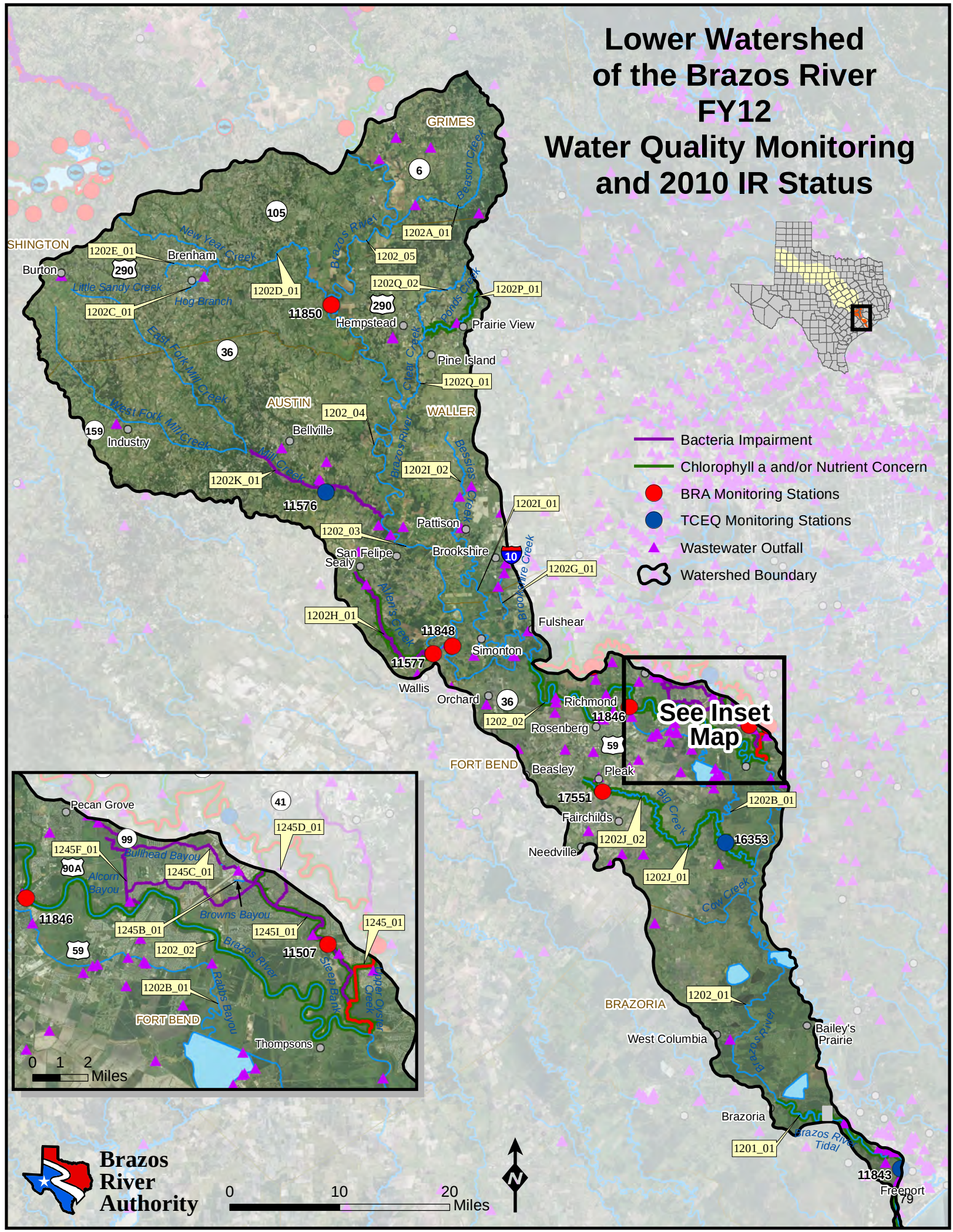


Table 3.3.12.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Lower Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[3] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1201	**Brazos River Tidal**	**PCR**	**H**				**4.0/3.0↑**	**6.5-9.0**	**35**	**95**		**0.46↓**	**1.10↑**	**0.46**	**0.66**	**21.0**
1202	**Brazos River Below Navasota River**	**PCR**	**H**	**300**	**200↓**	**750↓**	**5.0/3.0**	**6.5-9.0**	**126↓**	**95**		**0.33↓**	**1.95**	**0.37↓**	**0.69↓**	**14.1↑**
1202A	Beason Creek	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202B	Rabbs Bayou	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202C	Hog Branch	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202D	New Year Creek	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202E	Little Sandy Creek	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202F	Unnamed Oxbow Slough	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202G	Brookshire Creek	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202H	Allen's Creek	PCR	H	300	200	750	3.0/2.0	6.5-9.0	126	95		0.33	1.95↑	0.37	0.69	14.1
1202I	Bessie's Creek	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202J	Big Creek	PCR	H	300↑	200	750↑	5.0/3.0	6.5-9.0↑	126	95		0.33	1.95↑	0.37↑	0.69↑	14.1
1202K	Mill Creek	PCR	H	300↓	200↓	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202P	Pond Creek	PCR	H	300	200	750	3.0/2.0	6.5-9.0	126	95		0.33	1.95	0.37	0.69	14.1
1202Q	Clear Creek	PCR	H	300	200	750	5.0/3.0	6.5-9.0	126	95		0.33	1.95↑	0.37	0.69	14.1
1245B	Brown's Bayou	PCR	L	140	75	1070	3.0/2.0	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1
1245C	Bullhead Bayou	PCR	L	140	75	1070	3.0/2.0	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1

1245D	Unnamed Tributary of Bullhead Bayou	PCR	L	140	75	1070	3.0/2.0	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1
1245F	Alcorn Bayou	PCR	L	140	75	1070	3.0/2.0	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1
1245I	Steep Bank Creek	PCR	J	140	75↓	1070	3.0/2.0↑	6.5/9.0	126	95		0.33↓	1.95↑	0.37	0.69	14.1↓

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

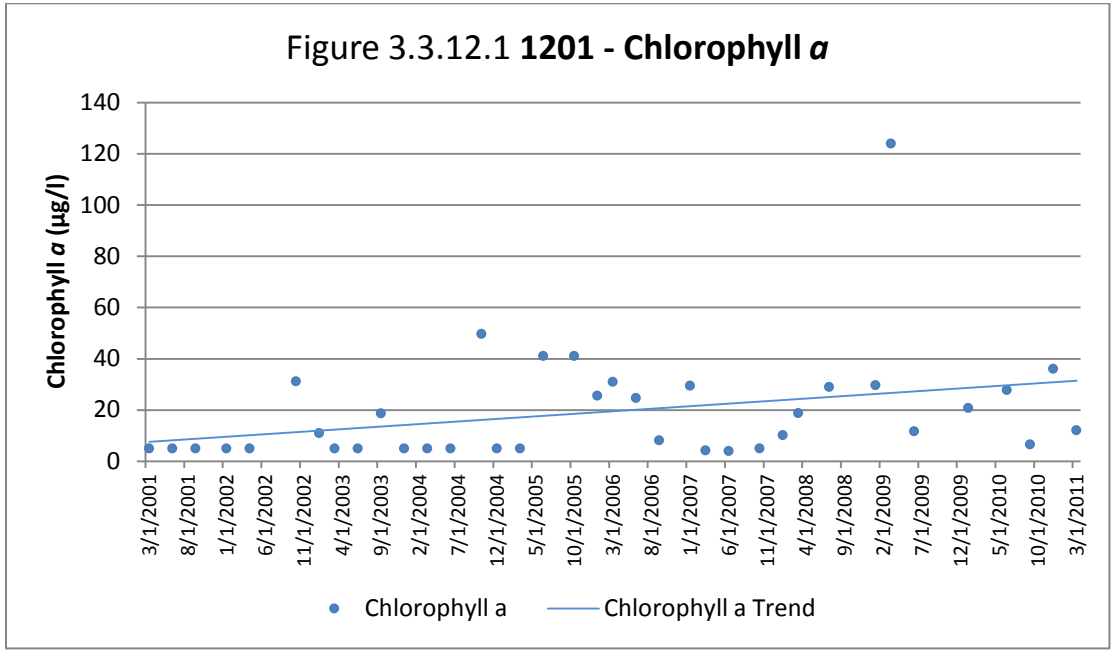
Lower Watershed of the Brazos River

The Lower Brazos watershed begins at the confluence of the Navasota River and the Brazos River and continues downstream where the Brazos River empties into the Gulf of Mexico. Encompassing 2,077 mi^2, the Lower Watershed is a combination of two classified water bodies, segment 1202, a freshwater portion of the Brazos River, and segment 1201, the tidal portion of the Brazos River. In addition, 2010 saw six of the thirteen unclassified water bodies in segment 1202 assessed.

Land use in this area of the Brazos River varies greatly from upstream to downstream. The Lower Watershed traverses land that includes agriculture, mining facilities, small municipalities, as well as the far southern portion of the Greater Houston area. Agriculture in this area ranges from livestock to row crops of sorghum, rice, corn, and cotton. A surface mine operation, located in Grimes County, is in active operation. Another active mining operation is located on the Brazos River along the Austin County and Waller County line. Fort Bend County has experienced significant growth, which has lead to sedimentation and runoff effects in the Brazos River. This runoff includes fertilizers, pesticides, sewage treatment effluent and even animal waste. All of these contribute to an increase in nutrients, bacteria and organic matter build-up.

According to the 2010 TCEQ assessment the Brazos River mainstem (**1201** and **1202**) has only concerns for chlorophyll *a*. The tributaries, however, contribute the majority of the concerns and exceedances of the standards and nutrient screening levels. Throughout the watershed the main stem is showing a significant historical trend of reduced nutrient load and potential water quality contaminants. Many of these trends may be attributed to the continual technological advances in wastewater treatment, continual education of agricultural land owners, or improved residential land owner

practices. In both segments, when data is considered over the past 10 years the trends show some differences in directionality. However, the trends that are most strongly correlated to nutrient loading from runoff and industrial and residential discharge have seemed to show no significant trends, or a downward significance. The concerns in segments **1201** and **1202** lay solely in chlorophyll *a*. When looking at trends occurring in this area over the previous 10 years, there are no significant trends. However, segment **1201** does have a concerning increasing trend upward (Figure 3.3.12.1). While this trend may not be significant in the past ten years, this increase can most likely be attributed to continual urban expansion and possibly ill equipped or outdated wastewater treatment plants. This continual eutrophication of the river may lead to issues if not handled properly in the near future. TDS and sulfate (Figure 12.2), over the last ten years in segment 1202, have a slightly significant trend upward which may be attributed to flow regime in this area of the river. Even with a short-term positive trend, neither environmental factor is near a level for concern.



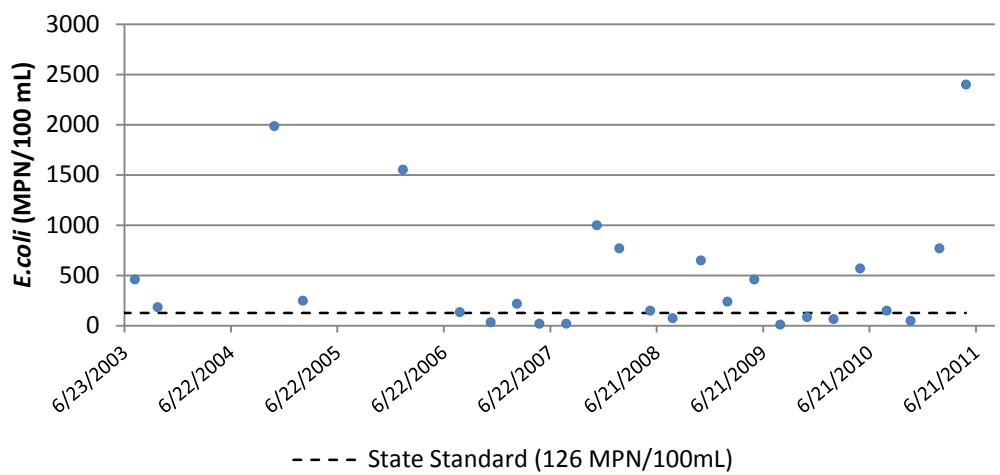
Site 11846, Brazos River at US90A in Richmond is a site contributing to the use concern for segment **1202**. This site, located at a busy bridge near the center of the city just outside of Houston, is one prone to receive excessive runoff during storm events. Another possible contributing factor to continual blooms in this area is the seven wastewater outfalls located upstream between this site and site 11848. With this increased nutrient input, chlorophyll *a* continues to thrive in this

area. Algal blooms may have the propensity to cause aquatic inhabitants to lose habitat, further deteriorating the quality of this site in particular. This site on the main stem is driving the concern for use due to chlorophyll *a* levels for the entire segment.

Segment **1201** has no unclassified segments associated with it. Segment **1202** has 13 associated unclassified segments, of which six were assessed in this given time period. The unclassified segments in this watershed have a greater number of impairments and concerns than the mainstem itself. This is due largely to the agricultural areas that the unclassified segments flow through. This can be attributed to nutrient run off from crop rows and pastures. Some of these same tributaries flow through small municipal areas that could be accelerating some issues with surface runoff.

Segment **1202H**, the entirety of Allen's Creek, is listed on the 303(d) List for its impairment due to bacteria levels (Figure 3.3.12.2). While there is no trend indicating a rise or fall in the *E.coli* levels, samples consistently yield levels that are above the state standard level. This may be attributed to the Allen's Creek headwaters in Sealy, TX, a municipal area with a small population. Surface runoff from this area coupled with the wastewater outfall located just below the town could be driving the *E.coli* level impairment. The monitoring location on this sub-segment is just upstream of the confluence of the mainstem, and between Sealy, TX and this location there is an abundance of agricultural land, which could further lead increased nutrients and livestock contributions to the water. Associated with this impairment is the concern with depressed dissolved oxygen levels, as well as high levels of orthophosphates.

Figure 3.3.12.2 **1202H - *E.coli***



Segment **1202J**, has concerns for nitrate, orthophosphate, total phosphorus, and chlorophyll *a*, however, it was delisted for bacteria. The two assessment units of Big Creek are surrounded by row crop land. When nutrient levels, such as these are increased it is often a result of nonpoint source pollution, such as rangeland and agricultural runoff. It has also been determined that Segment **1202J** has impaired habitat and a concern for use in the fish community. The need for a Use Attainability Analysis has been identified. These two areas of concern in the waterbody

can be associated with the lack of riparian buffer in the sub-watershed (Figure 3.3.12.3). Segment **1202J** has an alarming historical trend associated with all of its water quality parameters. There seems to be a significant upward trend among those that have been measured. Chloride, TDS, pH, nitrate, orthophosphate, and total phosphorus are those parameters that are being impacted. These parameters are also being affected by the land that surrounds the sub-watershed. The orthophosphates is most probably being impacted by the more densely populated areas. All of these factors compounded are most likely yielding slightly depressed dissolved oxygen, which could lead to further impairments if proper action is not taken.

Segments **1202K**, Mill Creek, and **1202P**, Pond Creek, each have one issue in water quality. Segment **1202K** has similar riparian land use as the other sub-segments. There is very little riparian buffer between the stream and the row crop and pasture land that surrounds the sub-watershed. This has led to a bacteria geomean greater than the state standard level of 126 MPN/100 mL, but not necessarily high enough to categorize the sub-segment as impaired. Since the inception of monitoring for *E.coli* this segment has had MPN/100 mL greater than the state standard in nearly 45% of the samples. Segment **1202P** has a concern for orthophosphates, which is likely a result of anthropogenic effects from the town of Prairie View, and the university which lies within the city limits. There is a wastewater discharge point on this sub-segment just on the northwest side of town, which is likely the major contributor to this concern. There are no significant trends in any of the parameters, which is a sign the wastewater is most likely being properly treated.

Figure 3.3.12.3. Segment 1202J_02 Big Creek at Trinity Rd

Special Studies:

A permit support study ended in FY 2011 on Hog Branch upstream of the Brenham WWTP, station 20651, in segment **1202C**. This was being conducted in order to assure the permits for WWTP were being abided by, and not degrading the streams in which they were permitted to discharge into.
A Recreational Use Attainability Analysis has been completed on Allen's Creek, segment **1202H** and is under review. This sub-segment, as previously mentioned is listed on the 303(d) List, and this study was conducted in order to assess the effect on recreational use that this impairment may have.

RUAAs have been completed and recommendations have been made for Bullhead Bayou and the Unnamed Tributary of Bullhead Bayou.

Natural water levels decrease the likelihood of primary contact recreation use. The shallow average depths and lack of evidence of primary contact recreation supports reclassification to SCR1. Secondary Contact Recreation 2 is not justified, given the accessibility of the bayous. In accordance with §307.4 (j) (3)(C) of the Texas Surface Water Quality Standards, the TCEQ recommends reclassification of the contact recreation use to secondary contact recreation 1 and corresponding geometric mean of 630 colonies/100mL for all of Bullhead Bayou from its confluence with Steep Bank Creek in Fort Colony, upstream to its headwaters in Pecan Grove in Fort Bend County. The TCEQ also recommends a reclassification of the contact recreation use to secondary contact recreation 1 and a corresponding geometric mean of 630 colonies/100mL for all of Unnamed Tributary of Bullhead Bayou, tributary to Bullhead Bayou in Fort Bend County. These recommendations are due to "natural, ephemeral, intermittent low flow conditions or water levels" in accordance with reasons specified in 40 CFR §131.10(g)(2).

Prior to changing the currently assigned recreational use of Bullhead Bayou or Unnamed Tributary of Bullhead Bayou in the Texas Surface Water Quality Standards, TCEQ would provide additional public notice and opportunity for public comment; and the U.S. Environmental Protection Agency would review this proposed change under the provisions of the federal Clean Water Act.

Biological Assessments:

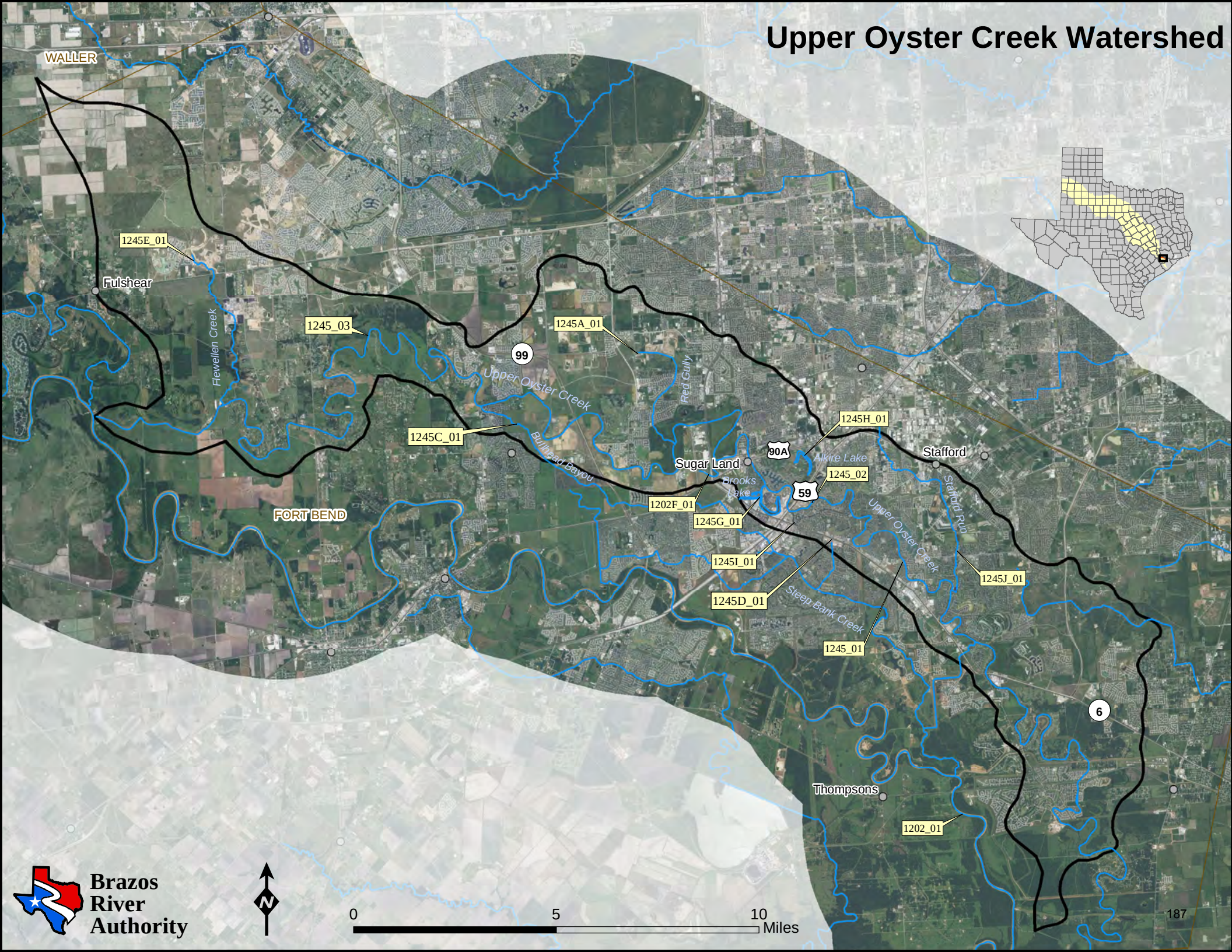
TCEQ is scheduled during FY 2011 and FY 2012 to complete a biological assessment on an eco region site, Mill Creek, segment **1202K**. Water quality, fish community, invertebrate community, and habitat assessments will be conducted. This

sub-segment is impaired for bacteria, and this report could provide information on what effects are being caused by this elevated level of *E.coli*.

Table 3.3.12.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Bacteria Impairment	• Allen's Creek • Bullhead Bayou and Unnamed Tributary • Alcorn Bayou • Steep Bank Creek	• Municipal runoff	• RUAA for Allen's Creek has been completed and is under review • Standards change has been recommended for Bullhead Bayou and Unnamed Tributary based on outcome of RUAA • RUAAs recommended for Alcorn Bayou and Steep Bank Creek

Upper Oyster Creek Watershed



3.3.13 Upper Oyster Creek Watershed

Watershed Area	Active Surface Water Monitoring Stations	Monitoring Agencies	Permitted Dischargers	Potential Stakeholders	Classified Segments
127 mi^2	3	BRA, TCEQ	26	Missouri City, Fort Bend County	1245

Description of Segments:

1245: **Upper Oyster Creek** – From Steep Bank Creek/Brazos River confluence in Fort Bend County to pumping station on Jones Creek at Brazos River in Fort Bend County (includes portions of Steep bank Creek, Flat Bank Creek Diversion Channel, and Jones Creek).

Segment Length: 48 miles

Assessment Units (Stations): 1245_01 (12074, 12075, 12077, 17690, 18211), 1245_02 (12079, 12082, 12083, 17373), 1245_03 (12085, 12086, 12087, 12088, 12089, 12090, 12091, 17685)

Unclassified Segment: **1245A**: Red Gully, **1245E**: Flewellen Creek, **1245G**: Brooks Lake, **1245H**: Alkire Lake, **1245J**: Stafford Run.

Assessment Units (Stations): 1245A_01 (11516; 18212), 1245E_01 (17686), 1245G_01 (11510), 1245H_01 (17687), 1245J_01 (17688)

Upper Oyster Creek Watershed FY12 Water Quality Monitoring and 2010 IR Status

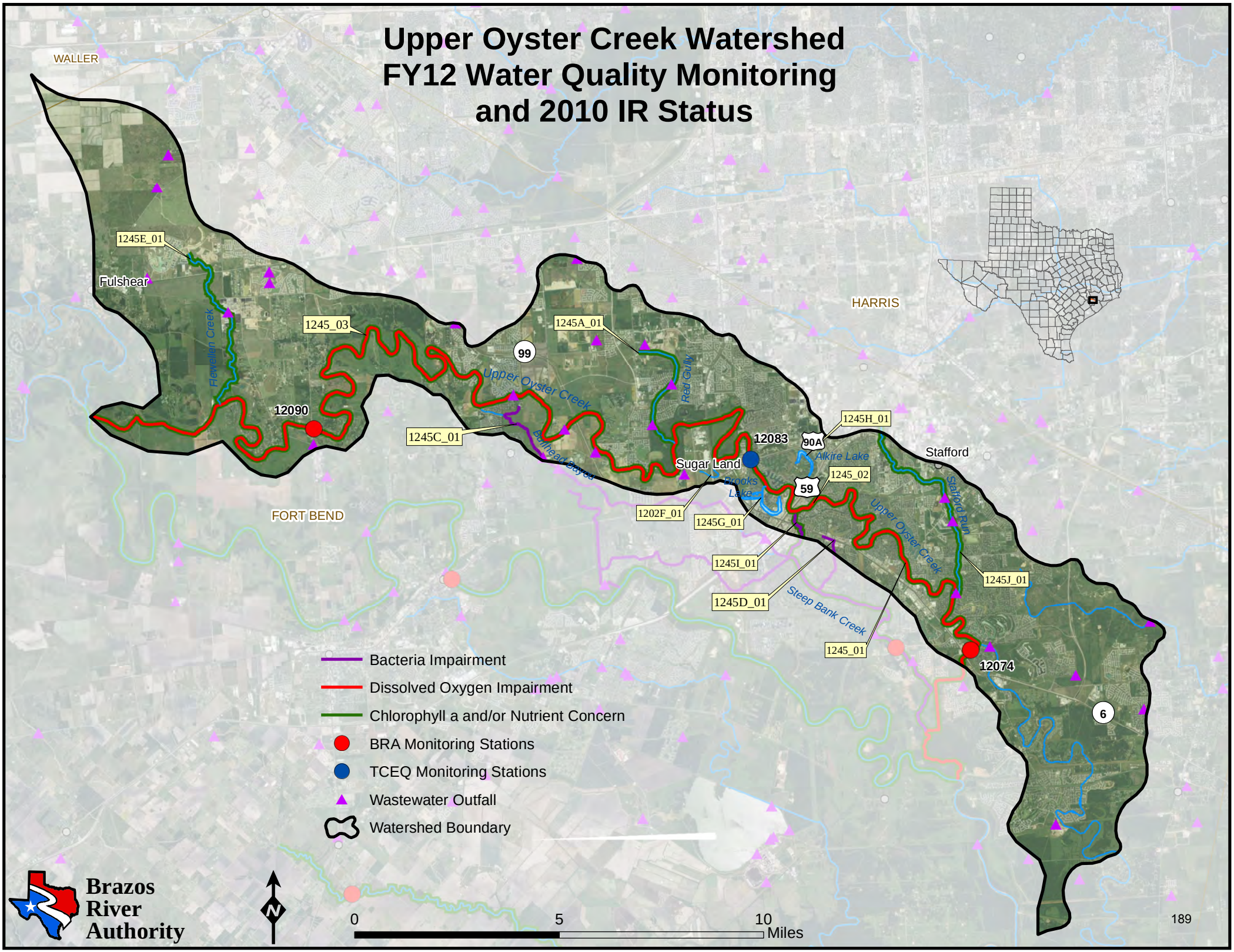


Table 3.3.13.1 Segment Specific Water Quality Standards with Indications of Impairment and/or Concern from the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) and Significant Long-term Trends[1]

Upper Oyster Creek Watershed		Uses		Surface Water Quality Standards								Nutrient Screening Levels				
Segment	Name	Recreation[2]	Aquatic Life[3]	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	Dissolved Oxygen Average/ Minimum (mg/L)	pH	Bacteria[4] (MPN/100ml)	Temperature (°F)	Chlorophyll *a* (µg/l)	Ammonia - N (mg/l)	Nitrate - N (mg/l)	Orthophosphate Phosphorus (mg/l)	Total Phosphorus (mg/l)	Chlorophyll *a* (µg/l)
1245	**Upper Oyster Creek**	**PCR**	**I**	**140**	**75**	**1070**	**4.0/3.0↑**	**6.5-9.0↑**	**126**	**95↓**		**0.33↓**	**1.95↑**	**0.37↓**	**0.69↓**	**14.1↓**
1245A	Red Gully	PCR	I	140	75	1070	4.0/3.0	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1
12485E	Flewellen Creek	PCR	M	140	75	1070	2.0/1.5	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1
1245G	Brooks Lake	PCR	H				5.0/3.0		126		26.7	0.11	0.37	0.05	0.20	
1245H	Alkire Lake	PCR	H				5.0/3.0		126		26.7	0.11	0.37	0.05	0.20	
1245J	Stafford Run	PCR	H	140	75	1070	5.0/3.0	6.5/9.0	126	95		0.33	1.95	0.37	0.69	14.1

[1]Long-term trends were calculated with all data available and not less than 10 yrs. Significance was determined at p-value <0.05.
[2]PCR- Primary Contact Recreation
[3]E-Exceptional, H-High, I-Intermediate, L-Limited
[4] The criteria numbers represent the geometric mean for *E. coli*

Segment or portion of segment impaired

Segment or portion of segment has a concern for the standard or screening level

↑ Statistically significant increasing trend

↓ Statistically significant decreasing trend

Upper Oyster Creek Watershed

Upper Oyster Creek (**1245**) is located within the Brazos River Basin, Southwest of Houston in northern Fort Bend County and varies from a natural stream course to a highly modified system of canals and dams which create impoundments that maintain nearly constant water levels for industrial, residential, recreational and drinking water supply. The canal system was dredged to serve as a conveyance for water pumped from the Brazos River into Jones Creek to be diverted into Upper Oyster Creek.

Flewellen Creek (**1245E**) and Stafford Run (**1245J**) are new listings for bacteria impairments. Steep Bank Creek is currently below screening levels for nitrate, trend analysis indicates that these levels are increasing (Table 3.3.13.1).

Special Studies:

One Total Daily Maximum Daily Load (TMDL) for Bacteria in Upper Oyster Creek
The Upper Oyster Creek Bacteria TMDL process was initiated by TCEQ in June 2001 through a contract with the Texas Institute for Applied Environmental Research (TIAER). The goal of this TMDL is to restore the water quality in this segment so that it meets the state's standard criteria. The TMDL was widely accepted by local stakeholders and was adopted by TCEQ in August of 2007 and approved by the EPA September 2007. Additional information can be obtained at the TMDL web site.

Two Total Maximum Daily Loads for Dissolved Oxygen in Upper Oyster Creek.
TCEQ first indentified the impairment low dissolved oxygen in 1996. The goal of this TMDL is to restore water quality in the segment so that it moots the state's standard criteria. The TMDL was adopted in by TCEQ in July 2010 and approved by the EPA September 2010 Additional information can be obtained at the TMDL web site.

RUAA Upper Oyster Creek
Recreation Use Attainability analysis was conducted on Upper Oyster Creek to evaluate if whether the existing and/or attainable recreational \uses of the segments might be different than the current presumed recreational use designation. Data collected included general stream characteristic, observations and evidence of recreational use, surrounding conditions that promote recreation, and surrounding conditions that impede recreation, including channel obstructions. Full report can be obtained at the TCEQ Standards web site.

Table 3.3.13.2 Water Quality Issues Summary

Water Quality Issue	**Affected Area**	**Possible Influences/Concerns**	**Possible Actions Taken/to be Taken**
Low Dissolved Oxygen	• All of Upper Oyster Creek	• Poorly maintained or inoperable septic systems. • Increased inputs of carbonaceous biochemical oxygen demand and ammonia nitrogen municipal discharges.	• TMDL for carbonaceous biochemical oxygen demand and ammonia nitrogen is in implementation phase.
Bacteria	• Upper Oyster Creek • Flewellen Creek • Stafford Run	• Poorly maintained or inoperable septic systems. • Runoff from pasture land.	• TMDL in implementation phase for Upper Oyster Creek • RUAAs suggested for Flewellen Creek and Stafford Run

4.0 RECOMMENDATIONS AND CONCLUSIONS

4.1 Recommendations and Comments

Findings

- Seventeen classified stream segments in the basin are listed on the 303(d) List.
- Sixty-eight unclassified waterbodies are listed on the 303(d) List.
- Most of the rapidly developing regions in the basin could benefit from additional monitoring to document baseline conditions and monitor changes as development increases.
- There is a lack of flow and precipitation data to correlate with other parameters.
- There is limited biological data available to assess aquatic life conditions throughout the basin.

Recommendations

- Focus monitoring activities according to the unique characteristics of each subwatershed.
- Conduct special studies in sub-watersheds where development is occurring.
- Continue performing biological assessments to better characterize status of aquatic life in the basin.
- Attempt to build a larger flow dataset to correlate with other parameters and verify flow classifications.
- Continue to leverage federal and state funds for the benefit of water quality and tax and fee payers.

BACTERIA

Findings

- Twelve classified segments in the Brazos River basin are listed on the 303(d) List for bacterial impairments.
- Sixty-two unclassified waterbodies are listed on the 303(d) List for bacterial contamination.
- Impairment and concern listings appear appropriate when compared against current data analysis methodologies.
- Most of the unclassified waterbodies that are listed on the 303(d) list for bacterial contamination are small, rural streams with low to intermittent flow.

Recommendations

- Reduce monitoring of small, rural unclassified waterbodies with low to intermittent flow where a baseline data set has been established.
- Work with TCEQ regarding the appropriateness of designating contact recreation use for small, rural streams with low to intermittent flow where meeting the contact recreation standard is hindered by the natural features of the microwatershed.

DISSOLVED OXYGEN

Findings

- Four of the classified segments in the Brazos River basin are listed on the 303(d) List for dissolved oxygen impairments.
- Six unclassified waterbodies are listed on the 303(d) List for dissolved oxygen impairments.

Recommendations

- Work with TCEQ regarding the appropriateness of assuming high aquatic life use standards for small streams with low to intermittent flow where meeting the high aquatic life use standard is hindered by the streams inability to buffer against high ambient air temperatures during summer months.
- Work with TCEQ to perform Use Attainability Analyses on impaired stream segments to determine the most appropriate dissolved oxygen standard for each segment.

NUTRIENTS AND CHLOROPHYLL *a*

Findings

- Thirty-one of the classified segments in the Brazos River basin have concerns for nutrients and/or chlorophyll *a*
- Fifty-six unclassified segments in the Brazos River basin have concerns for nutrients and/or chlorophyll *a*
- There is limited low-level nutrient data in the basin. TCEQ has requested that CRP Partner Agencies begin to collect low-level nutrient data at strategic locations in the basin.

Recommendations

- Attempt low-level nutrient collection at strategic locations in the basin.
- Continue to support on-going and planned special studies addressing nutrient concerns in the basin.

- Continue to follow and support the TCEQ Nutrient Criteria Development process.

NATURAL SALT

Findings

- Salt in the mainstem of the Brazos River basin comes from natural brine springs in Stonewall, Kent and Garza counties that deposit highly concentrated groundwater into the watershed of the Salt Fork and Double Mountain Fork of the Brazos. Rainfall then flushes this residual salt into the rivers.
- The natural salt produced in the uppermost portion of the Brazos River basin affects the mainstem throughout its entire reach and is subject to drought and flood.

Recommendations

- Continue to support on-going and planned special studies regarding natural salt in the basin
- Support development of a model to predict salt concentration transport through the basin

4.2 Conclusions

The Brazos River Basin Clean Rivers Program's watersheds are spread over a wide variety of land uses and ecoregions. Water travels from the undeveloped regions through increasingly urbanized areas, through arid West Texas to wet Gulf Coastal Plains and finally into the Gulf of Mexico. The largest water quality management issue facing the Brazos River basin is the intrusion of natural salt into the mainstem of the Brazos River from brine springs in the northern portion of the basin and from the Gulf of Mexico in the south. Elevated chlorides and total dissolved solids affect water usability along the entire mainstem. The Authority is working to develop a predictive chloride model so that stakeholders may be better informed of chloride concentrations flowing down the Brazos Basin. Bacteria and nutrients are a problem in over a quarter of the basins segments. Great strides have been made through the use of RUAAs to better classify recreational use of many impaired streams in the basin and the Authority will continue to support this effort.

Throughout this report, the Authority has outlined areas that need more detailed analysis or more information to better assess water quality conditions. The Authority will continue to coordinate with the Technical Advisory Committee, local entities and stakeholders to gather this data. As the Authority gains understanding of the dynamics within each of the watersheds, we are able to better inform and educate the public on water quality in their community.

To address all the problems identified in this report will require intense participation by local stakeholders in addition to federal, state and regional entities. The most important factor determining the success of activities to improve the waters of the Brazos basin will be the commitment and understanding of individuals in the basin to water quality.

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Brazos River Authority

THE TEXAS CLEAN RIVERS PROGRAM

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