Task 5: Data Analysis and Reporting

Table of Contents

Task 5: Data Analysis and Reporting

Introduction

This task involves the examination of water quality conditions through data analysis and reporting to establish a more complete understanding of water quality conditions within the basin. The information in these reports will be communicated to basin stakeholders and will help shape decisions and the focus of work in the basin.

The major deliverables due as a part of this task are the:

- Basin Highlights Report (annually, except when Basin Summary Report is due)
- Basin Summary Report (once every 3rd State Fiscal Biennium)

Basin Highlights Report

The Basin Highlights Report provides information on water quality conditions throughout the basin and updates on Clean Rivers Program activities from the previous year. This document needs to be both user-friendly and accessible to a wide audience. Therefore, document layout and content should provide information in a manner that explains why conditions exist. It is important to get stakeholder input on the format and content of the document prior to its finalization. For ease of distribution, the Basin Highlight Report does not need to be printed but can be provided to interested parties on CD or via a web link.

Basin Highlights Report Formats

There are three different report formats a Basin Planning Agency can use to communicate program activities and water quality information on an annual basis.

- The Standard Report
- Watershed Characterization Report
- Program Update

The different formats allow variety in the content of each year's report to reduce unnecessary repetition of information that does not change on an annual basis. The Basin Planning Agency will coordinate with the TCEQ CRP Project Manager to determine which formats to write into the contract work plan. The Basin Planning Agency will also negotiate report content with the TCEQ CRP Project Manager. Report format should fluctuate on a cycle like this:

Year 1 – Basin Summary Report

Year 2 – Program Update

Year 3 – Watershed Characterization (ABC & XYZ Watersheds)

Year 4 – Standard Basin Highlights Report

Year 5 – Watershed Characterization (DEF & TUV Watersheds)

The Standard Report

This report provides a complete overview of all major activities and water quality issues that occurred within the basin during the previous year. An outline for the Standard Basin Highlights Report is provided in Exhibit 5A with examples of satisfactory text. At a minimum, the report should include:

- an overview of basin water quality monitoring describing each organization's participation
- the top water quality issues in the basin for stakeholder prioritization and monitoring decisions
- a description of water quality conditions for each segment/water body
- a summary of findings from special studies
- maps showing the location of sampling sites and water quality issues
- map(s) showing the location of the basin or watershed within the state
- Steering Committee and other public outreach activities
- instructions on how to become involved in steering committee meetings, volunteer monitoring, and other participation opportunities
- information on the CRP content featured on the Planning Agency's Web site

Watershed Characterization

This report serves to characterize impaired water bodies and/or water bodies of interest by reviewing data, mapping land use and permits, tracking watershed events, reviewing information from site visits and communicating with monitoring personnel, stakeholders and local residents.

The goal of this report is to describe key sources that are likely to impact water quality and provide a collection of "on the ground", local knowledge for other TCEQ program areas to use when prioritizing monitoring efforts. This document will provide useful information about a watershed that can be used for a variety of purposes including the Watershed Action Planning activities (see Task 6). An outline and example of the report is provided in Exhibit 5B. Characterization should occur by segment and include the following information:

- Segment descriptions
- Stream/reservoir hydrology
- Impairment/area of interest description
- Land use & natural characteristics
- Potential causes of impairment or interest
- Potential stakeholders
- Recommendations for improving water quality
- map(s) showing the location of the basin or watershed within the state
- maps showing the location of sampling sites and water quality issues
- Ongoing projects
- Images
- Major watershed events (present and future)

The Watershed Characterization report content must be coordinated and discussed in detail with the TCEQ CRP Project Manager while developing the CRP work plan and prior to beginning the report. The TCEQ CRP Project Manager must review and approve the watersheds before characterization begins. The following conditions apply:

- Characterization must include 1-3 watersheds
  - Exceptions, upon approval, can be made due to watershed size or complexity
- Watersheds must be of suitable size and have impairments (i.e. the smallest watershed cannot be repeatedly chosen unless justifications are presented and approved)
- New watersheds must be chosen each year or on a rotating cycle
- Only discuss segments located within the watershed being characterized

The TCEQ CRP Project Manager must approve any exceptions to these conditions.

Program Update

This report strives to provide a brief update on the major basin activities and water quality issues that occurred during the previous year. It should be undertaken to reduce repetition of information that does not change on an annual basis and be thought of as a shortened version of the Standard Basin Highlights Report.

An example of the Program Update Report is provided in Exhibit 5C. The report should include:

- an update on major basin activities, changes and events
- an update of basin water quality monitoring activities
- an update on the top water quality concerns and issues in the basin
- a summary of findings from special studies
- maps showing the location of sampling sites, major water quality issues, and the basin or watershed within the state
- an update on public outreach and educational activities
- links to additional resources

Basin Summary Report

The Basin Summary Report is designed to provide a comprehensive review of water quality data and involves a detailed discussion of data analysis findings. This report serves to develop a greater understanding of basin water quality conditions, identify trends and changes, and aids in making decisions regarding water quality issues in each river and coastal basin in Texas. The report is completed once every third state fiscal biennium for each river and coastal basin.

To aid in future planning, Basin Summary Reports are due according to the following rotation. The particular year within the biennium that the Basin Summary Report will be produced will be detailed in contractual agreements.

Biennium Due	River Authorities
2020-2021	LNVA, ANRA, TRA, HGAC
2022-2023	LCRA, BRA, LNRA, GBRA, NRA, SARA
2024-2025	RRA, NETMWD, SRBA, SRA, IBWC
2026-2027	LNVA, ANRA, TRA, HGAC

Goals of the Report

This report serves to provide an explanation for ***why*** current water quality conditions exist by incorporating and interpreting the findings from the various data analysis functions. By explaining the findings, we can better describe the reasons for the problem and potentially determine future action plans.

The information from the review will support the following functions:

- developing monitoring plans and updating priorities
- enhancing knowledge and understanding of water quality issues
- verifying and explaining findings on the *Texas Water Quality Integrated Report*
- correlating water quality conditions with possible sources
- prioritizing water bodies for action
- selecting watersheds for special studies
- highlighting those sections of the basin that need more land use information
- assessing the success of water quality improvement projects

Report Content

The outline and description of content for the Basin Summary Report can be found in Exhibit 5D - Basin Summary Report Outline. The outline is provided to ensure content is consistent from basin to basin. Input from report users has been favorable when all information specific to a watershed is cohesively presented to provide a more complete picture of water quality. This report should answer the questions most stakeholders have, which tend to be:

- What are the water quality issues?
- Why do the issues exist?
- What are the possible effects?
- What should be/could be done about it?

In the watershed summary section in Exhibit 5D, there is a stepped approach to help answer these questions. The data review and analysis methods, Exhibit 5E, that can help answer the questions include: descriptive statistics (percentiles for comparison), trend analysis (changes over time), spatial analysis (differences from upstream to downstream, and watershed characteristics to describe why the issues exists).

Preparing for the Report

The following review process should be adhered to when preparing the Basin Summary Report:

- A planning meeting with the TCEQ CRP Project Manager and CRP Task 5 Coordinator to discuss the format and organization of the report will occur prior to significant work on the report. Report framework and data analysis methods should be discussed and confirmed. Typically, the meeting will occur in conjunction with the annual SWQM Workshop but can be scheduled separately as necessary.
- A pre-draft of at least one watershed summary will be submitted to the TCEQ by December 15th for review.
- After the pre-draft is approved, a draft of the entire Basin Summary Report will be submitted to the TCEQ CRP Project Manager by March 15th for review and comment.
- After the draft of the Basin Summary Report is approved by the TCEQ CRP Project Manager, the Planning Agency will request input from stakeholders. The draft can be made available to the public by posting on the Basin Planning Agency website, through email, and/or at the steering committee meeting.
- A copy of the completed final report is due to the TCEQ CRP Project Manager electronically by May 31, and written approval must be obtained before the report can be sent to printing.
- As a part of the report development process, the Planning Agency will coordinate review and comments with fee payers and steering committee members as detailed in the Texas Water Code.

Distribution Requirements

- A copy of the final report needs to be made available to each stakeholder. This may be accomplished by: handing out copies at the steering committee meetings, putting the report on the Internet, and/or mailing notices of its availability in hard copy upon request.
- Five copies of the final report are to be sent to the TCEQ CRP Project Manager.
- The Planning Agency must additionally fulfill the distribution requirements detailed in the Texas Water Code as described below.

From the Texas Water Code, Section 26.0135, Clean Rivers Act, the summary report shall:

- be sent to the State Soil and Water Conservation Board and Parks and Wildlife Department by the Planning Agency
- identify water quality concerns, impaired or potentially impaired uses, the cause and possible source of use impairment, and recommended actions the commission may take to address those concerns
- discuss the public benefits from the water quality monitoring and assessment program,

including efforts to increase public input in activities related to water quality and the effectiveness of targeted monitoring in assisting the permitting process
- be approved by the basin steering committee and coordinated with the public and the commission
- include a review of wastewater discharges, nonpoint source pollution, nutrient loading, toxic materials, biological health of aquatic life, public education and involvement in water quality issues, local and regional pollution within the watershed
- identify significant issues affecting water quality

and with respect to the summary report each Planning Agency shall:

- identify water quality problems and known pollution sources and set priorities for taking appropriate action regarding those problems and sources
- recommend water quality management strategies for correcting identified water quality problems and pollution sources
- inform those parties (persons who pay fees under Section 26.0291 and steering committee members) of the availability and location of the summary report for inspection and shall solicit input from those parties concerning their satisfaction with or suggestions for modification of the summary report
- summarize all comments received from persons who pay fees under Section 26.0291 and from steering committee members and shall submit the report and the summaries to the governor, the lieutenant governor, and the speaker of the house of representatives not later than the 90th day after the date the river authority submits the summary report to the commission and other agencies

Basin Summary Report Review Overview

The primary goal of the Basin Summary Report review by the TCEQ is to ensure that the document is meeting the minimum requirements of the report as set forth in Task 5 of the CRP Guidance.

Who's reviewing the BSR?

- CRP Task 5 Coordinator
- CRP Project Manager
- *CRP Work Leader if significant issues warrant additional review and/or oversight

Additional considerations by TCEQ during the review:

- Grammar, punctuation
- Maps, map elements (north arrow, scale bar, title, etc…)
- Data analysis methodology

- Terminology
- Website links
- References to any TCEQ database, program, publication, etc.

Required changes vs. suggestions to improve the overall quality of the report.

Please be aware that the TCEQ makes many suggestions and comments regarding the content of the Planning Agencies BSR; this includes both required changes and suggested changes. So, how does a Planning Agency distinguish between what is required and what is suggested? Guidelines for this are as follows:

- If the comment is related to any of the minimum requirements for the BSR, as stated in Exhibit 5D – Basin Summary Report Outline, then that is a required change
- Any comment which references the TCEQ data, databases, programs, publications, etc. is a required change. It is imperative to accurately represent the products of the TCEQ in CRP Publications where they are referenced.
- Any additional comment, such as, grammar, punctuation, website links, map elements, terminology (*not already referenced in the Task 5 Guidance) are typically suggested changes that the reviewers believe would strengthen the overall BSR and better inform the basin stakeholder commission.

Exhibit 5A

Standard Basin Highlights Report Outline and Examples

EXHIBIT 5A

Standard Basin Highlights Report Outline

This Year's Highlights

- What were the major events or occurrences during the previous year (positive and negative)?
- What major issues (e.g., extreme drought, increasing development, confined animal operations, ongoing issues, natural salt pollution, record flood) are plaguing water quality for the basin?
- How have these events impacted water quality?
- What has been done to respond to water quality issues?

Water Quality Monitoring

This section involves a summarization of the monitoring that was planned, or occurred, during the past year including any participating entities and special projects. Present information on monitoring for the current fiscal year, to include:

- Number of sites per entity, frequency, type of monitoring
- Map the coordinated monitoring schedule for the entire basin
- Show and label sampling sites, water bodies, county boundaries, highways, & cities
- Explain what the water quality parameters mean and why they are important
- Provide a link to the web page that shows the entire monitoring schedule
- Highlight other organizations' participation in the monitoring program

Water Quality Conditions

The key to ensuring this portion of the report is adequate is to answer the questions the reader would ask, "why are levels elevated and what is being done about it?" When the answers to the questions are unknown and/or cannot be estimated, this *information gap* should be stated. If the previous year's report (including Basin Summary Report) contains a description of water quality for each TCEQ segment, then this section can be copied from the previous year's report. A statement should be included that no new assessment information is available since the previous report. The examples provided after this outline are highly recommended.

Explain the TCEQ assessment and categorization process

- Explain the assessment and categorization methods used for the latest state-approved Texas Water Quality Integrated Report and provide the web address for reference.

Describe water quality

- For each segment/water body, provide a concise description of the key watershed and water body characteristics that draw a picture of water quality
- Indicate the status of the segment/water body on the latest TCEQ Water Quality Inventory and provide some possible reasons if there is a *Concern, Use Concern,* and/or *Impairment*.
- Highlight those water bodies that may have a water quality issue, or are significant due to size, location, or public interest, but which do not have a *Concern, Use Concern, and/or Impairment* and provide some possible reasons why the water quality is an issue.

Provide information on current or proposed work in the watershed

- Monitoring activities done in response to a water quality issue
- Proposed monitoring needed to better describe water quality (e.g., diel sampling for 2 years; monthly sampling for bacteria under a variety of flow conditions for 2 years; collect TDS in subwatersheds throughout the affected watershed to identify source areas)
- Describe **special studies**, activities to date, and any findings (reference special study reports that have been completed or will be completed in the near future)
- Accomplishments in the past year, or several years (e.g., 100 wells have been capped; 100,000 tons of manure have been composted and hauled out of the watershed; riparian buffers restored on over 15 miles of stream banks)

Map water quality issues

The map(s) should be at a scale that allows the reader to recognize where sampling sites and water quality issues are located in relation to major landmarks. It is important to show the location of factors influencing water quality, such as wastewater treatment plants, CAFOs, and row-crop operations in order to show their spatial relationship to the water quality conditions and the sampling sites.

- Highlight segments or sections of segments with water quality issues (e.g. *Concerns, Use Concerns,* and/or *Impairments*)
- Include and label, at a minimum: streams/reservoirs, county boundaries, highways, cities, and segment boundaries
- Include map(s) showing the basin or watershed within the state

Stakeholder Participation & Public Outreach

- Describe opportunities for involving other monitoring entities in the program
- Who is currently involved? What is their contribution?
- Explain the purpose of Steering Committee meetings (e.g. forum for providing input on water quality issues, establishing priorities for future work, and providing feedback on reports)
- Include a section on how individuals and organizations can get involved in the program
- Outline efforts that have been taken to get more involvement in the program

- Summarize prior Steering Committee discussions
- Summarize volunteer monitoring activities in the basin
- Include information on volunteer organizations and their activities, with contact information

Web Site

- Provide an overview of the information available on the web site
- Provide links to important pages, especially those with further detail on issues discussed in this report and those that allow the public to check on upcoming events

Example Text for the Basin Highlights Report

This Year's Highlights

The most significant factor affecting water quality throughout the basin in 2018 was the severe drought. In the upper portion of the basin, much of the River east of the City went completely dry, forcing some residents to transport water to storage tanks at their homes. The decreased flows resulted in elevated chloride levels in the river above the reservoir. In the middle portion of the basin, the Lake was 21 feet below average in August, a level not seen since 1984. The river at State Highway 180 also went dry. In November and December 2018, base flows returned to the River and many of its tributaries. The rains came with a cost, however. During one particularly heavy rain, approximately 37,000 fish were killed in the River when stormwater runoff transported pollutants that depleted the oxygen supply in the river.

The major events relating to water quality that occurred this year include the updated State of Texas Integrated Report, the completion of the first year of the Reservoir #1 Water Quality Monitoring Program, the initiation of the dissolved metals study, identification of a leaking sewer main, improvements to the City #2 wastewater collection system, and a new fish consumption advisory for Lake #4. The State's Integrated Report identified eight new concerns (3 for nutrients, 3 for dissolved oxygen, and 2 for pH) and 5 new impairments (3 for bacteria and 2 for dissolved oxygen). The Reservoir #1 Water Quality Monitoring Program was developed to address growing concerns over water quality conditions due to wastewater treatment facilities at the local paper mill. Significant improvements in wastewater discharge from the paper mill should help water quality in the long-term. In addition, the paper mill is in the process of renovating its wastewater treatment facility to significantly reduce waste loads.

For fiscal year 2019, the River Authority has added four routine and three flow sites to the monitoring plan. Three of the routine sites are on River #1. These sites were added in response to concerns about water quality impacts resulting from increased public use of the river. The fourth site was added downstream of a petrochemical plant on the River #2. A polluted groundwater plume has been identified very close to the river. Efforts have been made by the plant to keep the plume from entering the river. In addition, three sites were added to monitor flow on a monthly basis for one year to enable calculations to be made for wastewater effluent assimilative capacity. This data will replace assumptions made by the TCEQ when assigning allowable permit effluent limits.

Water Quality Monitoring

Sampling Entity	Field	Conventional	Bacteria	Biological	Metals in Water	Organics in Water
River Authority	20 monthly; 8 quarterly	20 monthly; 8 quarterly	20 monthly; 8 quarterly	2 annually	9 annually; 1 semi-annually	2 semi-annually; 2 quarterly
TCEQ	23 quarterly	23 quarterly	23 quarterly		5 annually; 4 semi-annually	1 semi-annually
City	4 quarterly	4 quarterly	4 quarterly			

What are the Water Quality Groups?

Field - physical and chemical water quality characteristics that can be measured on-site. These generally include: dissolved oxygen (DO), specific conductance, pH, temperature, stream flow, flow severity, secchi disc, and field observations/conditions.

Conventional - chemical and biological constituents in water that typically require laboratory analysis, and generally include: nitrogen, phosphorus, chlorophyll-a, total dissolved solids, and total suspended solids.

… etc.

What is Dissolved Oxygen and Why is it Important?

Dissolved oxygen (DO) indicates the amount of oxygen available in the stream. Certain minimum concentrations are needed to support aquatic life. DO can be reduced by several factors such as elevated water temperatures and the loading of organic substances that require oxygen for decomposition (e.g., plant debris and wastewater effluent).

Why do we collect nutrients?

To determine compliance with water quality standards that are set by the TCEQ to protect human health and to determine if there is an unnatural loading of nutrients. High levels of nutrients can cause excessive plant growth which can lead to reduced dissolved oxygen in the stream; in turn this can reduce the survivability of fish. In addition, at certain levels nutrients can cause an excessive growth of algae which can result in taste and odor problems in drinking water.

See Exhibit 5F for example descriptions of water quality groups, dissolved oxygen, and nutrients.

Water Quality Conditions

Example #1

Segment Description: The Creek begins in northeastern County at about FM 2 and continues 15 miles to the confluence with the River south of City in County. The Creek is typically a shallow, slow moving stream flowing through gently rolling hills lined with agricultural fields and scrub oak trees.

Segment Concerns: In 2014, The Creek was identified as impaired for E. coli bacteria, with concerns for nutrients. Based on stakeholder input and land use analysis, sources of the bacteria pollutants include urban nonpoint sources, such as rapid urban development and pet waste in the upper portion of the watershed, and range cattle and wildlife sources in the middle and lower portions of the watershed. The nutrient concerns are related to significant inputs from wastewater treatment plants in the upper portion of the watershed with some spikes in ammonia found downstream of City.

Actions to Address Concerns: The Creek Watershed Partnership has completed the Watershed Protection Plan (WPP) for the Creek and its tributaries. The Creek WPP is the first watershed protection plan in the state to receive confirmation from EPA that it meets all nine elements of a WPP. The project has moved into the implementation phase of the WPP. Over seven tons of illegally dumped waste was removed from the stream at road crossings; training was provided for municipal officials, on-site septic systems maintenance providers and homeowners; and on-line educational computer modules were developed covering topics such as wastewater treatment, on-site septic systems and disposal for household hazardous wastes. Grant funding received in this phase is covering urban nonpoint source pollution management strategies for the cities of #1, #2 and #3, feral hog management education in the rural portions of the counties, and nonpoint source pollution outreach and education. A link to the status of activities and quarterly newsletters can be found at www.abc-organization.org.

Example #2

Segment Description: The Creek extends 27 miles beginning in County, including the 3,100-acre Creek Reservoir to the confluence with the River in County. Because of the size of the drainage basin, this normally slow-moving creek can become a fast, flowing river during a typical Texas rainstorm. Much of the creek bottom is made up of sand with typical vegetation ranging from mesquite and huisache to large live oaks and anacua trees. Because of its rural setting and limited development, you can still find a wide range of Texas wildlife along its shores ranging from turkey and deer, to red fox and bobcats.

Segment Concerns: The Creek Reservoir is used for cooling water by the LP coal-fired power plant. This use may impact aquatic life (temperature, dissolved oxygen). Other activities in the watershed that may impact water quality include oil field activities, increasing numbers of subdivision developments, land clearing on existing ranches along the creek, and introduction of non-native aquatic plant species into the Creek system. The watershed is mostly rural, but is undergoing land use changes, including a renewed interest in uranium mining.

Actions to Address Concerns: An examination of the hydrology and groundwater recharge/discharge in the upper Creek is being conducted by the U.S. Geologic Survey. Surface water from the #1 and #2 Creeks and groundwater data from the #1 and #2 aquifers are being collected. The study will provide information that can be used to develop appropriate natural-resource management strategies. The Uranium Corporation is proposing to lease property in County to mine uranium by in-situ leaching. In-situ mining is the stripping of uranium from underground formations by the injection of acid and water. The subsequent solution containing dissolved uranium is pumped to the surface and piped to a production facility. Interested in the possible impacts that this process could have on surface and ground water, stakeholders have asked CRP to collect background samples from the Creek for radiological compounds. Those samples are being collected through fiscal year 2019.

Stakeholder Participation & Public Outreach

Focus on Outreach

This River Authority's Clean Rivers Program public outreach activities include involving stakeholders and committee members in the watershed management planning and analysis process and providing watershed and water quality education to the public.

There are three main groups that help set priorities and direct water quality assessment activities for the program. They include a Steering Committee, a Technical Advisory Group, and a Regional Monitoring Workgroup. For more information on the roles of these committees and how to get involved, please visit: www.abcdefg.abcd.tx.us/intro/introcmte.html

The River Authority has instituted several new approaches to raising awareness of watersheds and water quality throughout the region. While continuing to participate in environmental festivals and outdoor events, the River Authority has also devised ways to reach others who may not attend or have access to those types of events.

One approach has been through direct mail outs. A brochure that summarizes Watershed #1 was mailed out randomly to approximately 3,000 residents in that watershed. Enclosed in the mailing was a postcard response survey that asked the recipient:

1) How familiar they were with the concept of a watershed,

2) Before receiving this document, did they know they lived in Watershed #1, and

3) Had they learned anything new about the health of the aquatic environment from the information provided?

Many of the cards received indicated that the recipient had never heard of the watershed concept, did not know they lived in Watershed #1, and did learn something about the health of the aquatic environment. In addition, almost half of the recipients who returned their survey cards requested more information.

How Do I Get Involved?

- Learn more about how to prevent nonpoint source pollution, request a FREE copy of our brochure, "What Watershed Do You Live In?"
- Be aware of local laws and ordinances that aim to protect our waterways
- Report spills, fish kills, or illegal dumping to TCEQ's Pollution Hotline at 1-800-3OURBAY or to Texas Parks and Wildlife at 281-842-8100
- Volunteer to monitor a nearby creek or lake. Join the River Authority Texas Watch team,

please visit: www.abcd.123
- Volunteer for other activities such as the annual Trash Bash, which aims to remove thousands of pounds of trash from area waterways, visit www.trashbash.org
- Check out our Data Clearinghouse for information, interactive maps, online databases, and more at: www.abcdefg.123.org
- Attend our next Clean Rivers Program Steering Committee Meeting which will be posted on our web site at www.abcdefg.123.steeringcmtmtgs.org

Web Site

The River Authority Clean Rivers Program web page contains a variety of different information. The Data Clearinghouse, www.abcdefg.123/waterdata, is full of information on watersheds, water quality, and includes other data resources. The main features of the clearinghouse are: interactive mapping and customized water quality data query.

The complete 2017 Basin Summary Report, including trend analyses and detailed data reviews for each watershed, is available online at: www.abcdefg.123.resources/crp/watersheds.html

Special study summaries and reports are highlighted on the main CRP page at: www.abcdefg.123/intro.html.

End of example text for the basin highlights report.

Exhibit 5B

Watershed Characterization Report Content & Examples

EXHIBIT 5B

Watershed Characterization Report Contents

Each segment discussed in this document should be organized numerically by segment number followed by the watershed name.

Content	Description
Segment Description	Describes the segment, assessment unit boundaries contained in each segment, historically monitored sites and site(s) believed to be responsible for the impairment or interest.
Hydrologic Characteristics	Streamflow variability, reservoir dynamics, seasonality of flow, typical flow trends
Description of Water Quality Issue	Identify why the water body is listed and when it first appeared on the 303(d) List or why it is an area of interest. Include the number of samples, parameter(s) of concern or impairment, assessment results and the appropriate state standards for comparison.
Land Use & Natural Characteristics	Describe the land surrounding the segment with the help of Google Earth satellite imagery or GIS. Include cities, agricultural lands, location(s) of permitted discharges, landfills, quarry operations, industrial areas, animal feeding operations and oil/gas operations. Other information could be included, such as, topography, slope, soils, vegetation, wildlife, average annual precipitation, average high and low temperatures, eco-regions.
Potential Cause of Water Quality Issue	Identify possible causes of the water quality issue using satellite imagery, watershed surveys, and communication with stakeholders and staff from state and local agencies.
Potential Stakeholders	Companies, agencies or organizations who have a vested interest in the area and who may have a representative serve as a stakeholder.
Recommended Actions	Proposed next steps based on the potential causes of impairment or interest, number of years on the 303(d) List, quality of the listing data and knowledge of the site.
Maps	Include Google Earth aerial images or GIS renderings beginning at the watershed level and "drilling down" to the monitoring site level. Maps define segment and AU boundaries, watersheds, monitoring sites, permitted discharges and animal feeding operations.
Ongoing Projects	Describe current or future projects that will occur in the segment (e.g. TMDLs, special studies, NPS projects, etc.)
Major Watershed Events	Anticipated or known occurrences that have the potential to either positively or negatively impact water quality (e.g., new/amended permits, fish kills, flood/drought, implementing management measures, land development).
Images	Photographic images of the watershed and areas of interest

EXHIBIT 5B

Watershed Characterization Report Example Text

Segment # and Name

Segment Description: Segment # begins from a point just upstream of the confluence with the Bayou and stretches up to its headwaters near the Road in the County. The segment is approximately # miles long and has historically been monitored at the following sites (bolded sites are currently monitored):

- # – the Creek at FM #
- # – the Creek at SH #
- # – the Creek at FM #, southwest of CR #
- # – the Creek above Tidal at the Ranch

There are two impaired AUs in above tidal segment of the Creek, #1 and #2. AU #1 is defined as the # miles surrounding SH #. AU #2 is defined as the upper # miles of the Creek. Data responsible for the listings are from sites #, # and #.

Hydrologic Characteristics: The median instantaneous flow at the site during the historical record of sampling events was 232 cubic feet per second (cfs) and 127cfs at FM. State of the site during high flows, is it flashy, evidence of scouring? Is it often affected by drought? What seasonal trends are observed?

Impairment/Area of Interest Description: Segment # is identified on the Draft 2008 303(d) List for not supporting contact recreation and its designated aquatic life use. The segment was first listed for not meeting contact recreation criteria in 2012 and its aquatic life use in 2009.

In Segment #1, the geometric mean of 24 samples of E.coli bacteria that were assessed was 139 MPN, exceeding the criteria of 126. The bacteria impairment is currently classified as 5a, meaning a TMDL will be scheduled. The assessment indicated that dissolved oxygen levels were consistently low at monitoring sites in Segment 31. Twenty-four hour average dissolved oxygen levels did not meet screening levels for 3 of 4 samples (75 percent) assessed, and 16 out of 32 grab samples (50 percent) were below screening levels triggering a concern for aquatic life use.

In Segment #2, three of six samples failed to meet the criteria for 24-hour average dissolved oxygen levels resulting in an impaired aquatic life use with limited data. From 2010 to 2012, TCEQ performed a Use Attainability Analysis (UAA) on Segment # to assess the aquatic life use and determine if the dissolved oxygen standard of 5.0 mg/L was appropriate. Results of the biological portion of the UAA found that a high aquatic life use criteria was met. Analysis of the dissolved oxygen data did not show such clear results. Average dissolved oxygen levels varied from 2.0 mg/L to 4.0 mg/L at each site. At the time of this printing a report on the UAA was not completed. The dissolved oxygen impairment is currently classified by TCEQ as 5b, meaning a review of water quality standards for this segment will be conducted before a TMDL is scheduled. The TCEQ Draft 2014 Integrated Report also identified concerns for dissolved oxygen levels and orthophosphorous based on data collected from site #.

Land Use: Based on satellite imagery, the majority of the land in the segment is farmed or ranched. There are two permitted dischargers at the upper end of Segment #1; the Municipal Water District, and the County Power. The Farm is a permitted facility that does not discharge into a stream but applies chicken manure to land in the area.

There are no urban developments in Segment #. A small subdivision is located along the river at the monitoring site. The houses appear to have been built in the 1960s and 1970's and presumably use septic systems. Two permitted discharges are located upstream of the monitoring site. One belongs to the Corporation, a maker of solvents. The corporation has a permit to discharge 2.28 MGD of treated domestic wastewater and process water and is located eight miles upstream of the monitoring site. The other permit belongs to the Chemical plant, a producer of polymers and plastics. The chemical plant has a permit to discharge 0.65 MGD of treated domestic wastewater and process water and is located two miles upstream of the monitoring site.

Possible Causes of Impairment or Interest: *Nonpoint Sources* - The Creek is a meandering creek with oxbow lakes and natural dams that slow flow, creating pools of stagnant water and hindering aeration. The lack of aeration coupled with the breakdown of naturally occurring organics in the water may cause dissolved oxygen levels in the creek to frequently fall below the state standard of 5.0 mg/L. Deer, hog and bird populations likely contribute to bacteria levels in the creek. Further study would need to occur before determining the extent of bacteria from wildlife sources.

Agricultural - practices such as plowing to the creek bank and watering cattle in-stream contribute to low dissolved oxygen and elevated bacteria levels. Farming practices in the area are not known, but the results of the UAA performed by TCEQ in 2012 may help determine current agriculture practices in the segment and their impact on water quality.

Wildlife – The field crew make every effort to sample upstream of the bridge at the sampling site, but sometimes access to a safe area upstream of the bridge is limited and samples are collected under the bridge. Influence of waste from birds nesting in the bridge is unknown. Deer live in the area upstream of the sampling site. According to a rancher, who has lived near the sampling site since 1960, feral hog populations have increased dramatically. Wildlife probably contributes to bacteria levels at the site, but the extent can't be determined.

Urban Runoff - The City is less than a mile south of the site. GIS analysis shows that the western portion of the city drains storm water into the river upstream of the site.

Influences of Flow - Since Segment # is tidally influenced, flow is not measured at Site #. The influence of the tide and pulsed releases from upstream dams play a role in how bacteria are transported, but further study is necessary to determine the extent of flow on bacteria at this site.

Potential Stakeholders:

- AgriLife Extension
- Landowners
- Natural Resource Conservation Service
- Texas Department of Agriculture
- Texas State Soil and Water Conservation Board
- Texas Parks and Wildlife Department
- US Fish and Wildlife Service

Recommendation(s): After the Segment # UAA is complete, work with TCEQ to help determine the status of the water body and if a TMDL is needed. Continue to monitor monthly to obtain enough data for a full assessment in 2010. Evaluate wastewater collection infrastructure including a review of the City Clean Water Program Survey the watershed to verify potential sources of bacteria.

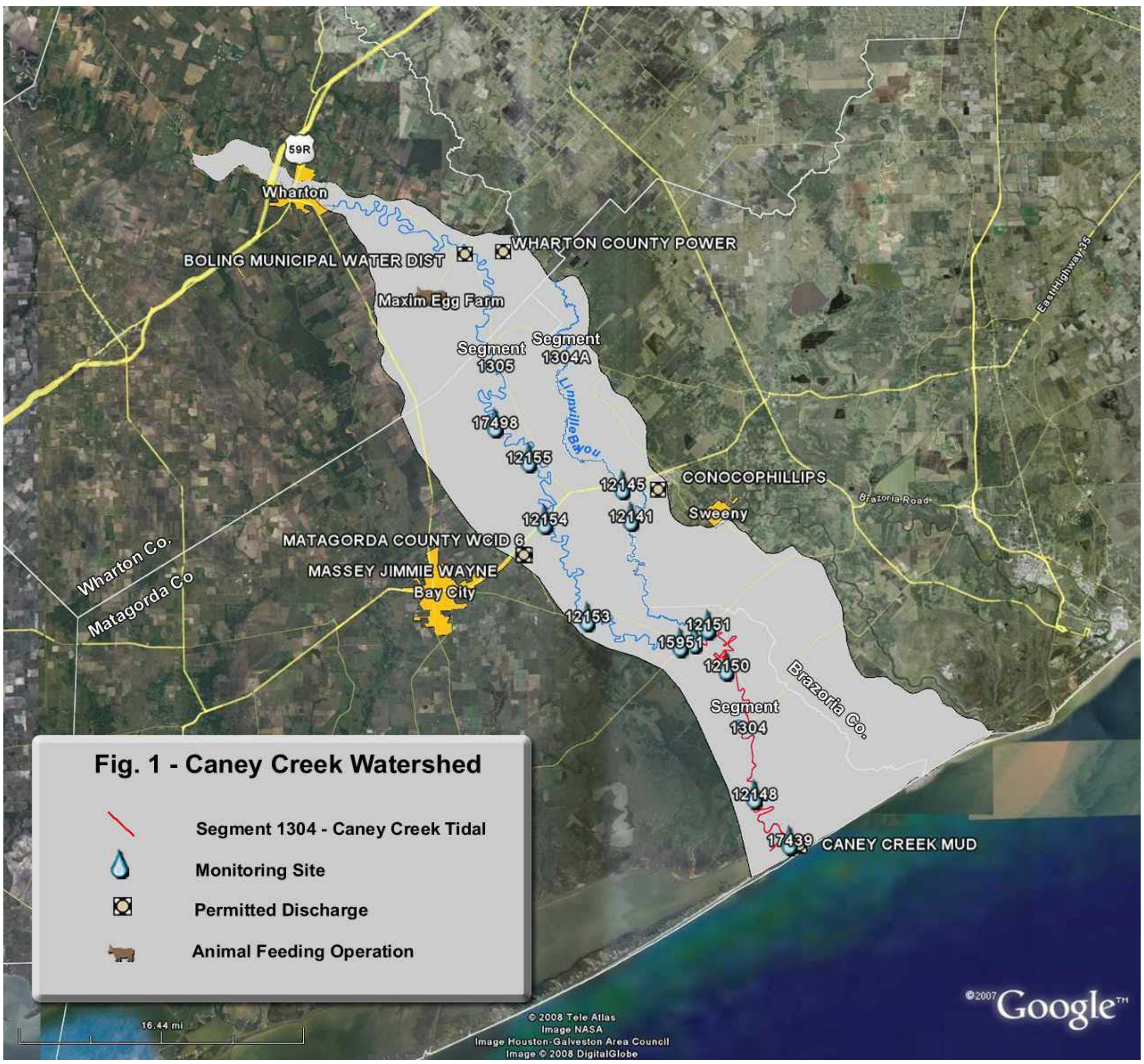



Fig. 2 - Segment 1304
Caney Creek Tidal
Assessment Unit 01 Boundary
Water Monitoring Site
Permitted Discharge
FM-457
12150
521
FM-2611
FM-521
Seg 1304
12148
17439
CANEY CREEK MUD
3.95 mi
Image © 2008 TerraMetrics
Image Houston-Galveston Area Council
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
©2007 Google™

End of example text.

Exhibit 5C

Outline & Example for the Program Update Report

EXHIBIT 5C

Program Update Report Outline & Example

Introduction

The Introduction should succinctly provide the reader with the purpose of the report and sufficient background to understand the scope of the Clean Rivers Program (CRP) and the information provided within the report.

This Year's Highlights

- What were the major events or occurrences during the previous year (positive and negative)?
- What major issues (e.g., extreme drought, increasing development, confined animal operations, ongoing issues, natural salt pollution, record flood) are plaguing water quality for the basin?
- How have these events impacted water quality?
- What has been done to respond to water quality issues?

Public Involvement / How to Get Involved

This section describes basin efforts to promote public involvement in water quality issues. Planning Agencies will summarize public information and education activities undertaken and evaluate the success of these activities.

Water Quality Monitoring

This section should include a summarization by segment of the monitoring that was planned, or occurred, during the past year including any participating entities and special projects. Ideas for this section include:

- Present information on monitoring for the current fiscal year, to include:
- Number of sites per entity, frequency, type of monitoring
- Provide a table showing water quality impairments and concerns from the Texas Water Quality Integrated Report
- Map the coordinated monitoring schedule for the entire basin;
- Additionally, provide map(s) showing the basin(s) or watershed within the state
- Show and label sampling sites, water bodies, county boundaries, highways, & cities.

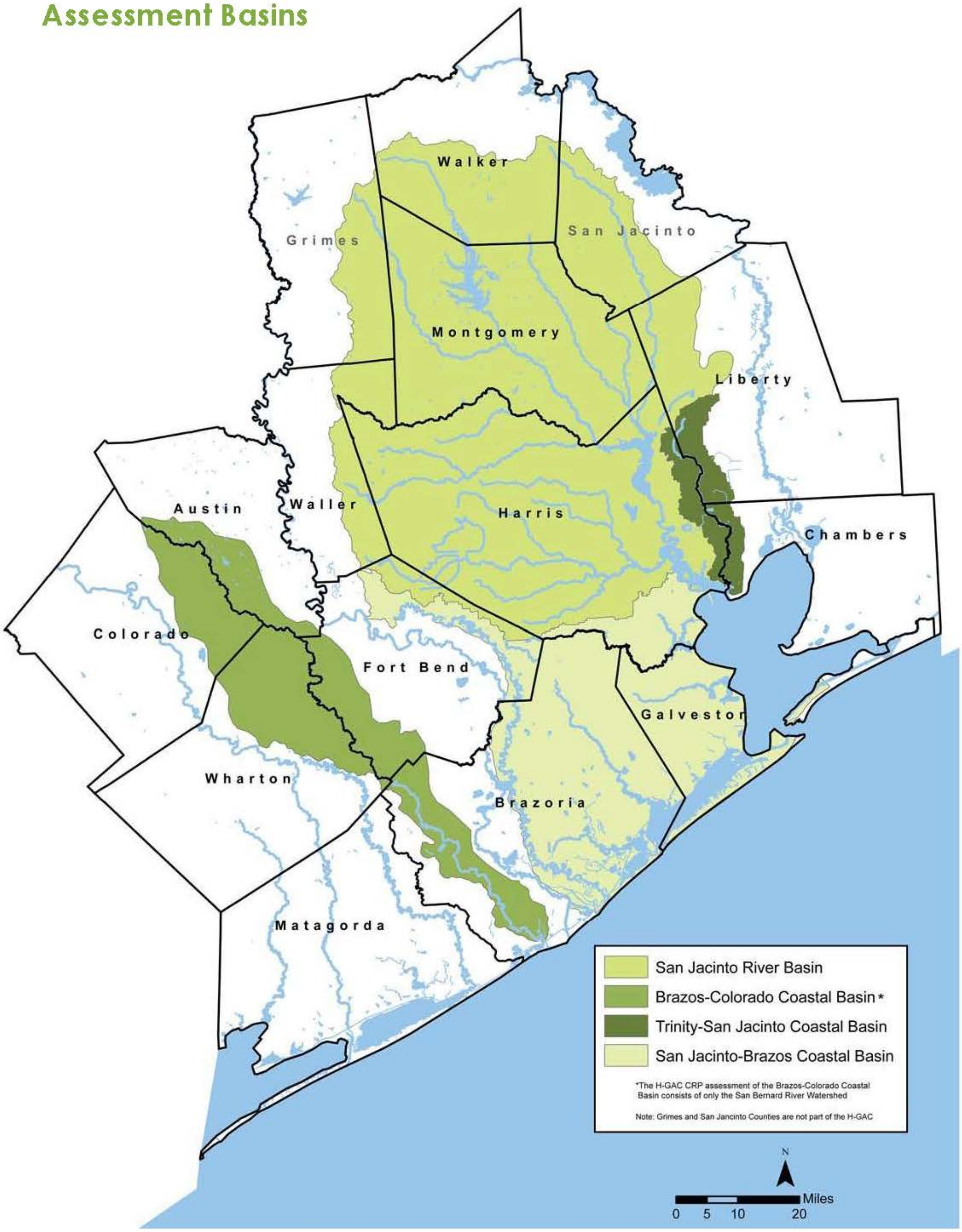
Photo by Sara Robertson

The Houston-Galveston Area Council's Clean Rivers Program produces "How's the Water?" highlighting the region's water quality and various programs and plans that were implemented in the past year. This year, we turn our focus to "Where's the Water?" as we consider what happens when our region faces unprecedented drought.

Beginning in October 2010, the Houston-Galveston region has been suffering from one of the worst droughts on record. Though the rains in late 2011 and early 2012 made significant steps toward overcoming the rain deficit, as of February 21, 2012, most of the region is still classified as under drought conditions by the U.S. Drought Monitor. For a region that historically spends its time and resources developing plans to address too much water (floods, tropical storms, hurricanes), the challenge of solving the problems that arise when there is not enough water has been eye-opening. No longer can we consider water quality and water quantity in isolation from each other. This drought has been an excellent reminder that water is not an infinite resource, and a drought contingency plan must be a part of any resiliency or sustainability plan. This renewed awareness will be essential to protecting our most precious resource.

2

Clean Rivers Program Assessment Basins



3

2012 Basin Highlights Report

The Effects of the Drought

The drought had an immediate cost impact on not only water quality monitoring but also on other end users of surface water.

Partner Monitoring

Although very limited amounts of data were collected at many monitoring sites during the drought, partners still incurred travel costs. Local Clean Rivers Program partners did, however, realize savings by not sending as many water samples from these sites to labs for analysis.

Water Lines

Water lines are more prone to breakage during a drought. As the soil dries out it shrinks or moves, causing buried pipes to break. In June 2011, the City of Pasadena responded to 558 calls for water leaks and line bursts, compared to 99 service requests at the same time in 2010. By the end of 2011, the City of Houston had responded to and repaired 17,756 water line breaks, an increase from 10,821 in 2010. In September 2011, Houston City Council approved spending more than $7 million for emergency water line repairs and continued to appropriate funds to repair lines through January 2012. Street repairs on top of water line breaks added time and expense.

Fishing and Oyster Harvesting

The drought had significant impact on commercial and recreational fishing in the region. Galveston Bay closed to all oyster harvesting on October 5, 2011, due to red tide. Other bay systems closed effective November 1, 2011, the beginning of the 2011-2012 commercial oyster harvesting season. According to the Galveston Bay Foundation, Galveston Bay's oyster fisheries produce more oysters than any other water body in the United States, and the Texas Parks and Wildlife Department indicates the oyster business in Texas lost an estimated $7.5 million.

Trees

Thousands of trees throughout the region died as a result of the drought. In October 2011, the City of Houston contracted to spend $4.5 million to remove dead trees in rights-of-way, public parks and forested park lands. As of February 15, 2012, the City of Houston has removed 17,900 of the dead trees. According to the Harris County Flood Control District, Centerpoint Energy has also removed 19,000 trees on their rights-of-way at a cost of $5.1 million. The loss of tree canopy around area streams can be detrimental to water quality. Increased light can trigger nuisance algal blooms and cause daily water temperatures to increase, affecting the water's ability to hold dissolved oxygen (DO) and support aquatic life.

Silver Lining

When Lake Houston's water levels sank to historic lows, members of the Houston Police Department's Lake Patrol Department removed debris that was not visible or accessible when the lake was at full capacity. The debris removal ranged from navigational hazards, such as pilings, to large debris, including tires and vehicles.

Overall awareness of the importance of water has increased. As more people are seeking information about the drought, they are also learning about water conservation, water quality, watershed protection plans and other water related issues they may not have considered in the past.

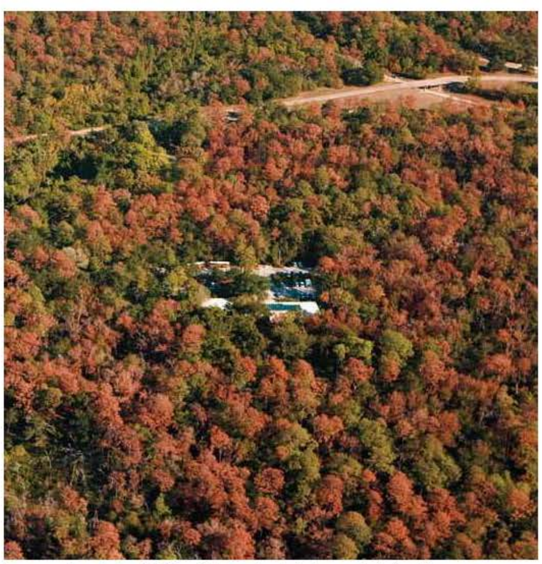
Photo by Houston Council Member Mike Sullivan

4

Were We Ready?

The H-GAC Clean Rivers Program and our partners have never experienced a drought of this extent. Monitoring parameters, such as flow, DO and bacteria could not be measured at many sites due to the lack of water. While data was captured in some cases, it represents unusual conditions for a short period of time and is unlikely to cause a change in a streams assessment. H-GAC staff and local partners were unable to collect water quality data during 37 visits to monitoring stations from October 2010 through December 2011 because the sites were inaccessible due to low water levels, were completely dry, or had only small, isolated pools. In the 10 years prior to the drought, staff encountered low- or no-water circumstances only 11 times. Monitors at these dry sites could only report field observations, including the date, time, and weather but could not take field measurements or collect samples for lab analysis.

As a result, the TCEQ worked with monitoring partners across the state to develop drought-condition monitoring procedures so all partners will be more prepared to characterize the next drought. The new procedures, released in November 2011, direct the monitors to survey the stream bed at a site with no or low flow conditions to note pool coverage (length and depth of visible pools). Samples taken from appropriate pools (1 foot deep and 10 feet wide) may be used as a baseline for low flow conditions in the future.



Approximately 90% of Houston's Memorial Park's canopy cover has died as a result of the drought. (photo by Jim Olive)

11.18 inches

Average rainfall from October 2010 to September 2011 -- 16 inches below normal (Office of the Texas State Climatologist, October 31, 2011)

100 percent

Percent of the state under drought conditions (U.S. Drought Monitor, September 27, 2011)

4 million

Approximate acres of land damaged or destroyed by wildires (Texas Forest Service, November 2010 to February 2012)

500 million

Number of trees killed (Texas Forest Service, December 19, 2011)

$5.2 billion

Agricultural losses (Texas AgriLife Extension Service at Texas A&M, August 17, 2011)

2012 Basin Highlights Report

Where's the Water?

According to the TCEQ, at the height of the drought (September 2011) 916 water systems in the state were enforcing voluntary or mandatory water rationing in an effort to help conserve a rapidly depleting supply of water.

Though the region was not faced with the prospect of running out of water, like the community of Spicewood* in central Texas, all three of the City of Houston's water sources (Lake Houston, Lake Conroe and Lake Livingston) dropped to an average of 73% capacity by fall 2011. In February 2012, following above average rainfalls, Lake Livingston and Lake Houston had returned to 100% capacity, according to the Texas Water Development Board. Lake Conroe remained at 80.62% capacity, but that number continues to rise.

Lake Conroe reached much lower levels than Lake Houston and Lake Livingston as a result of the additional water being released from the Lake to the City of Houston. In August 2011, the City of Houston ordered a measured release of its share of the water rights in Lake Conroe because the city needed additional water to maintain operation of its Northeast Water Purification Plant. The City of Houston owns 70% of the water rights of Lake Conroe and Lake Livingston and 100% of the water rights of Lake Houston. In December 2011, Lake Conroe reached its lowest water level when it fell to 8 feet below normal or 65.92% capacity. The City of Houston stopped calling for water to be released from Lake Conroe in November 2011.

*Spicewood's water supply was almost completely depleted by January 2012. The Lower Colorado River Authority brought water to the community from other LCRA water systems by tanker trucks.

Photo by Bill Hoffman

What's the Difference?

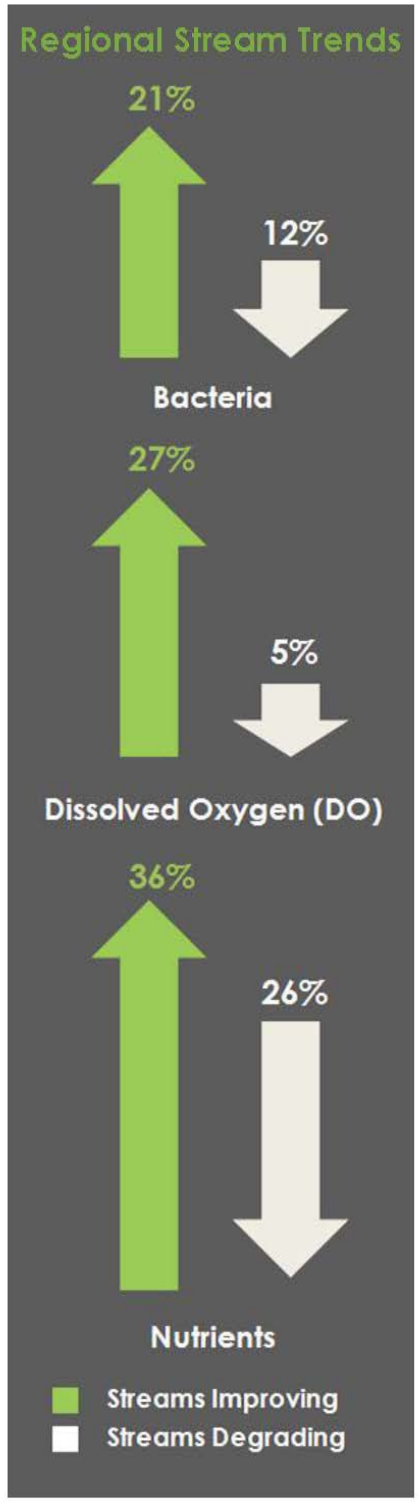
During routine monitoring of Persimmon Bayou in November 2011, professional monitors from the Environmental Institute of Houston (EIH) noted speciic conductance, or the measure of salinity, was 20,000 micro Siemens/cm , which is signiicantly higher than it should have been for this fresh water or slightly brackish water site. (Sea water ranges from 48,000 to 58,000 micro Siemens/cm). In response to the EIH data, H-GAC submitted and TCEQ approved a request to reclassify the station as tidal instead of freshwater. In January, 2012, following a signiicant rainfall, conductance was once again measured at 200 microsiemens/cm. This site also saw a signiicant difference in bacteria levels - Escherichia coli (E.coli) levels of 200 MPN/100 mL in November, followed by an increase to 10,000 MPN/100 mL after the rain. Lower bacteria densities might suggest enhanced support for recreational uses, but higher salinity levels that accompanied them adversely affect aquatic life and reduce support for aquatic life uses.

This illustrates the potential for extreme swings in data during drought conditions. This site had historically produced conductance measurements of a freshwater site, but the lack of rain led to increases in measured conductance. The surge of freshwater from the rains signiicantly reduced the conductance. This occurrence also allows us to determine that bacteria levels at this site increased after a rainfall and therefore are signiicantly affected by runoff pollution.

6

How's the Water?

The drought, although unwelcome, provided an opportunity for H-GAC and local partners to take a closer look at data collected to determine the impacts of drought on bacteria levels and other parameters. H-GAC staff analyzed water quality data collected during routine monitoring at stations on freshwater streams to investigate the effects of the drought on water quality by comparing the levels of *E.coli* bacteria, DO, and nutrients (phosphorus and nitrogen compounds) before and after the official start of the drought.



Bacteria

In the assessment units where *E. coli* is the indicator bacteria, 73% of the monitoring sites exhibited lower average bacteria levels than the seven-year period before the drought. Conversely, only 15% of the monitoring sites showed higher average bacteria levels. *E. coli* is the indicator bacteria for freshwater sites, while enterococci is the indicator bacteria for saltwatersites.

This supports the idea that runoff pollution is likely a significant source of *E.coli* in most streams. Several factors may also have contributed to the higher bacteria levels observed at several stations, including pollution from sources other than runoff. Poor quality effluent from waste water treatment plants, undetected broken sewer lines in the collection system, wildlife, and bird droppings could create areas of concentrated bacteria that would ordinarily be diluted during conditions of normal flow.

In addition to less runoff, lower bacteria levels could also be attributed to broken drinking water lines. In some instances broken water lines have leaked into waterways that normally have elevated bacteria levels. The disinfecting properties of chlorinated drinking water, coupled with dilution, may have temporarily decreased bacteria levels at the time of sampling. However, the reductions in bacteria levels did not mean that the stream was meeting the recreational water quality standard. Bacteria levels in most cases were still quite high but were less than previous levels.

Dissolved Oxygen and Nutrients

DO is vital to the health of aquatic ecosystems. Our analysis shows moderate, but significant, decreases in DO in the bays and estuaries in our region during the drought. DO problems are often caused by elevated nutrient levels, including total phosphorus. Prior to the drought, 36% of samples exceeded screening levels for total phosphorus. During the drought, 45% of samples exceeded these limits, and 74% of samples showed at least a 10% increase in median concentration of total phosphorus. Possible explanations for higher nutrient concentrations include higher evaporation rates and a higher proportion of phosphate-rich wastewater treatment plant effluent in area waterways.

2012 Basin Highlights Report

Nature's Contributions

According to the Texas Parks and Wildlife Department Spills and Kills Team, tidal tributaries in the Galveston Bay area experienced more frequent and more widespread fish kills during the drought than in previous years. The primary species killed was gulf menhaden. Low DO is the leading contributor to fish kills. During the drought, the region experienced higher water temperatures generally associated with low DO. Algal blooms also contributed to low DO.

As a result of little or no rainfall, water bodies are subject to lower than normal flows and can become stagnant. Nutrients in this stagnant water lead to flourishing algal blooms. This algae then consumes the oxygen overnight, drastically reducing the oxygen supply in the water and causing fish and other aquatic life to die.

High salinity also created problems for aquatic life in Galveston Bay. Texas Parks and Wildlife reports that Galveston Bay recorded the highest salinity (42 parts per thousand in West Bay in late summer 2011) since the department's routine monitoring was initiated more than 30 years ago. Oysters need just the right balance of freshwater and saltwater to survive and thrive in Galveston Bay. According to Texas A&M University-Galveston, too much freshwater is devastating to the oyster population. However, too much saltwater, high temperatures, low wind and decreased fresh water inflows from rainfall contribute to ideal conditions for the influx of oyster predators and parasites (e.g. oyster drill and Dermo disease) or blooms of harmful algae such as red tide. Texas saw one of the longest occurrences of red tide in the state's history during the drought.

The Texas Department of State Health Services closed all Texas coastal waters to commercial and recreational harvesting of mussels, clams and oysters because of the red tide in October 2011. By early February 2012, some waterways, including portions of Galveston Bay, North and Central provisional areas and East Bay) and San Antonio Bay were re-opened. This was good news for the $30-billion oyster industry.

Photo byJustin Bower

8

Photo by Justin Bower

Impact on Wildlife

- Migrating birds rely on forage, like rice ields. Lack of water decreases rice production and decreases forage and habitat for the birds.
- Wetland species, including the American Alligator, must relocate or face increasingly stressful conditions to survive as shallow wetlands dry up from lack of rainfall.
- Many wild animals, including feral hogs, are driven into populated areas to seek food and water. Other wild animals, including ish, were forced from their indigenous areas to populated areas, disrupting the delicate balance of that area's ecosystem.
- Reproduction rates of many species may be negatively impacted.
- Dry streams have led to a decrease in ish communities.

From the Texas Parks and Wildlife Department:

Red tide is a marine species and prefers higher salinities which are linked to periods of drought. Red tide is a single celled microscopic algae (Karenia brevis) that produces a neurotoxin that affects a ish's ability to respire causing ish kills. Striped mullet was the primary species killed during the 2011-2012 red tide. However, oysters and clams accumulate the neurotoxin while ilter feeding. The toxin is heat resistant and can't be neutralized by cooking. People who eat ish or shellish contaminated during red tide may become ill. Red tide can also cause respiratory problems for people who inhale the airborne toxin.

Photo by Jim Olive

2012 Basin Highlights Report

Other Highlights

Even in the face of the drought, the Clean Rivers Program and programs that rely on CRP data continued to make strides in 2011.

TCEQ Watershed Action Planning

The TCEQ has implemented Watershed Action Planning. This process helps the TCEQ coordinate, document and track activities and strategies for protecting and improving water quality. The TCEQ worked with the Texas State Soil and Water Conservation Board and CRP partners from across the state to develop the Watershed Action Planning strategy table which lists impaired and special-interest water bodies, the recommended strategies for addressing the problems or issues, the status of each strategy and the lead agency or program for tracking.

Water bodies of special interest are those that are not considered "impaired" by state standards, but are of concern to local agencies. This list will be used by TCEQ to help focus funding and other resources. Two water bodies in our region – Lake Creek and Lake Conroe – while not impaired, show deteriorating conditions, and at H-GAC's request, TCEQ added them to the list. H-GAC plans to start a watershed protection plan (WPP) project on Lake Creek when funds are available. The San Jacinto River Authority – Lake Conroe Division has started a WPP for Lake Conroe and can also use funds that may become available now that these two water bodies have been added to the list.

Bacteria Implementation Plan

In August 2011, the Bacteria Implementation Group approved the Bacteria Reduction Implementation Plan (I-Plan) for the Houston-Galveston Region to submit to the TCEQ for consideration and possible approval and support. More than 90 local governments, professional organizations, and environmental groups have passed formal resolutions of support or otherwise indicated support for the I-Plan.

The I-Plan, developed over three years, includes 34 implementation activities and four research priorities to address eleven strategies to reduce the amount bacteria entering impaired waterways in the project area. The project area is roughly 2,204 square miles, has a population of about four million people, and encompasses all or part of ten counties and 56 cities.

H-GAC calculated the seven-year averages for E. coli levels at 345 monitoring stations in the project area and determined that 63% had levels higher than the state standard for contact recreation. Data suggests bacteria levels are increasing at 13 of the sites and decreasing at 29 of the sites. Among the ten stations with the highest bacteria, concentrations at three sites are decreasing.

H-GAC is working with local governments to share information about the stations that have the highest bacteria levels in the region. Local governments are examining water quality data as well as complaint and violation data. The local governments are also conducting visual investigations and additional sampling to try to identify the source(s) of bacteria at each of the sites. For the sites that are at the most upstream portion of the waterway, preliminary investigations suggest that grease blockages may be contributing to sanitary sewer system overflows into the storm drains. It may take several months or more to determine the primary sources of bacteria, and longer in other sites with upstream contributions.

WRIM, How's the Water App.

In 2011, H-GAC's CRP updated the Water Resources Information Map to make it easier to query, provide more information, including data summaries, current assessments and more data points. In January 2011, 84 unique users visited the mapping resource. Typical users for this interactive tool are water quality professionals, students working on research or class projects, instructors and professors, and water quality volunteers. (www.h-gac.com/go/wrim)
This year, we also released our How's the Water iPhone app to give users on the go a snapshot of water quality, as well as the locations of water quality monitoring sites in their vicinity. Visit http://www.h-gac.com/go/cemobilegis or logon to the iTunes store and search for "How's the Water?"

Photo by Kristi Corse

10

Photo by Kristi Corse

When considering water quality, rainfall can be a double-edged sword. The region needs rain to fill reservoirs and waterways, and to support aquatic life. A slow, moderate rainfall is ideal, allowing water to soak into the ground. Torrential downpours and isolated thunderstorms cause many waterways to overflow their banks while carrying high concentrations of bacteria, heavy sediment, and other unknown pollutants to downstream waterways and, eventually, Galveston Bay.

Only time will tell if the 2011 Drought will have a significant long-term effect on water quality in the Houston-Galveston Region or if it will simply be an outlier of information like other extreme weather events. The H-GAC Clean Rivers Program will continue to work with partners to monitor water quality in the region, report those findings to area residents, and work to help develop solutions for the problems we find.

This report was prepared in cooperation with the Texas Commission on Envinromental Quality under the authorization of the Texas Clean Rivers Act.

H-GAC Houston-Galveston Area Council | TCEQ | THE TEXAS CLEAN RIVERS PROGRAM

HOUSTON-GALVESTON AREA COUNCIL 3555 TIMMONS LANE, SUITE 120 HOUSTON, TEXAS 77027
WWW.H-GAC.COM
CE0512

Exhibit 5D

Basin Summary Report Outline

EXHIBIT 5D

Basin Summary Report Outline

Executive Summary

The Executive Summary is intended to be an informative digest of the significant content and conclusions of the report. It is meant to be intelligible by itself, summarizing the purpose, findings, conclusions and recommendations. The following is an outline for this overview:

Activities and Accomplishments - Describe the successes of the program and how the basin objectives have been accomplished over the past five years. Discuss how efforts undertaken with regard to monitoring (i.e., level of effort), geographic data sets, prioritization of water quality issues, efforts to involve basin stakeholders, and public outreach endeavors, have provided a benefit to the public.

Significant Findings - Summarize the results of the data analyses (e.g., number of sites with high levels of nutrients, positive and negative trends, and any hits with toxics). Describe major water quality issues and the most likely reasons for the water quality conditions. Highlight water quality that appears to be improving and report on any actions that have been taken to improve water quality.

Recommendations - Include specific recommendations for each watershed and explain the basis for the recommendation. Describe how the findings from the data analyses will be used to focus resources in the next biennium.

Summary Report

1.0 Introduction

The Introduction will provide the reader with the purpose of the report and sufficient background to understand the scope of the Clean Rivers Program (CRP) and the information provided within the report. The introduction will also include subsections with the following general headings:

- CRP and basin goals/objectives;
- coordination/cooperation with other basin entities;
- descriptive overview of the basin's characteristics, including key factors influencing water quality;
- summary of basin's water quality characteristics.

2.0 Public Involvement

This section describes basin efforts to promote public involvement in water quality issues. Planning Agencies will summarize public information and education activities undertaken and evaluate the success of these activities. The report will also identify and discuss any public outreach materials developed (e.g., pamphlets for septic tank maintenance, NPS pollution education).

The Basin Steering Committee needs to be discussed fully in this section. This may include a general description of membership, how the committee functions, and typical topics that are discussed at the meetings. This section should define how the committee's input is incorporated in decisions for focusing CRP resources (e.g., special studies, adding sites, adding parameters).

This section also should include efforts to seek public input for prioritizing water quality issues and monitoring projects, including Watershed Protection Plan/TMDL coordination efforts, review of stream standards, the State's Water Quality Inventory, and basin planning initiatives. Where applicable, include a discussion on volunteer environmental monitoring (VEM) groups and the function of these groups.

If any watershed-based technical sub-committees have been formed, a short overview of the functionality of those committees should be provided. A more in-depth discussion of how a committee has been involved in a special study can be provided in the Watershed Summaries section of this report.

3.0 Water Quality Review

3.1 Water Quality Terminology

This section needs to provide a description of any technical terms, including monitoring parameters and how they relate to maintaining water quality standards. A short discussion of the quality controls behind the data should also be included.

A table with parameter descriptions can be found in Exhibit 5F.

3.2 Data Review Methodology

This section will include a discussion of the methods used to evaluate the data and should provide enough detail for the reader to be able to re-create your steps. Some of the process overviews include:

- an explanation of TCEQ's assessment methodology, along with how the State's information will be used in the report
- a discussion of the methods used to conduct the Trend Analysis specifying the parameters used to screen the data (e.g., number of records, period of record) and the criteria used to determine whether a trend exists (e.g., percent change per parameter)
- an explanation of any additional evaluation methods (e.g., compare descriptive statistics from site to site for similar watersheds to determine the relative level of concern; compare descriptive statistics upstream to downstream to find significant changes, then relate factors in the watershed to the change)
- a description of the index of biotic integrity used for biological surveys

3.3 Watershed Summaries

The review of water quality data and watershed characteristics should be presented within the context of a watershed to keep information for stations that are in close geographic proximity and subject to similar watershed characteristics together. For our purposes, a watershed is typically defined by a segment and the land/tributaries that drain to it. The following information will make up each Watershed Summary (see Exhibit 5E for Data Analysis Steps and Exhibit 5F for an example Watershed Summary) and will help answer the questions:

- what are the water quality issues?
- why do the issues exist?
- what are the possible effects?
- what should be/could be done about it?

What are the Water Quality Issues?

The first step in the review of water quality is to *identify water quality issues*. A water quality issue may be identified in one or more of the following ways:

- listed as an Impairment or Concern on the latest TCEQ Water Quality Integrated Report;
  - Impaired/concern because 8 samples out of 28 collected over the past five years were over the criteria/screening level
- local concern of stakeholders; and/or
- through the Data Analysis (see Exhibit 5E) conducted by the Planning Agency;
  - The 8 samples typically 3 times higher than the criteria/screening level
  - The trend analysis indicates a significant upward trend, and concentrations are getting close to the criteria/screening level
  - This water body exhibits the third highest median concentration of the parameter in the central watershed over the past five years

Note: In those cases where there is no “identified water quality issue”, the report needs to include some discussion of water quality. The discussion should include an overview of the watershed characteristics, results from the latest TCEQ Assessment, and the descriptive statistics (e.g., percentiles) to show how they compare to other similar water bodies in the area.

Next, for identified water quality issues, a description of the findings from a data analysis is needed to lay the groundwork for understanding the status of water quality. This will be a discussion based on the *Data Analysis* (see Exhibit 5E) conducted to determine if any trends exist, and how other corollary factors, such as flow or another parameter, are influencing water quality conditions. Examples for this type of discussion are provided in *Exhibit 5F – Example Watershed Summary*.

Why Do the Issues Exist?

Once a water quality issue has been identified and defined, a description is needed *explaining the possible reason(s) it is an issue* (e.g., what is causing the problem) to improve overall understanding of the issue and its relative importance. The following is example text for this type of explanation:

- rapid urban development bringing additional land application of fertilizers, pesticides, pet waste, septic systems, and new sewage outfalls, which can result in increased concentrations of nutrients, bacteria, and organic constituents in the water body
- large areas of cropland involving tillage, the use of fertilizers and pesticides, which can result in increased sediment loads to the water body, as well as nutrients and organic constituents from the fertilizers and pesticides
- wildlife waste which can add bacteria and nutrients
- low flows, combined with pollution sources, do not provide adequate assimilative capacity
- a review of the flows related to the 8 elevated samples shows a direct correlation to rainfall and run-off, indicating that nonpoint sources are more likely to cause concentrations to exceed criteria, although base-level concentrations are somewhat elevated pointing to some influence from wastewater outfalls
- a review of the water quality upstream and downstream of the site show a decline from upstream to downstream possibly due to increased spring flows and distance from the rapid

urban development in the upper portion of the watershed

Note: A set of base maps showing the relationship of watershed characteristics with water quality conditions will be included in each Watershed Summary. The maps need to be at a suitable scale and contain an appropriate amount of detail, such as: water bodies with labels, major roads with labels, sampling sites with labels, counties and cities, segment boundaries, locations of water quality issues and factors influencing water quality.

What are the Possible Effects?

An explanation about how the water quality issue will affect the uses of the water body is important to determining the relative importance of the issue. Some examples for the possible effects of the water quality issue include:

- the increased sedimentation can reduce the survivability of aquatic life and reduces the aesthetic use of the stream
- when flows increase after a rain event, the stream may not be suitable for swimming because bacteria concentrations increase by up to five times the state-established criteria
- nitrate concentrations at levels above 10 mg/L are considered too high for drinking water use, and levels above 30 mg/L are shown to have a negative impact on aquatic life in the stream
- the EPA has stated that perchlorate can cause developmental problems in children if consumed in drinking water

What Should be/Could be Done About It?

A discussion of the “next steps” that need to be taken to reduce the impact of the water quality problem will help in setting future priorities for monitoring and strategies for improvement. Some examples of possible next steps to addressing a water quality issue include:

- continue the Planning Agency’s supporting/technical role in the ongoing Watershed Protection Plan
- enhance stormwater controls for rock quarry operations
- work with local farmers to find an alternative to the use of atrazine
- obtain support for the regional wastewater treatment plan from local municipalities, developers, and county government
- conduct a special study to include two biological surveys including 24 hour dissolved oxygen measurements, target monitoring to run-off events as well as non-run-off events, and monitor monthly for two years at five sites in the watershed at locations near potential sources

See Exhibit 5E for specific steps for conducting the Data and Trend Analysis. These represent the minimum requirements for data analysis and should be at least as robust as described in the Exhibit 5E.

Evaluation of Biological and Toxics (Organics, Metals) Data

The information developed from biological surveys should be incorporated into the Water Quality Review to complement the findings from the water quality data. A comparison of the latest results to any previous results should be included to provide a long-term view of the information.

For toxics data compare the results to water quality standards, maximum contaminant levels, and/or screening levels and describe the relevance of the findings.

4.0 Recommendations and Conclusions

4.1 Recommendations and Comments

While watershed-specific recommendations are made in the Watershed Summaries (see Exhibit 5E), this section needs to include recommendations and comments made by stakeholders who reviewed the draft Basin Summary Report. In addition, an outline of the programmatic, regulatory, and legislative recommendations to protect and improve water quality throughout the basin need to be discussed. These recommendations may include a consideration of resources available for implementing the action.

The results of the analyses for this report, as well as input from stakeholders, should be used to set some preliminary priorities for addressing water quality issues. These priorities will help define where additional analysis may be needed for the Basin Summary Report. This will also help determine where additional information could be collected under the next biennium's Work Plan.

4.2 Conclusions

The report concludes with a discussion of how the Planning Agency's efforts have advanced the understanding of water quality. Also, this section will describe the Planning Agency's long-term vision of how basin efforts need to be directed during the next biennium to improve water quality.

Exhibit 5E

Data Analysis Steps (for the Basin Summary Report Section 3.3)

EXHIBIT 5E

Data Analysis Steps

1. **Divide the basin into manageable sections (watersheds and/or segments)**
2. **Review the data and describe the water quality conditions**
   a. **Graph the Priority Parameters** (see Exhibit 5G for a list of priority parameters)
      (1) Graph data for all segments whether or not they have an impairment (this will help in describing water quality).
      (2) Graph data over time and include related parameters to help describe any correlations (especially flow).

   b. **Run a Trend Analysis**
      (1) If there is enough data (>9 years, >19 records, consistent sampling with no significant data gaps), run a regression against time and describe the results (trend is significant with t-ratio = or > |2|, p-value < 0.1).
      (2) If more that 50% of the samples in the dataset are censored, do not apply a trend analysis.

   c. Include Graphs for Identified Water Quality Issues
      (1) Put graphs in the report for water quality issues that will benefit from a visual representation (especially for *Impairments, Concerns,* major exceedances, and other significant issues).

   d. **Describe the Water Quality Shown on the Graphs** (whether you include the graphs in the report or not).
      (1) Describe the range (variability).
      (2) Explain any measurements that do not meet criteria/screening levels.
      (3) Does water quality vary with flow?
      (4) Is there a seasonal component?
      (5) What percent of the data exceeds the screening level for the past 7 years? Is it a *Concern* or an *Impairment*?
      (6) Is a change in data over time visible?
      (7) Is there any corollary information to explain the effect of the issue (e.g., how do other related parameters vary)?

Tips for Conducting the Data Analysis

1. Pull all data for sites in the basin that provide a good representation of a water body. In some cases, more than one site will be needed to adequately represent a water body. Associate flow with every record, and in reservoirs, get information on releases and/or inflow if available.
    - **a.** Put the data for each watershed into a spreadsheet (Station, Date, Time, Depth, Parameter code, GTLT, and value) for all data. Select stations based on longevity, significance, and coverage. (If there are stations that are very close to each other, then you may want to select one over the other. If there are significant differences in the data, or known influences between the two sites, it may be necessary to keep both.)
    - **b.** In some cases, one station was dropped and a different one was picked up nearby, you will need to add those data sets together to achieve a longer data set; however, do not overlap data for the same period of record, since we do not want to double count data that may skew the results (e.g., data on the same day, data during the same month, more data in one month/quarter/year than in others).
2. Prepare the data for graphing and analysis.
    - **a.** Sort the data by Parameter code, station, and date.
    - **b.** Check for data that may need to be combined (e.g., put on the same graph) to lengthen the period of record (be careful not to double-up within a time period). For instance, nitrates have three or four different, yet comparable Parameter codes (00593, 00620, 00621, 00630, 00631), orthophosphate phosphorus has two (00671 and 70507), E. coli has at least two (31648, 31699), and chlorophyll a has two (32211, 70953). You might consider plotting fecal coliform values and E. coli values on the same graph to see if a trend is evident in both (but be sure to show them with different symbols).
    - **c.** Consider converting spec. conductance to TDS (let the reader know you have done this).
    - **d.** Censored data can generally be left as is, ignoring the less than sign; however, in cases where a trend is visible, consider editing the censored values to make them consistent. This can be done by changing all the censored measurements to the lowest reporting limit.
    - **e.** In most cases, it will be necessary to transform the bacteria data by taking the log of that data prior to performing any type of regression analysis.
3. Graph the data for each significant Parameter over time (nitrate, phosphorus, DO, pH, bacteria, TDS, TSS, ammonia, chlorophyll *a*)
    - **a.** Use a graph template and plot flow with the parameter whenever possible.
    - **b.** Check the scale to see if it needs to be adjusted. There may be a few high values that cause all the low values to be unrecognizable. Use some judgment as to where you should draw the line, but be as consistent as possible for each parameter.
    - **c.** If there are a few values that occurred years ago, exclude these from the graph.
    - **d.** If the data set is very long, and the earlier years do not show anything significant, consider plotting only the last 15-20 years of the data set. Be consistent on period of time.
    - **e.** If there is a value that appears to be unreasonable (almost impossible), it may be an outlier and should be excluded from the data review.
    - **f.** Be sure to plot the criteria or screening level on the graphs.

Exhibit 5F

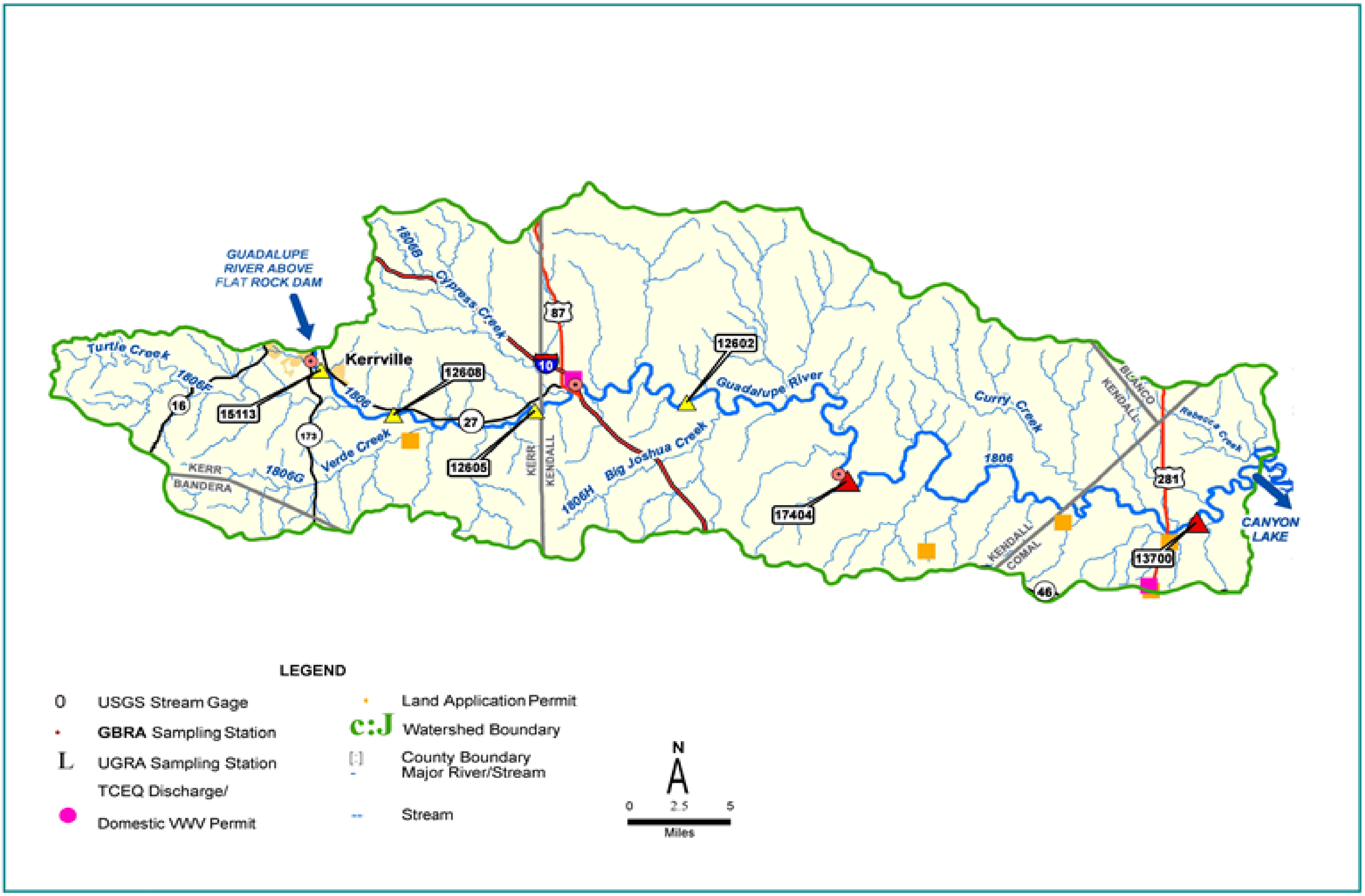
Example Watershed Summary (Example for the Basin Summary Report Section 3.3)

Water Quality Issues Summary

Water Quality Issue	Affected Area	Possible Influences / Concerns Voiced by Stakeholders	Possible Effects	Possible Solutions / Actions Taken
Impairment for E. coli bacteria on 2006 Water Quality Inventory	Upper and lower portion of the watershed	▪ Rapid urbanization, impervious cover ▪ Construction stormwater controls failing ▪ Developments with septic tanks or small, privately-run wastewater treatment plants ▪ Small, slow moving stream with little assimilative capacity Illegal dumping at creek crossings	▪ Increased quantity of stormwater scouring stream beds, creating additional sediment loading and urban-related pollutants ▪ Bacteria load from land use and effluent is not reduced by instream flow ▪ Significant contact recreation (e.g., swimming) could lead to gastrointestinal illnesses	▪ Improve stormwater controls in new developments ▪ Adequate construction oversight ▪ Wastewater regionalization to prevent multiple small package plants and reduce septic tanks ▪ See *Response to Concerns*
Elevated Ammonia-N	Upper portion of watershed	Wastewater treatment plants	Detrimental effect on aquatic biological community	Wastewater treatment plant improve operations
Concern for Nutrient Enrichment (Nitrates and Phosphorus)	Entire watershed	▪ Wastewater treatment plant effluent ▪ Spring water high in nitrates from geology of aquifer formation ▪ Row-crop agriculture	▪ Can increase production of algae causing an aesthetic nuisance ▪ Can cause significant swings in dissolved oxygen, affecting viability of aquatic life ▪ In moderate amounts, can actually enhance the fish population	▪ If dissolved oxygen swings are significant and biology shows a related effect, then some phosphorus controls may be needed for wastewater treatment plants ▪ Water golf courses and other open areas with effluent- may actually reduce water quality due to reduced flows instream
Stakeholder concern for oil and gas operations	Lower portion of the watershed	▪ Recent increased oil and gas activity ▪ Historical stakeholder accounts indicate sheens in 70s and 80s, but not today	▪ Detrimental effect on biological community ▪ Drinking water polluted with organic oil field by-products ▪ Contact recreation use could lead to illnesses	RA sampled two sites, twice, and found no detection of related pollutants

Water Quality Issue	Affected Area	Possible Influences / Concerns Voiced by Stakeholders	Possible Effects	Possible Solutions / Actions Taken
Decreasing Trend for Total Phosphorus	Lower portion of the watershed	▪ Reduction in wastewater treatment plant effluent ▪ Unknown*	▪ Reduction in algae production instream ▪ Reduction in diurnal swings in dissolved oxygen, reducing stress on aquatic biology	Re-use of wastewater treatment plant effluent during dry, low-flow periods

GUADALUPE RIVER BELOW FLAT ROCK DAM



28

GUADALUPE RIVER BELOW FLAT ROCK DAM

Segment 1806 comprises the 103 mile portion of the Guadalupe River that flows from the confluence between the North Fork and South Forks in Kerr County to Canyon Reservoir in Comal County. This summary report will discuss this segment as two sub-watersheds in order to better describe the effects of a Total Maximum Daily Load (TMDL) implementation plan that has been put into place upstream of Flat Rock Dam in the City of Kerrv ille. The TCEQ has divided th is segment into eight assessment units (AUs). The three AUs that describe the lower sub-watershed below Flat Rock Dam are 1806_02 from the confluence with Big Joshua Creek to Flat Rock dam in Kerrville, 1806_08 from the confluence with Honey Creek upstream to the confluence with Big Joshua Creek and 1806_01 which covers the lower 25 miles of segment from 1. 7 miles downstream of Rebecca Creek Road up to the confluence with Honey Creek. These three AUs represent over 93% of the total river reach for this segment. For information regarding the remaining five AUs in this segment please refer to the section of this report covering the Guadalupe River above Flat Rock Dam.

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

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

CONTINUED ON PAGE 30

Guadalupe River below Flat Rock Dam
Drainage Area: 827 square miles
Streams and Rivers from Flat Rock Dam to Canyon Lake: Silver Creek, Turtle Creek , Steel Creek, Verde Creek (1806G), Bluff Creek, Cherry Creek, Bruins Creek, Wilson Creek, Cypress Creek (18068), Holliday Creek, Flat Rock Creek, Block Creek, Joshua Creek (1806H), Violet Creek, Sister Creek, Jacobs Creek, Wasp Creek, Bear Creek, Sabinas Creek, Goss Creek, Spring Creek, Swede Creek, Panther Creek, Walter Creek, Honey Creek, Curry Creek, Spring Branch, Swine Creek, Elm Creek, Cypress Creek, Miller Creek
Aquifer: Trinity, Edwards Plateau
River Segments: 1806
Cities: Center Point, Comfort, Kendalia, Bergheim, Bulverde, Spring Branch
Counties: Kerr, Comal , Kendall, Blanco
EcoReglon: Edwards Plateau

Climate: Average annual rainfall 31.68 inches, Average annual temperature January 38 °, July 95 °
Vegetation Cover: Evergreen Forest 30.7%; Deciduous Forest 7.0%; Shrubland 48.8%; Grassland: 9.6%; Cultivate Crops 0.4%; Pasture Hay 0.4%
Land Uses: urban, unincorporated suburban sprawl, cattle, goat and sheep production, light and heavy industry, and recreational
Development: Low Intensity 0.5%; Medium Intensity 0.2%; High Intensity 0.1%; Open Space 2.3%
Water Body Uses: aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: Land Application 6, Domestic 1

GUADALUPE RIVER BELOW FLAT ROCK DAM

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

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

GUADALUPE RIVER BELOW FLAT ROCK DAM

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

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

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

CONTINUED ON PAGE 32

GUADALUPE RIVER BELOW FLAT ROCK DAM

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

The most downstream AU 1806_01 covers a 25 mile reach in Comal County from a point 1.7 miles downstream of Rebecca Creek Road upstream to the confluence of Honey Creek near the Kendall County line. This AU is represented by a single monitoring station 13700. Station 13700 is located on the Guadalupe River upstream of the FM 311 Bridge near the USGS gaging station in Spring Branch and has been monitored monthly by the GBRA since 1996. This segment of the Guadalupe River immediately upstream of Canyon Lake is a part of the Guadalupe River Paddling Trail and is known for clear water with abundant contact recreation. There are no known permitted discharges into this assessment unit. The 2014 Texas Integrated Report of Water Quality indicates full support of all designated uses and the geometric mean of E. coli was well below the primary contact reaction standard of 126 MPN/100 ml with a concentration of 62 MPN/100 ml. A review of the data from December of 2002 to November of 2016 was conducted at this station. The average stream flow at the nearby USGS gage during this time period was 362 cfs. Several important data trends were identified at this station. Much like the other stations upstream, stream flow at this station appears to be significantly declining (Figure 15). This trend is most likely due to several years of drought, beginning in 2008, including an extended period during from August till October

GUADALUPE RIVER BELOW FLAT ROCK DAM

of 2011 , when the stream flow at this station was measured at 0.00 cfs and the river was reduced to unconnected pools of water. A significant increase in chlorides and sulfates over time was also identified at this station (Figure 16 & 17). These rising chloride and sulfate levels can be at least partially explained by the overall reduction in streamflow, because chlorides are significantly increasing as stream flow decreases (Figure 18). Although the concentrations of these anions appear to increasing, at no point did any value exceed the stream general use screening criteria of 50 mg/L. All of the available data shows that this station appears to support the AU's designated uses (Table 6). The geometric mean of E. coli at this station remains at 64 MPN/100 ml with a maximum recorded value of 2400 MPN/100 ml. The average concentrations measured for all water quality parameters fall within the designated use criteria for this segment.

Table 1

Station 15113 - Guadalupe at Spllt Rock Road 02/2003 • 12/2016					
AU1806_02GeneralUse					
Parameter	**Mean**	**Maximum**	**Minimum**	**#of Measurments**	**Screening Criteria**
Temperature ('CJ	**21.8**	**30.0**	**9.8**	**65**	**32.20**
pH(S.U. J	**8.1**	**8.5**	**7.6**	64	**6.5- 9.0**
Chlorlde	**26.4**	**45.1**	**17.6**	**55**	**50.00**
SuHate	**17.1**	**23.8**	**10.8**	55	**50.00**
Total DISSOived Sollds (mg/l)	**316**	**378**	**268**	64	**400.00**
NH3·N (mg/l)	**N/A**	N/A	N/A	N/A	0.33
Total Phosphorus (mg/l)	<0.04	0.08	<0.04	55	0.69
Chlorophyll-a (pg/l)	<1.0	13.3	<1.0	54	14.10
Nitrate Nitrogen (mg/l)	0.63	1.4	<0.04	52	1.95
TKN (mg/l)	0.41	0.71	<0.2	21	N/A
AU 1806_02 Recreatlonal Use					
Ec o//(MPN/ 100ml)	23Geomean	120	<1	54	126Geomean
AU 1806_02 Aquatic Llie Use					
Dlssolved Oxygen	9.5	14.2	5.5	64	i!:4.0 Minimum & i!:6.0 Average

Table2

Station 12615 - Guadalupe at Center Point 02/2003 - 12/2016					
AU 1806_02 General Use					
Parameter	Mean	Maximum	Minimum	#of Measurments	Screening Criteria
Temperature (' CJ	21.7	31.5	9.1	73	32.20
pH(S.U.J	8.0	8.4	6.6	73	6.5-9.0
Chlorlde	26.2	45.6	16.0	55	50.00
SuHate	22.5	32.0	14.9	55	50.00
Total DISSOived Sollds (mg/l)	322	385	267	73	400.00
NH3·N (mg/l)	N/A	N/A	**N/A**	**N/A**	0.33
Total Phosphorus (mg/l)	<0.04	0.15	<0.04	55	0.69
Chlorophyll-a (pg/l)	<1.0	6.6	<1.0	54	14.10
Nitrate Nitrogen (mg/l)	0.57	1.48	<0.05	52	1.95
TKN (mg/l)	0.35	0.59	<0.2	20	**N/A**
AU 1806_02 Recreatlonal Use					
İc.o//(MPN/ 100ml)	62Geomean	3500	5	144	126Geomean
AU 1806_02 Aquatic Llie Use					
Dlssolved Oxygen	8.5	8.4	6.6	73	i!:4.0 Minimum & i!:6.0 Average

GUADALUPE RIVER BELOW FLAT ROCK DAM

Table3

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

Table5

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

Table4

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

Table&

Station 13700 - Guadalupe at FM 311In Spring Branch Data from 12/2002 • 11/2016					
AU 1806_01General Use					
Parameter	Mean	Maximum	Minimum	#of Measurments	ScreeningCriteria
Temperature ('Cl	20.8	33.0	5.3	161	32.20
pH(S.U.)	8.0	8.5	7.5	161	6.5-9.0
Chloride	21.9	35.6	9.1	161	50.00
SuHate	24.1	33.9	12.5	161	50.00
Total DISSOlved Solids (mg/l)	339	644	275	161	400.00
NH3-N (mg/l)	<0.10	0.95	<0.10	80	0.33
Total Phosphorus (mg/l)	<0.02	0.28	<0.02	161	0.69
Chlorophyll-a (pg/l)	<1.0	6.2	<1.0	159	14.10
Nitrate Nitrogen (mg/l)	0.36	1.78	<0.02	159	1.95
TKN (mg/l)	<0.2	0.95	<0.2	63	N/A
AU 1806_01 Recreational Use					
Ec.o/i(MPN/ 100ml)	64Geomean	>2400	<2	161	126Geomean
AU 1806_01 Aquatic Llie Use					
Dissolved Oxygen	9.5	14.9	5.2	160	Il:4.0 Minimum & Il:6.0 Average

34

GUADALUPE RIVER BELOW FLAT ROCK DAM

Figure 7

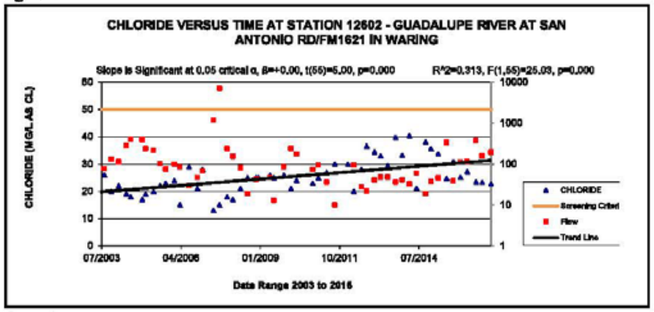


Figure 8

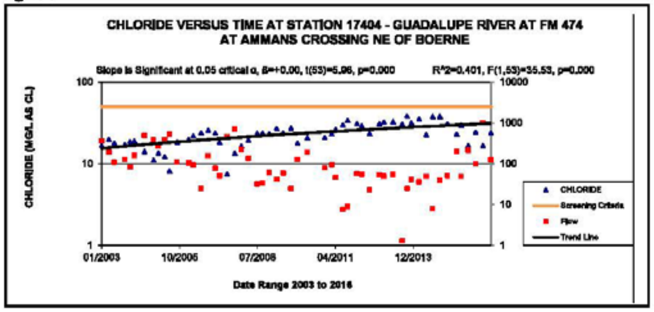


Figure 9

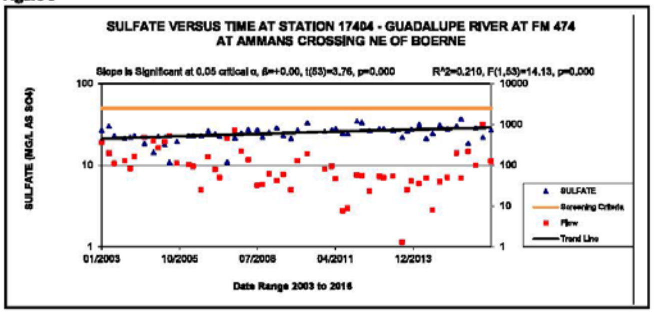


Figure 10

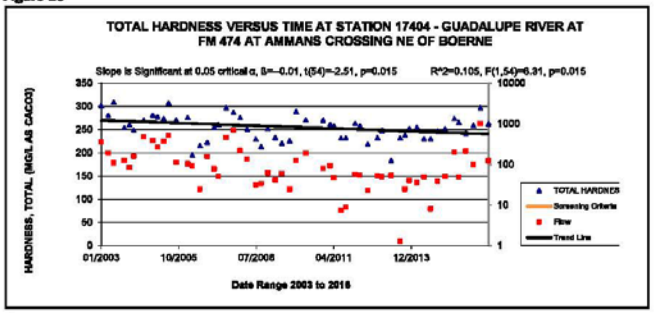


Figure 11

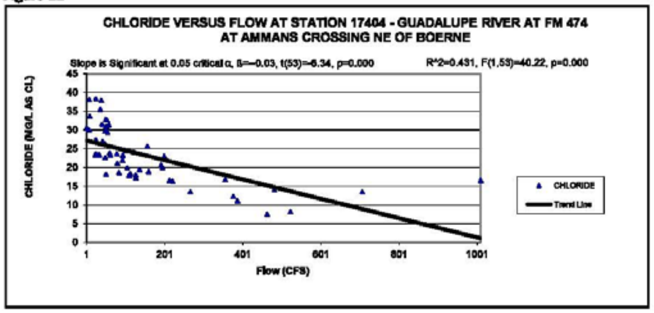
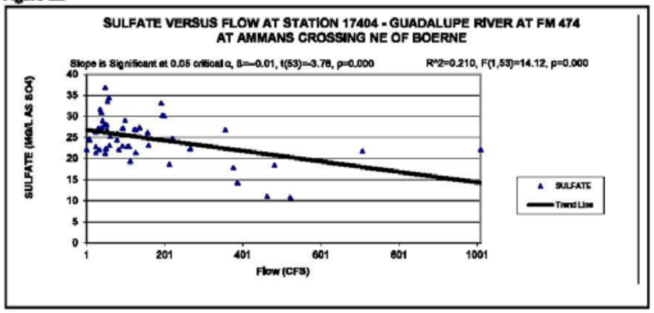


Figure 12



GUADALUPE RIVER BELOW FLAT ROCK DAM

Figure 13

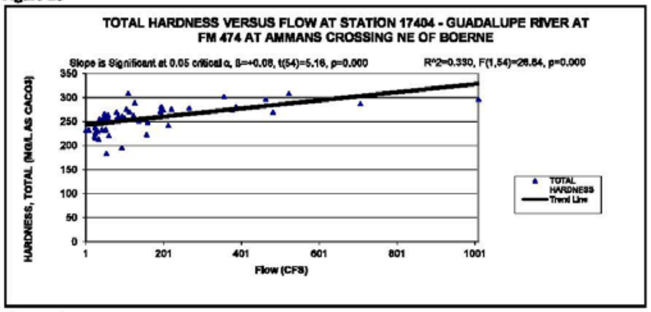


Figure 14

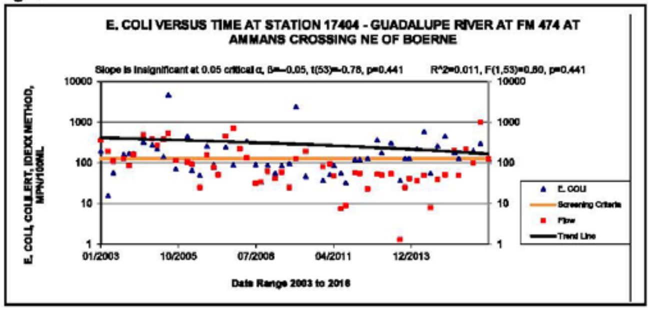


Figure 15

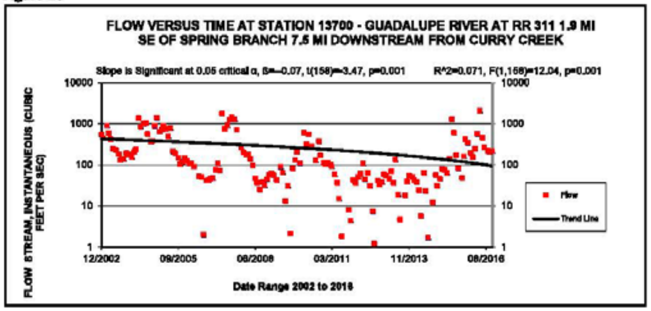


Figure 16

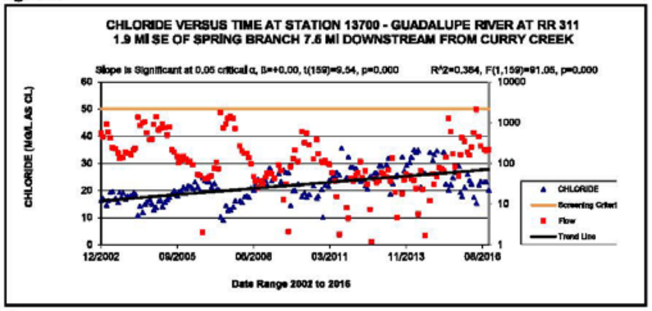


Figure 17

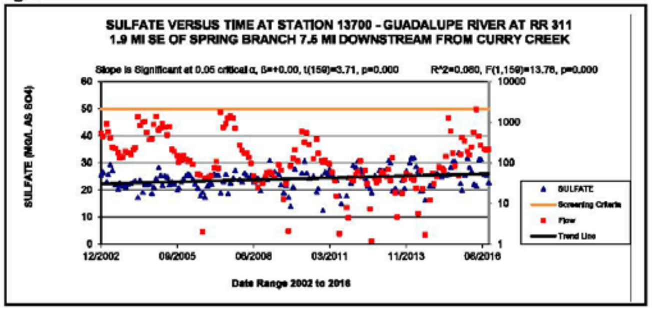
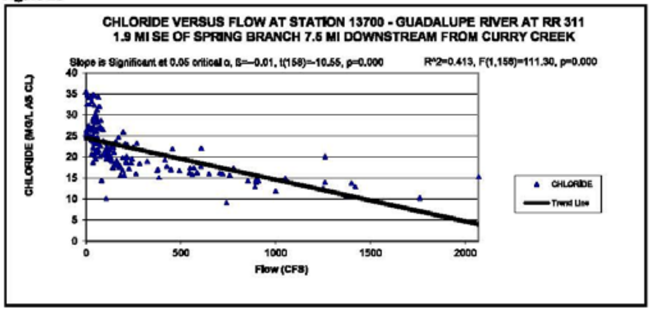
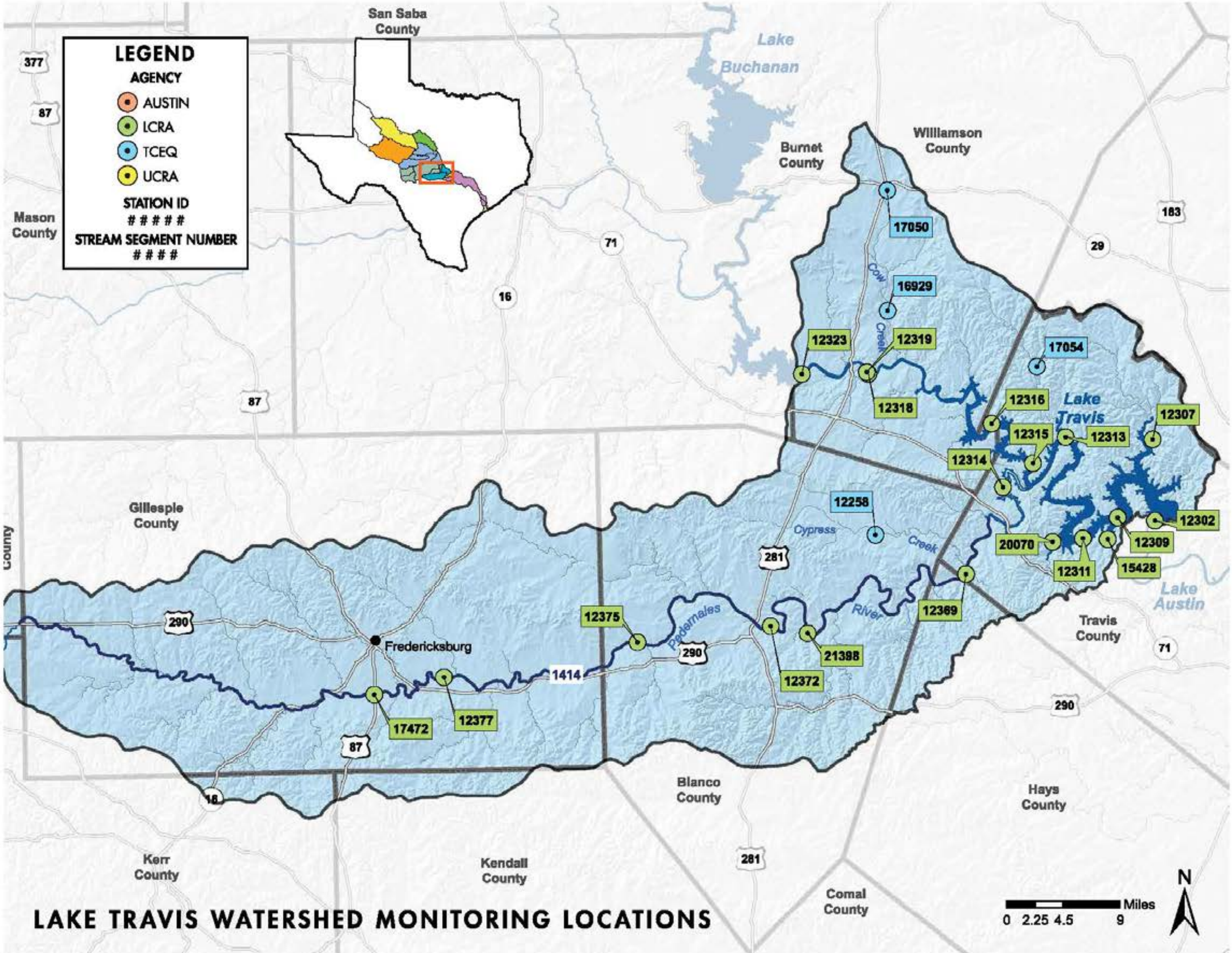


Figure 18



37


LEGEND
AGENCY
AUSTIN
LCRA
TCEQ
UCRA
STATION ID
# # # # #
STREAM SEGMENT NUMBER
# # # #
LAKE TRAVIS WATERSHED MONITORING LOCATIONS
San Saba County
Lake Buchanan
Burnet County
Williamson County
Mason County
Gillespie County
Blanco County
Kerr County
Kendall County
Comal County
Hays County
Travis County
Lake Travis
Lake Austin
Fredericksburg
Cow Creek
Cypress Creek
Pedernales River
1414
17050
16929
12323
12319
12318
17054
12316
12315
12313
12307
12314
12258
12302
12309
20070
12311
15428
12369
12375
12372
21388
17472
12377
Miles
0 2.25 4.5 9
N

LAKE TRAVIS WATERSHED

Twenty stations in the Lake Travis Watershed were monitored from 2006 to 2016.

Segment 1404 – Lake Travis
Segment 1405 – Lake Marble Falls
Segment 1414 – Pedernales River
Segment 1414B – Cypress Creek

Watershed Characteristics

Located in the Texas Hill Country, the Lake Travis watershed, including the Pedernales River and lakes Travis and Marble Falls, is approximately 1,830 square miles. The watershed lies within the Edwards Plateau, a region distinguished by rocky terrain and clear perennial streams. Growth and development have dramatically changed the landscape in the region over the past 20 years.

Lack of rainfall since 2008 lowered Lake Travis to levels not seen since the drought of record during the 1950s. Inflows to the Highland Lakes in 2013 were the second lowest on record; 2011 and 2008 were first and third, respectively. Lake Travis and other Central Texas lakes began to fill as a result of floods and increased rainfall in the region late in 2015 and into 2016.

Lake Travis

SEGMENT SUMMARIES

Segment 1404 – Lake Travis

Mansfield Dam impounds Lake Travis on the Colorado and Pedernales rivers in western Travis County. The reservoir, which is about 18,929 surface acres, originally was designed to contain floodwaters. It is one of the clearest reservoirs in Texas and is a popular recreation destination.

Monitoring data from stations near Lakeway indicate a concern for low dissolved oxygen. First noted in the TCEQ 2010 Integrated Report, it is likely a result of lake mixing – a natural phenomenon that can cause dissolved oxygen levels to temporarily drop as cold, oxygen-depleted water rises from the bottom and mixes into the water column.

Trend analysis on Lake Travis showed an increase in salts in five of the nine water monitoring stations on Lake Travis. Chloride, sulfate or TDS concentrations trended higher at stations 20070, 12313, 15428, 12307 and 12302. The trend is a function of low lake levels during the drought as demonstrated by the decreasing values after significant rains raised lake levels in 2015 at Station 15428 (Figure 69). Values for each of the salt parameters remain well below the criteria at all stations.

M - Meets water quality standard
C - Concern for water quality standard

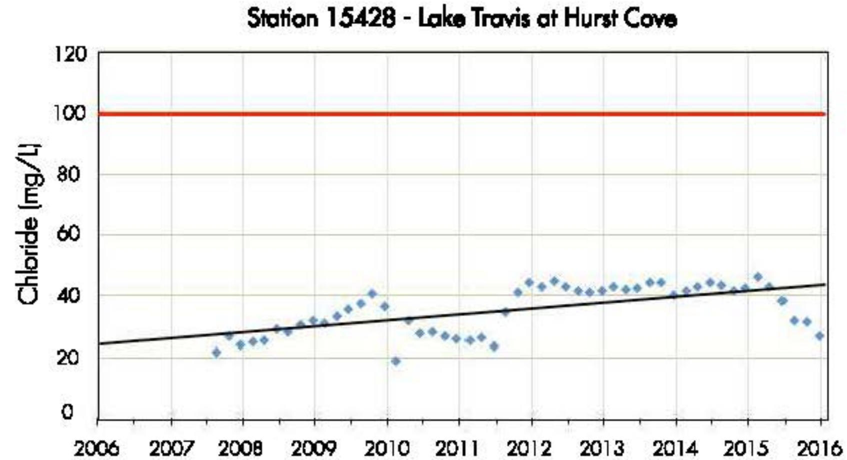


Figure 69. Chloride Trend / Lake Travis

	Aquatic Life		Recreation	General				
Station ID	Dissolved Oxygen	Biology	Bacteria	Temperature	pH	Salts	Nutrients	Chlorophyll
12302	M	-	M	M	M	M	M	M
12307	M	-	M	M	M	M	M	M
12309	C	-	M	M	M	M	M	M
12311	M	-	M	M	M	M	M	M
12313	M	-	M	M	M	M	M	M
12315	C	-	M	M	M	M	M	M
12316	M	-	M	M	M	M	M	M
15428	M	-	M	M	M	M	M	M
20070	C	-	M	M	M	M	M	M

Table 46. Summary of the 2014 Integrated Report / Llano River

80

Mansfield Dam at Lake Travis / 2016

Colorado River Environmental Models

Ongoing LCRA initiatives to protect the lake include the Highland Lakes Watershed Ordinance and the Colorado River Environmental Models (CREMS). The watershed ordinance (see LBJ Watershed Summary) manages nonpoint-source pollution around the lake, and CREMS is a modeling tool used to determine how various development scenarios impact water quality.

Stricter management of water supply and river flows, increasing pollution loads brought about by a growing population, and greater regulatory pressures all require sophisticated management and analysis of water data. CREMS is a system of integrated computer-based models and data sets developed to help LCRA manage the Highland Lakes and the lower Colorado River system. CREMS serves as part of a decision support system that facilitates decision-making for analyzing the water quality impacts of discharge permits, nutrient loading, stream and reservoir standards, water supply planning, implications or growth and development, and nonpoint-source pollution issues.

LCRA has used model outputs to help the cities of Burnet and Fredericksburg develop more protective discharge limits for their wastewater treatment plant and provided invaluable information that helped manage water supplies during the drought. LCRA will continue to develop the models as lake conditions change, and work with the Highland Lakes communities to develop reasonable treatment options that protect water quality. For more information on CREMS, visit **lcra.org/water/quality/water-quality-permit-review-program/pages/water-quality-models.aspx.**

Segment 1405 – Lake Marble Falls

Max Starcke Dam forms Lake Marble Falls on the Colorado River near the town of Marble Falls. With a surface area of 545 acres, it is the smallest reservoir in the chain of Highland Lakes.

All water quality standards were attained and no statistically significant trends were found for Lake Marble Falls.

M - Meets water quality standard

Lake Marble Falls

	Aquatic Life		Recreation	General				
Station ID	Dissolved Oxygen	Biology	Bacteria	Temperature	pH	Salts	Nutrients	Chlorophyll
12319	M	-	M	M	M	M	M	M

Table 47. Summary of the 2014 Integrated Report / Segment 1405

Segment 1414 – Pedernales River

The headwaters of the Pedernales River are located near Harper in Kimble County. The river flows east through Fredericksburg, Stonewall and Johnson City before reaching the mouth of Lake Travis. It is approximately 125 miles long. In the upper reaches, it is intermittent. Occasional, intense thunderstorms over the watershed create heavy rainfall that dramatically increases flow in the river. These surges of water typically transport large amounts of silt and organic debris downstream and into Lake Travis.

M - Meets water quality standard

	Aquatic Life		Recreation	General				
Station ID	Dissolved Oxygen	Biology	Bacteria	Temperature	pH	Salts	Nutrients	Chlorophyll
12369	M	-	M	M	M	M	M	M
12372	M	-	M	M	M	M	M	M
12375	M	-	M	M	M	M	M	M
12377	M	-	M	M	M	M	M	M
17472	M	-	M	M	M	M	M	M
21398	M	-	M	M	M	M	M	M

Table 48. Summary of the 2014 Integrated Report / Pedernales River

Segment 1414 – Pedernales River (cont.)

Monitoring data collected from stations near Harper, Fredericksburg and Johnson City show the river meets all applicable water quality standards.

Trend analysis indicated a decrease in chloride (Figure 70), sulfate and TDS on the Pedernales River near Hammett's Crossing.

Monitoring data showed increasing bacteria levels at stations 17472 and 12375 (Figures 71 and 72). The cause of the trend is unknown, but the trend line indicates both stations are approaching the state criteria of 126 MPN. The trend may be drought-related.

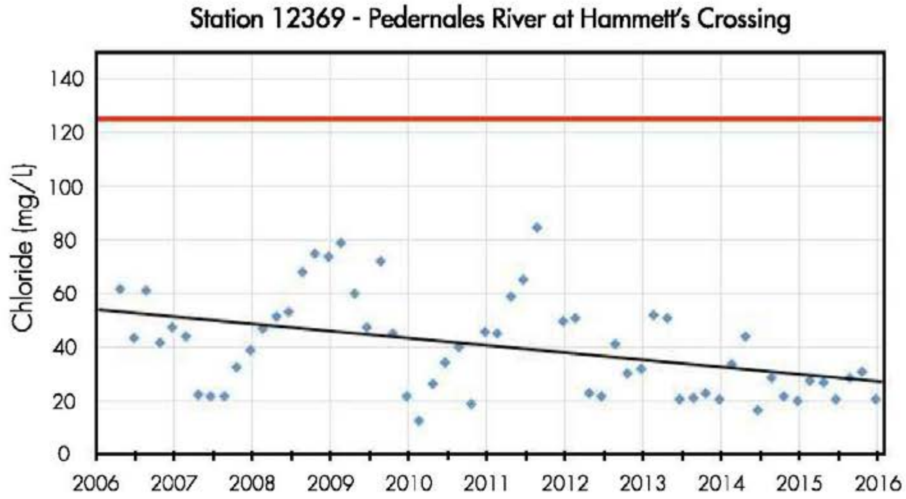


Figure 70. Chloride Trend / Pedernales River

Pedernales River in Blanco County

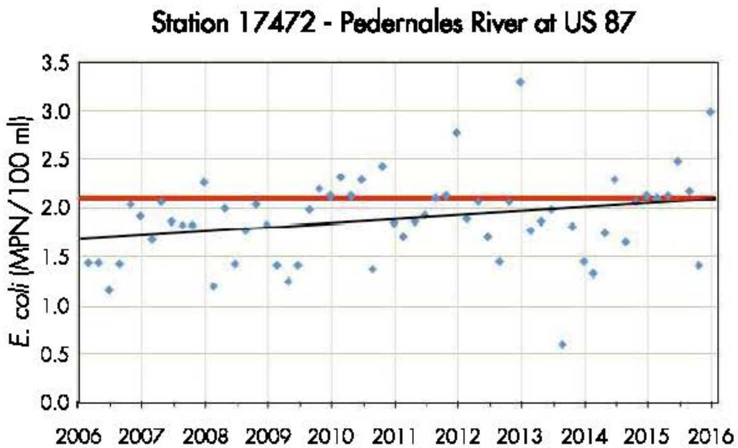


Figure 71. E. coli Trend / Pedernales River

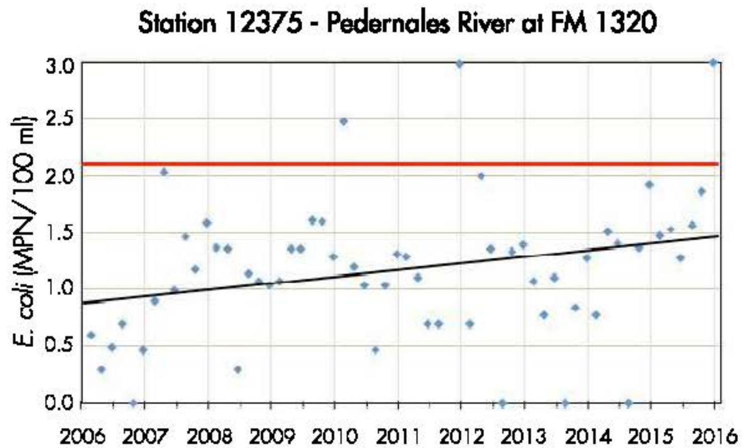


Figure 72. E. coli Trend / Pedernales River

Segment 1414B – Cypress Creek

Cypress Creek is a tributary of the Pedernales River near the confluence with Lake Travis. The stream is about 23 miles long, and historically has flowed year-round due to springs in the area. Intermittent flows have been recorded since the start of the drought in 2008. Water quality samples collected by the TCEQ from Station 12258 show the river meets all applicable water quality standards.

Bacteria levels have increased over time in Cypress Creek. Wildlife or livestock may be sources, but the reduced flow during the drought is a likely cause of the increasing trend. While the bacteria levels have not triggered an impairment, they are close to the state criteria, and they will exceed water quality standards if the trend continues over the next few years. TDS in Cypress Creek also increased. Despite the increase, TDS remains well below the criteria.

	Aquatic Life		Recreation	General				
Station ID	Dissolved Oxygen	Biology	Bacteria	Temperature	pH	Salts	Nutrients	Chlorophyll
12258	M	-	M	M	M	M	M	M

M - Meets water quality standard

Table 47. Summary of the 2014 Integrated Report / Cypress Creek

84

Station 12258 - Cypress Creek at FM 962

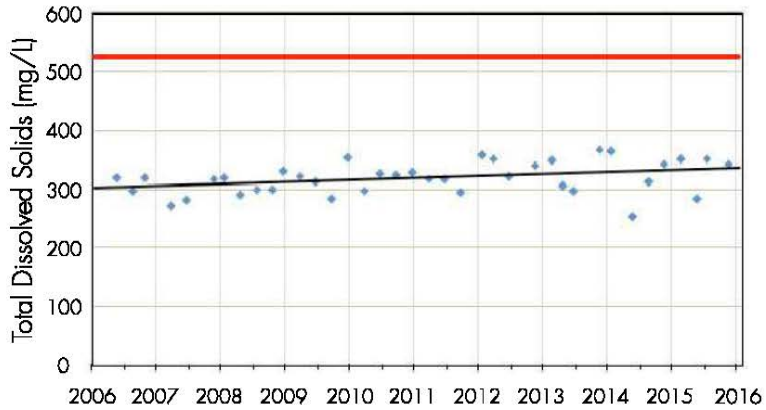


Figure 73. Total Dissolved Solids Trend / Cypress Creek

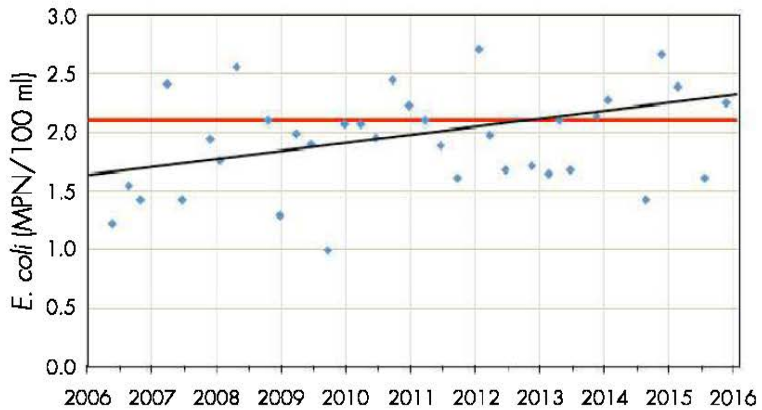


Figure 74. E. coli Trend / Cypress Creek

Cottonwood Hollows on Lake Travis

Future Challenges for the Lake Travis Watershed

- The continued surge in development around Lake Travis has the potential to increase runoff and nonpoint source pollution from impervious surfaces.
- Continued investigation of Increasing bacteria trend on the Pedernales River and Cypress Creek.

Exhibit 5G

Priority Parameter Descriptions (Example for the Basin Summary Report Section 3.3)

EXHIBIT 5G

Priority Parameter Definition Descriptions

Parameter	**Impact**	**Potential Causes**
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.
Conductivity	Conductivity is a measure of the water body's ability to conduct electricity and indicates the approximate levels of dissolved salts, such as chloride, sulfate and sodium 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).	Industrial and wastewater discharge, runoff from quarry operations and accidental spills.
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.	Modifications to the riparian zone, human activity that causes water temperatures to increase, increases in organic matter, bacteria and over abundant algae may cause DO levels to decrease.
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.
Secchi Disc	Transparency is a measure of the depth to which light is transmitted through the water column and thus the depth at which aquatic plants can grow.	Low secchi disc depth is an estimate of turbidity.

Parameter	Impact	Potential Causes
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.
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	Although fecal coliform bacteria may not themselves be harmful to human beings, their presence is an indicator of recent fecal matter contamination	Present naturally in the digestive system of all warm blooded animals, these bacteria are in all surface waters. Poorly

Parameter	Impact	Potential Causes
(E coli) or Enterococci	and that other pathogens dangerous to human beings may be present.	maintained or ineffective septic systems, overflow of domestic sewage or non-point 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 run-off, certain industrial wastewaters and runoff from animal feedlots.
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 can cover instream habitat, smother benthic organisms and eggs.	Excessive TSS is the result of accelerated erosion and is often associated with high flows where river banks are cut or sediment is suspended. 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, 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 chlorophyll can cause algae blooms, decrease water clarity and cause swings in dissolved oxygen level due to photosynthesis. Most commonly measured as chlorophyll a.	Algal blooms can result in elevated chlorophyll-a levels indicating an increase in nutrients that increase growth and reproduction in algal species.