HOW'S THE WATER?

2024 BASIN HIGHLIGHTS REPORT FOR THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Houston-Galveston Area Council
Clean Rivers Program

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The StoryMap version of this report can be found here:
https://storymaps.arcgis.com/stories/cb07286ad40b4f11afff963f37f38692

INTRODUCTION

The Houston-Galveston region is rich in water resources, with more than 16,000 miles of streams and shoreline that feed into one of the most productive estuaries in the United States, providing the region with a wealth of ecological, economic, and recreational assets. These water resources are shared among 7.2 million people for recreation, commercial fishing, shipping, and other industrial uses. With another 3 million people expected to move to the area over the next 20 years, the strain on these water resources will increase.

The Houston-Galveston Area Council (H-GAC) Clean Rivers Program (Clean Rivers Program | Houston-Galveston Area Council (H-GAC)) conducts water quality monitoring and assessment to determine the health of water bodies throughout the region. H-GAC does this through a coordinated effort with local partners and the Texas Commission on Environmental Quality (TCEQ). Along with analysis of this monitoring data, H-GAC assesses factors and activities impacting water quality. Information and recommendations on what individuals, industry, and local governments can do to make improvements and preserve local water bodies now and in the future are provided through public education and outreach organized by H-GAC. Clean Rivers Program data provides support for all watershed-based planning activities in the region.

Improving water quality requires more than the efforts of just one person or group of people. Progress is made when many stakeholder groups work together to manage water quality. The H-GAC Clean Rivers Program continues to coordinate the work of multiple stakeholder groups resulting in positive effects on water quality in the region.

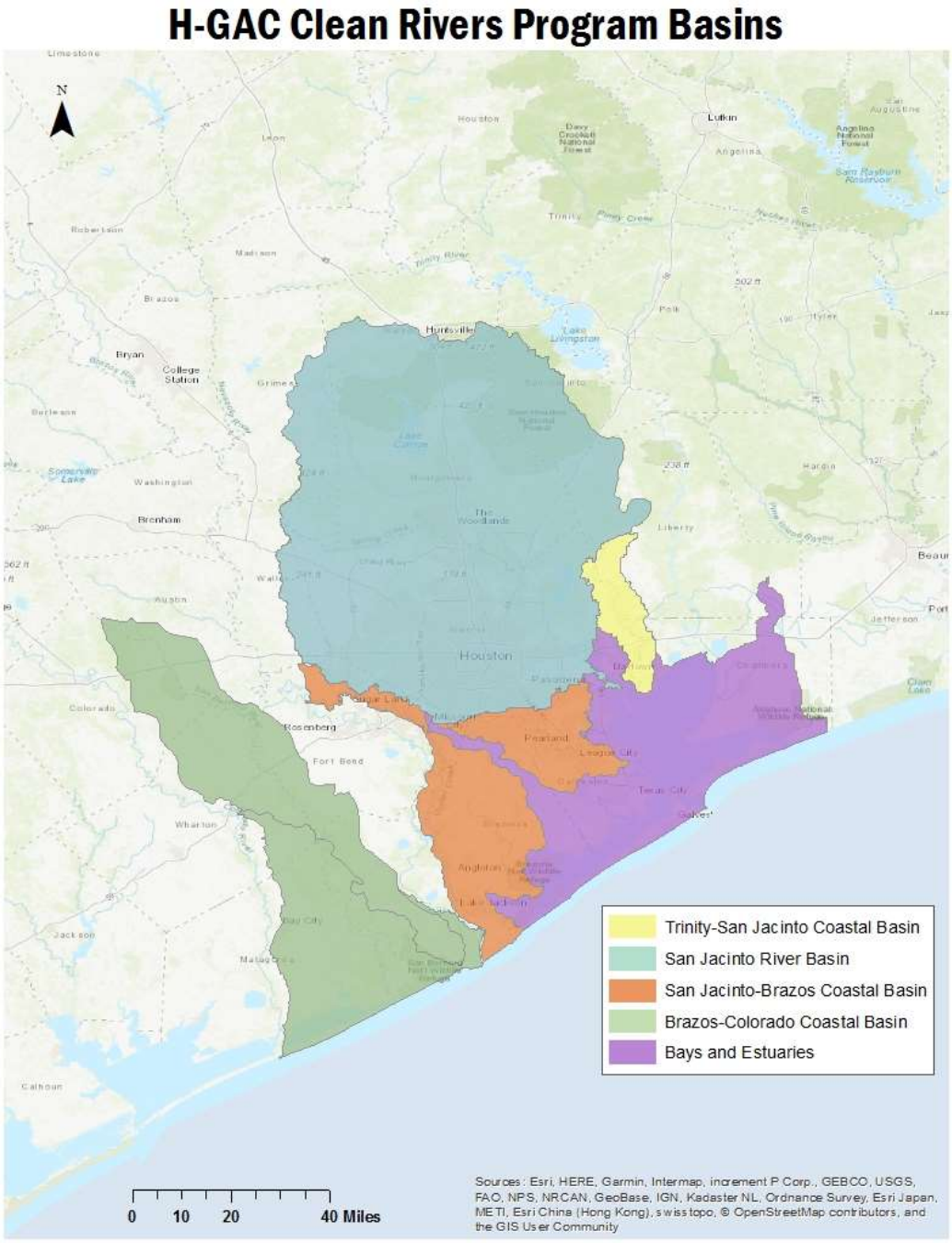
Five appendices are provided to help readers understand the complexities involved in conducting data analyses on area water bodies.

CLEAN RIVERS PROGRAM OVERVIEW

The H-GAC Clean Rivers Program is considered a model program throughout the state, thanks in large part to its coordinated approach to water quality monitoring. The H-GAC Clean Rivers Program facilitates water quality discussions with decision-makers and water quality partner agencies in the region through the Clean Rivers Program Steering Committee and the Regional Monitoring Workgroup and conducts ambient water quality monitoring, 24-hour dissolved oxygen monitoring, and targeted bacteria monitoring.

The H-GAC Clean Rivers Program covers all or a portion of 15 counties (Austin, Brazoria, Chambers, Colorado, Fort Bend, Galveston, Grimes, Harris, Liberty, Matagorda,

Montgomery, San Jacinto, Walker, Waller, and Wharton), four basins (Brazos-Colorado Coastal Basin, San Jacinto River Basin, the San Jacinto-Brazos Coastal Basin, and Trinity-San Jacinto Coastal Basin), and Bays and Estuaries.



Map 1: H-GAC Clean Rivers Program Basins

Map 2: TCEQ Assessment Units in H-GAC's Clean Rivers Program Basins.

The H-GAC Clean Rivers Program provides baseline data for many water quality studies and projects within the 15-county monitoring area at more than 400 sampling sites collected by H-GAC and six local partners:

- City of Houston Health Department
- City of Houston Drinking Water Operations
- Environmental Institute of Houston (University of Houston-Clear Lake)
- Harris County Pollution Control Services
- San Jacinto River Authority (Lake Conroe and The Woodlands Divisions)
- Texas Research Institute for Environmental Studies (Sam Houston State University)

Other agencies contributing data used by the Clean Rivers Program include:

- Texas Commission on Environmental Quality
- United States Geological Survey (flow gage data)

H-GAC's FY2024 Regional Coordinated Monitoring Stations

Map 3: Map of H-GAC's FY2024 Monitoring Stations.

Clean Rivers Program Steering Committee

The H-GAC Clean Rivers Program Steering Committee (Clean Rivers Program Committees | Houston-Galveston Area Council (H-GAC)) serves as the primary forum for discussion of various water quality issues raised through the assessment process. The committee advises staff on all administrative matters related to the Clean Rivers Program, including work plan and budget development, monitoring of progress toward project milestones, and review of the draft and final basin reports and other work items.

In 2023, the Steering Committee (Clean Rivers Program Committees | Houston-Galveston Area Council (H-GAC)) discussed key components of the Clean Rivers Program, including

- draft and final review of 2023 Basin Highlights Report;
- proposed changes to fiscal year 2024 regional coordinated monitoring schedule;
- updates on watershed protection plans and total maximum daily loads /implementation plans using Clean Rivers Program data; and
- public outreach activities for 2023.

Ambient Water Quality Monitoring Program and Regional Monitoring Workgroup

The Regional Monitoring Workgroup (Clean Rivers Program Committees | Houston-Galveston Area Council (H-GAC)), composed of field and laboratory staff from each of the local Clean Rivers Program partner agencies, meets quarterly to provide updates on individual monitoring programs, discuss quality assurance issues, and discuss solutions to common problems found in field and/or laboratory settings.

Each spring, the workgroup holds a coordinated monitoring meeting to discuss data gaps and set the monitoring schedule for the coming fiscal year. Changes in the schedule are determined using data analysis, recommendations of field or laboratory personnel, and recommendations or requests related to the needs of ongoing total maximum daily load implementation plans, watershed protection plans, TCEQ permitting, or changes to budgets.

All monitoring is conducted under a TCEQ-approved Multi-Basin Quality Assurance Project Plan (Multi-Basin Quality Assurance Project Plan | Houston-Galveston Area Council (H-GAC)). All laboratories used by Clean Rivers Program participants are accredited through the National Environmental Laboratory Accreditation Program (NELAP).

24-Hour Dissolved Oxygen Monitoring

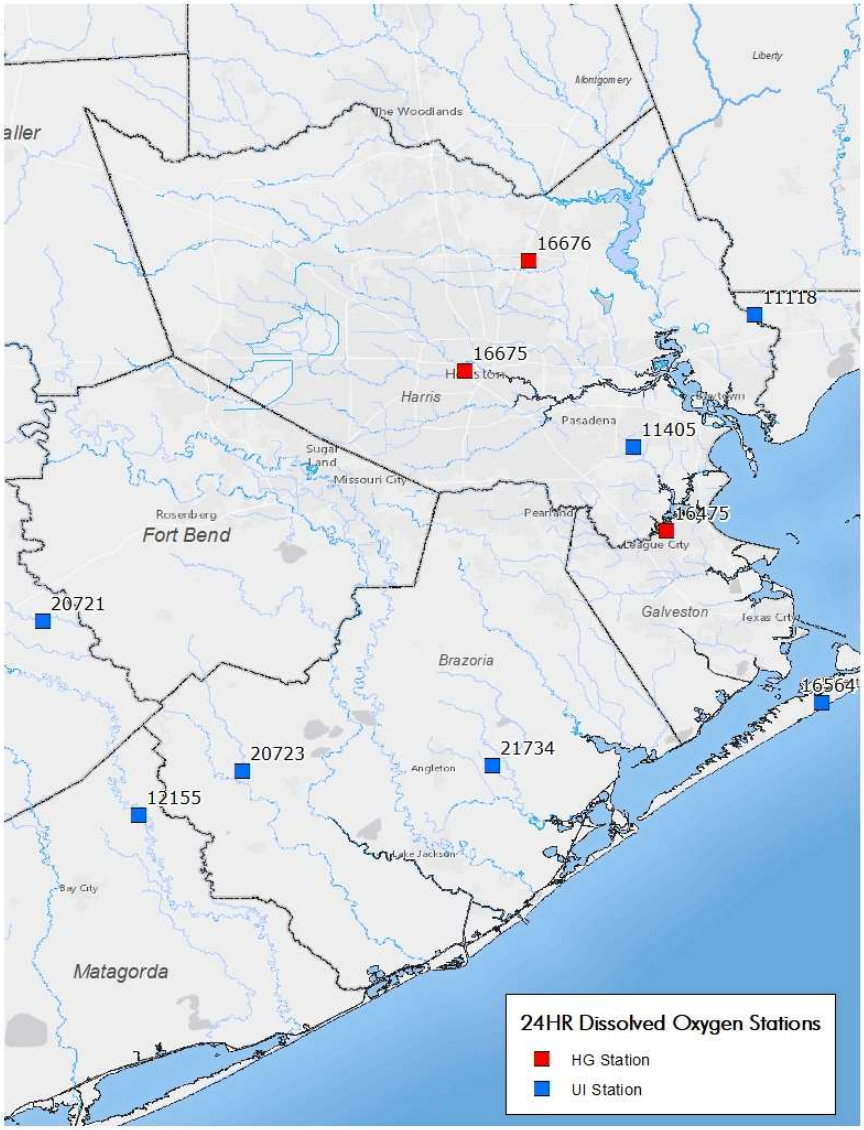
TCEQ established aquatic life use designations for all segments and many tributaries in the state. These designations (exceptional, high, intermediate, limited, and minimal) are based on established numerical criteria and are highly dependent on the desired use of the water body, the sensitivities of aquatic communities expected to be found in those

water bodies, and the local physical and chemical characteristics of the water bodies. One criterion used to evaluate aquatic life use is dissolved oxygen, which includes a 24-hour minimum and a 24-hour average. Routine monitoring generally collects dissolved oxygen grab samples only, which may identify concerns and impairments. Impairments must be verified through deployment of multi-parameter data sondes to determine current 24-hour minimums and averages.

H-GAC, with the help of the Environmental Institute of Houston at the University of Houston Clear Lake (EIH), conducts 24-hour dissolved oxygen monitoring to verify or determine the extent of the dissolved oxygen concern or impairment of 10 segments or tributaries. In FY2024, monitoring is being conducted at the following sites:

11118 – Cedar Bayou Above Tidal downstream of FM 1942 (segment 0902)
11405 – Armand Bayou at Fairmont Parkway, Pasadena (segment 1113A)
12155 – Caney Creek Above Tidal downstream of Ashwood Rd/FM 3156 (segment 1305)
16475 – Robinsons Bayou at FM 270 in League City (segment 1101D)
16564 – Lake Madeline in Galveston (segment 2424B)
16675 – Unnamed Tributary of Buffalo Bayou at Glenwood Cemetery Rd in central Houston (segment 1013C). Site was dropped partway through FY2024 due to safety after construction altered the banks and channel.
16676 – Unnamed Tributary of Greens Bayou at Smith Rd, Houston (segment 1016D)
20721 – West Bernard Creek at Wharton CR 225 east of Hungerford (segment 1302B)
20723 – Mound Creek at Brazoria CR 450/Jackson Settlement Rd near West Columbia (segment 1302E)
21734 – Brushy Bayou at FM 213 in Brazoria County (segment 1105E)

Monitoring of Robinsons Bayou, an Unnamed Tributary of Buffalo Bayou, an Unnamed Tributary of Greens Bayou, Armand Bayou, and Brushy Bayou are carry-over 24-hour dissolved oxygen monitoring sites from FY2023. Additional data are needed for TCEQ to determine whether these segments are supporting or not supporting their aquatic life use designations.



Map 4: H-GAC 24-hour dissolved oxygen stations being monitored in FY2024.

Targeted Monitoring Bacteria

In 2021 and 2023, H-GAC contracted with the EIH and the Texas Research Institute for Environmental Studies (TRIES) at Sam Houston State University to conduct investigations of numerous assessment units (AUs) looking for contaminated dry-weather flows. This Targeted Bacteria Monitoring Project focuses on the region's most prevalent pollutant – bacteria. The Bacteria Implementation Group (BIG) requested H-GAC produce a list of water bodies with the highest bacteria concentrations in the BIG project area to help identify bacteria (*E. coli*) sources within the H-GAC region. H-GAC performed a seven-year geometric mean analysis defining the severity of impairment of each AU within the region. As part of this project, H-GAC staff identified 12 AUs for field investigation. The AUs were selected by reviewing the highest geomeans identified. Staff then completed

an assessment of accessibility of each AU and the feasibility of being able to effectively conduct monitoring of the AU. Funding for the Targeted Bacteria Monitoring Project was provided by the Clean Rivers Program and the Total Daily Maximum Load (TMDL) Program.

Table 1. Assessment units (AUs) selected for investigation.

AU ID	AU Name	Bacteria Geomean (MPN/100 mL)	AU Length (miles)	Funding Source for Investigation
1004J_01	White Oak Creek (Conroe)	2981	2.79	TMDL Program
1007T_01	Bintliff Ditch	5969	3.90	Clean Rivers Program
1007U_01	Mimosa Ditch	1457	1.90	Clean Rivers Program
1014O_01	Spring Branch (Buffalo Bayou tributary)	1206	4.30	Clean Rivers Program
1016C_01	Unnamed Tributary of Greens Bayou	2023	5.64	TMDL Program
1016D_01	Unnamed Tributary of Greens Bayou	1536	3.30	TMDL Program
1017_03	White Oak Bayou Above Tidal	1625	1.63	Clean Rivers Program
1017A_01	Brickhouse Gully	1406	6.43	Clean Rivers Program
1017B_01	Cole Creek	1602	4.08	Clean Rivers Program
1017D_01	Unnamed Tributary of White Oak Bayou	1226	1.84	Clean Rivers Program
1017E_01	Unnamed Tributary of White Oak Bayou	2288	1.93	Clean Rivers Program
1101D_01	Robinson Bayou Tidal/Above Tidal	305 (enterococcus)	1.41	Clean Rivers Program

H-GAC and its subcontractors, EIH and TRIES, first conducted a windshield survey on each watershed. This survey served as a spatial assessment of the watershed and determined where hotspots of high bacteria concentrations existed along the water body and its tributaries. During the windshield survey, the field crew collected bacteria samples at easily accessible locations, such as major road crossings and public access points adjacent to the water body. Results from the survey aided in prioritizing intensive field investigations along the water body and tributaries of concern leading into the

main segment. Both survey events (windshield survey and field investigation) were only conducted during dry weather following a 72-hour antecedent dry period.

For the field investigation, samples were collected upstream and downstream of any outfall categorized as permitted or >12 inches in diameter and the difference in results was compared, but samples were not collected directly from the outfall source. Any outfall that was judged to be "unpermitted" in the field was sampled directly at the source. All tributary samples were collected far enough into the flowing water so that mixing was not a factor. In instances where no potential sources were observed for an extended section of the water body, a single ambient reference sample was taken mid-stream.

The team created reports for each AU detailing methods and findings. In total, 108 samples were collected in all windshield surveys, 587 samples were collected within the field investigations, and 109 sites were referred to the proper authorities. In addition to referrals for specific outfalls, some referrals included areas where high bacteria levels were found in ambient samples without any flows observed from nearby potential sources. Individual reports detailing methods and findings are available on H-GAC's website at https://www.h-gac.com/getmedia/c480c536-d024-440e-b7a5-7b01552d7e2a/Targeted-Bacteria-Monitoring-Project-FY2022-2023

So, How's the Water? (Water Quality Overview)

The Houston-Galveston region supports a population of more than 7 million residents and includes the fourth-largest city and third-most populous county in the nation. This concentration of people can place significant strain on the surface water quality in the region.

Water Quality Trends

H-GAC Clean Rivers Program staff summarized water quality in the major watersheds of the region by calculating the percentage of the streams and shoreline miles, of both classified and unclassified water bodies, in the watershed where water quality impairments or concerns were identified by TCEQ in the 2022 Texas Integrated Report of Surface Water Quality (https://www.tceq.texas.gov/waterquality/assessment/22twqi/22txir). The Integrated Report evaluates the quality of surface water in Texas and is used as a tool to make decisions about water quality programs across the state. Water bodies are assigned to categories based on how well they meet the standards established to define and

measure their quality. Water bodies can be designated as *impaired* by not meeting the standards or *of concern*, meaning they may not meet the standard in the future or a standard does not yet exist.

More than 89 percent of water body, stream or shoreline miles in the H-GAC Clean Rivers Program basins have a concern for or fail to meet one or more state water quality standards. The most common water quality indicators for the state water quality standards are bacteria, dissolved oxygen, and PCBs/dioxin. There are no water quality standards for nutrients (forms of phosphorus, ammonia, and nitrogen), but excessive concentrations are considered concerns.

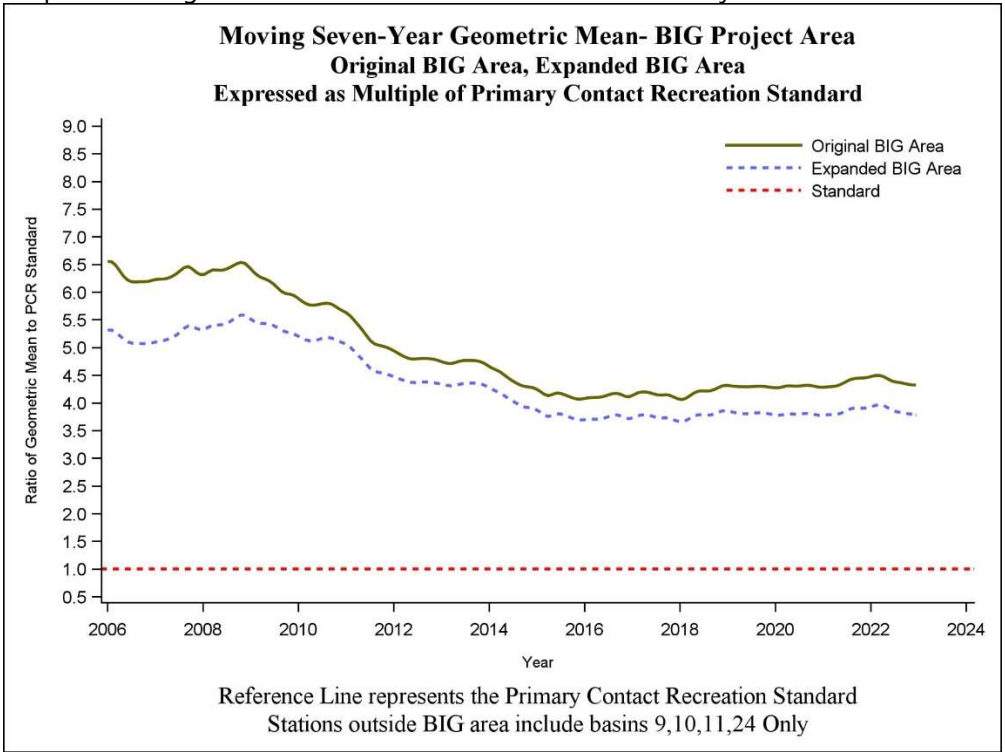
Staff identified trends for the major water quality indicators in each watershed and included these in the 2024 Regional Water Quality Summary Chart (locally referred to as the Frog Chart), analyzing data collected from December 31, 2015, through December 31, 2022. Data from the most downstream station identified as being statistically representative within a classified segment and all available data in the bays and estuaries were analyzed. The bacteria geomean trend was calculated using the same seven-year period. Clean Rivers Program staff used nonparametric correlation analysis to detect trends. Trends were considered statistically significant if the p-value was below 0.05.

Trends identified include the following:

- The good news is even though most of the region's water bodies do not meet one or more state water quality standards, about 56 percent have not seen further deterioration.
- Eighteen percent of segments have shown improvement in bacteria levels with five percent of segments deteriorating over the seven-year period H-GAC selected for analysis.
- Areas in the Bacteria Implementation Group (BIG) implementation plan, which provides recommendations for bacteria reduction in the greater Houston area, have experienced a significant reduction in bacteria levels since 2005. The BIG, due to new TMDLs completed for the East and West Fork of the San Jacinto River, Armand Bayou, and Jarbo Bayou, and at the request of those watershed stakeholders, expanded to include those watersheds within the BIG. Members of the BIG requested that bacteria geometric mean trends continue to express the original area and the original area plus the expanded area trend lines.
- Two percent of segments have shown improvement in dissolved oxygen levels over the seven-year assessment period. Eleven percent of segments are getting worse.

- Thirty-three percent of segments have shown improvement in nutrient levels over the seven-year assessment period. Just 22 percent have shown deterioration in nutrient levels. Trend analysis for nutrients was done for each nutrient parameter, but the reported trends are a composite of the nutrients analyzed. The segment summaries identify which nutrient parameters are of concern for those water bodies.

Graph 1: Moving Seven-Year Geometric Mean for the BIG Project Area



Improved water quality in the region may be attributed to several factors, including

- increased investigations of wastewater collection systems and resulting line repairs and facility improvements;
- improved regulation and maintenance of on-site sewage and wastewater treatment facilities;
- increased preservation of natural habitat and installation of water quality features in detention basins; and
- heightened public awareness and public participation.

Bacteria

Forty-four percent of stream miles in the Houston-Galveston region are affected by high levels of bacteria and are listed as impaired or of concern for contact recreational use.

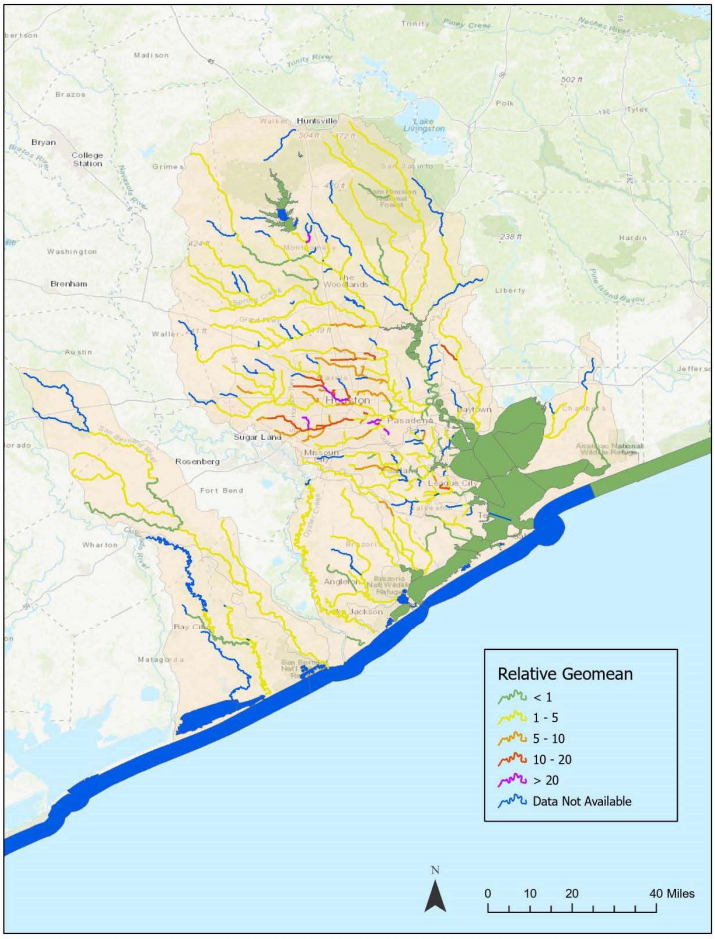
High bacteria concentrations can cause swimmers or waders who come into contact with the water to suffer from skin infections or mild to severe gastrointestinal illness. No bays are impaired for enterococci bacteria but may be impaired for oyster harvesting due to elevated concentrations of fecal coliform bacteria.

Bacteria concentrations are measured to ensure a water body is safe for recreation. Enterococci is collected in tidal water bodies, while *E. coli* is collected in freshwater. Both are found in the digestive tracts of people and animals and are used as indicators of the presence of sewage and pathogens (such as infectious bacteria, viruses, and protozoans).

TCEQ evaluates the results of bacteria testing to determine whether a water body is safe for contact recreational activities like swimming. A type of average called a *geometric mean* is calculated for a seven-year period. If the geometric mean is higher than the water quality standard, the water body may be considered impaired for contact recreation activities. H-GAC uses a moving seven-year bacteria geometric mean to show the change in bacteria levels in the region. Bacteria relative geomeans show the magnitude of impairments for water bodies, meaning how many times above the state standard the bacteria concentrations are, on average over the seven-year period. Because two different types of indicator bacteria with different water quality standard levels are analyzed, H-GAC standardizes the results so both can be displayed on the same graph. The moving geometric mean for all H-GAC Clean Rivers Program monitoring stations is above the standard; however, despite an increase in population and other pressures, bacteria levels have remained stable.

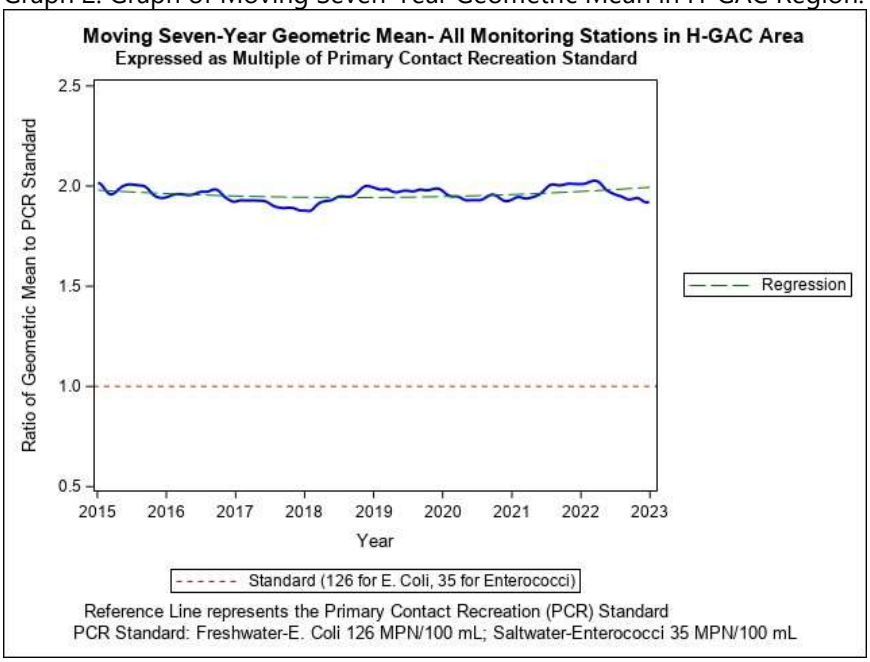
Sources of bacterial contamination include

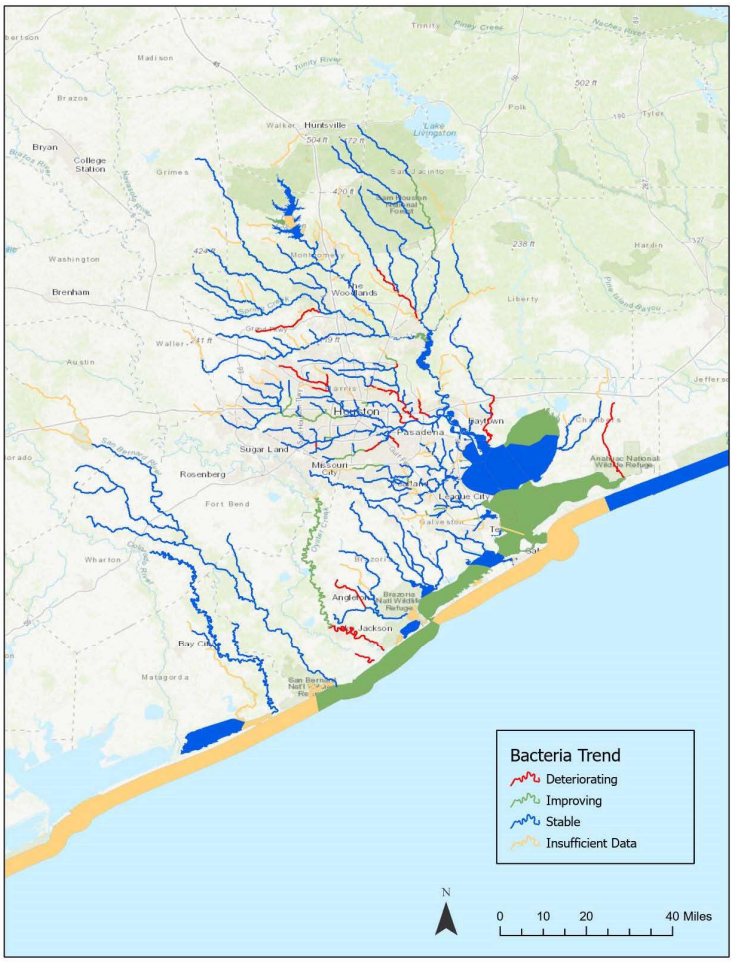
- Sanitary sewer overflows
- Untreated wastewater treatment facility (WWTF) releases
- Failing on-site sewage facilities (septic systems)
- Fecal waste from livestock, pets, feral hogs, and wildlife



Map 5: Relative Bacteria Geomean Map for Waterways in H-GAC Region

Graph 2: Graph of Moving Seven-Year Geometric Mean in H-GAC Region.





Map 6: Map of Bacteria Trends in the H-GAC Basins.

Dissolved Oxygen

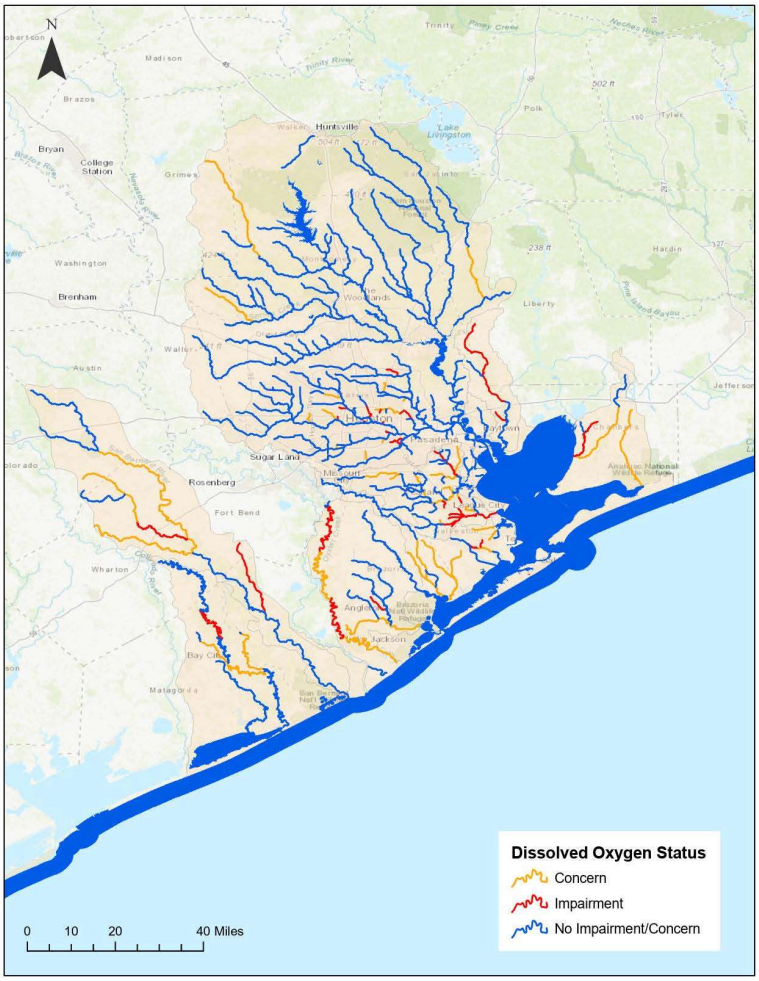
Seventeen percent of stream miles in the region are affected by low levels of dissolved oxygen (DO). Oxygen depletion in water bodies can create uninhabitable environments for fish and other aquatic life crucial to the region's economy.

DO levels are measured to ensure a water body can support aquatic life. Higher levels of DO can contribute to more abundant and diverse aquatic species. DO levels fluctuate naturally based on season, time of day, and human influences. Sudden or prolonged decreases in DO could result in fish kills.

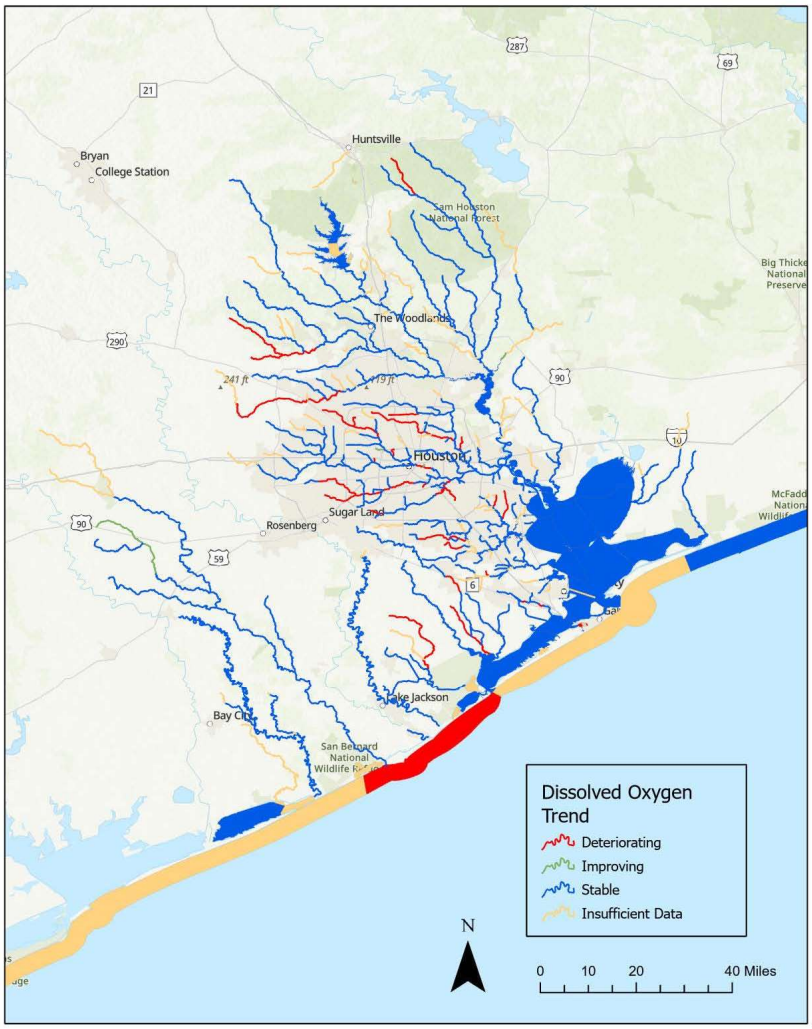
Dissolved oxygen can be negatively impacted by

- high concentrations of nutrients causing algal blooms;
- sediment from construction sites;

- overgrazing of livestock;
- stream channel modification and development; and
- reduced riparian tree cover.



Map 7: Map of Dissolved Oxygen Impairments and Concerns.



Map 8: Map of Dissolved Oxygen Trends in H-GAC Region.

PCBs/Dioxin

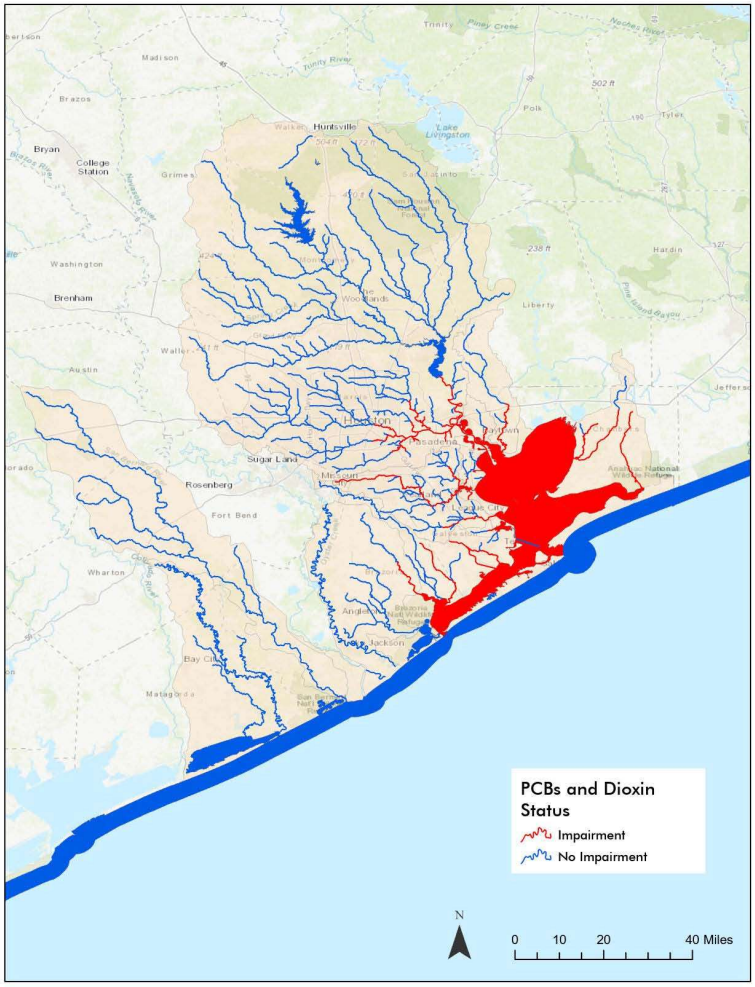
Two percent of freshwater streams, 70 percent of tidal streams, and 76 percent of bays in the region are impaired for PCBs and dioxin. No lakes in the region are impaired. Because fish and shellfish can accumulate contaminants from the waters they live in, they are monitored closely by federal, state, and local governments, and bans and advisories are issued when consumption may be a risk to human health.

The U.S. Environmental Protection Agency (EPA) website recommends "when contaminant levels are unsafe, fish and shellfish advisories help people make informed decisions about where to fish or harvest shellfish. Advisories recommend that people limit or avoid eating certain species of fish and shellfish caught in certain places."

The Texas Department of State Health Services Seafood and Aquatic Life Unit protects consumers from contaminants, disease, or other health hazards transmissible or found in fish or shellfish. They issue advisories and bans, and provide easy-to-use maps, including the online Texas Fish Consumption Advisory Viewer (www.dshs.texas.gov/seafood/TFCAV.aspx), to identify current water body-specific health advisories for fish and shellfish for all Texas waters.

Fish and shellfish consumption bans and advisories can also be found on the Texas Parks and Wildlife Department website (www.tpwd.texas.gov/regulations/outdoor-annual/fishing/general-rules-regulations/fish-consumption-bans-and-advisories).

For more information about PCBs/dioxin in area water bodies, see the Water Quality Summary Chart.



Map 9: Map of PCBS and Dioxin Impairments in H-GAC Basins.

Nutrients

Thirty-four percent of stream miles in the region exceed the state screening levels for nutrients, including nitrate, ammonia, and phosphorus.

Nutrients are chemical substances that promote the growth of aquatic organisms. TCEQ evaluates the amount of these nutrients (which include various forms of nitrogen and phosphorus) as part of their assessment process.

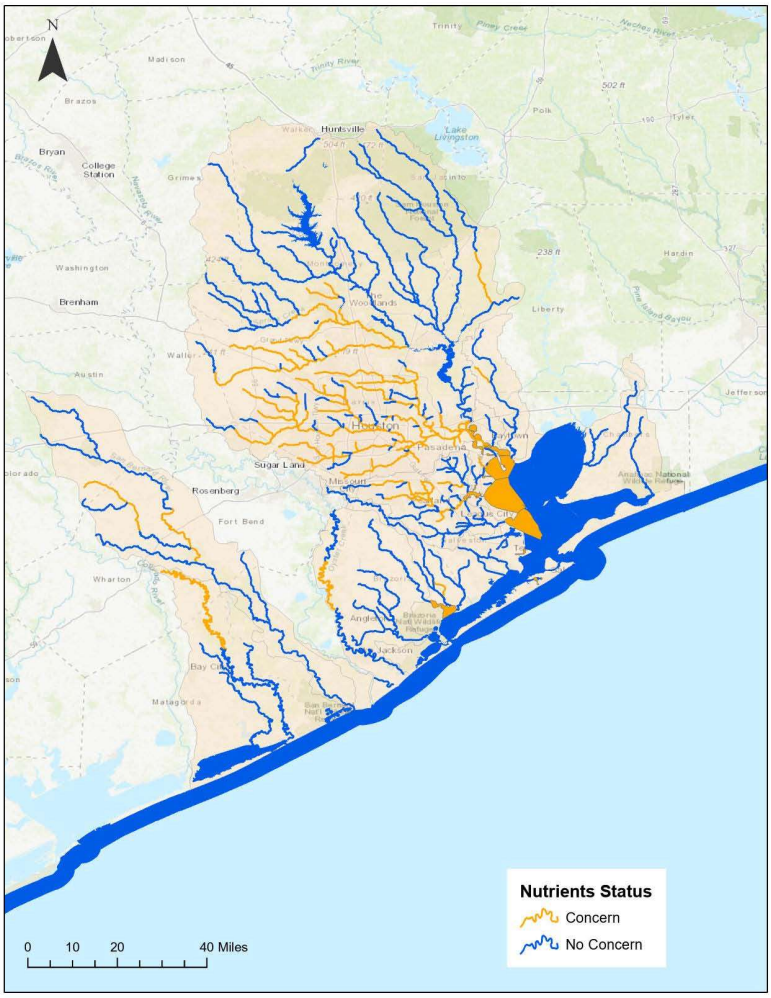
In high concentrations, nutrients can contribute to low dissolved oxygen levels and may result in unsightly or toxic algal blooms. Algae also produce chemicals which can cause taste and odor problems in drinking water.

Sources of nutrient pollution include

- fertilizer runoff from lawns and agricultural fields;
- manure;
- sewage treatment plant discharges;
- stormwater runoff; and
- failing on-site sewage facilities.

Statewide Development of Nutrient Criteria

In 2012, TCEQ established a Nutrient Criteria Development Advisory Workgroup tasked with developing nutrient criteria, including strategies for developing criteria, types of criteria, categorization of water bodies, and additional data needs to ensure water bodies throughout the state are meeting their designated uses. Criteria continue to be adjusted for specific regions rather than using a one-size-fits-all criteria. Only 39 lakes or reservoirs in the state currently have numeric criteria for nutrients. Lake Houston and Lake Conroe, the two drinking water supply reservoirs in the region, have narrative criteria only. The workgroup continues to hold public meetings and seeks stakeholder and subject-matter expert input for developing nutrient criteria. See Nutrient Criteria Development - Texas Commission on Environmental Quality.



Map 10: Map of Nutrient Concerns for H-GAC Basins.

Water Quality Summary

The Clean Rivers Program provides data for review and summary of ambient water quality conditions for the 56 segments in the four basins and bays and estuaries monitored and assessed by H-GAC and its Clean Rivers Program partners.

Regional Water Quality Summary Chart

To illustrate the region's impairments or concerns, the Clean Rivers Program compiled the Regional Water Quality Summary Chart, a comprehensive summary chart of regional water quality for six parameters for 55 of the 56 water body segments in the four basins and bays and estuaries (No data were collected for Cedar Lakes-segment 2442). The chart also illustrates whether the impairment or concern is trending for the better or worse or has stayed the same.

The numbers in the cells in the chart represent the percent of total segment length that is impaired or of concern for each parameter. Cells without numbers (blanks) represent stream segments that are currently meeting state standards but may be improving or degrading for each parameter. Trend columns indicate whether the segment is improving, deteriorating, or staying the same (indicated by grey cells) for four parameters.

Houston-Galveston Area Council

2024 REGIONAL WATER QUALITY SUMMARY

DO = Dissolved Oxygen Bact = Bacteria Chl-a = Chlorophyll-a Nutr = Nutrients PCB = PCBs/Dioxins OTHER = See Chart

Basin	Watershed	Segment	DO	Bact	Chl-a	Nutr	PCB	Other*	Frogs
Trinity-San Jacinto Coastal	Cedar Bayou Tidal	0901	14.2	100			85.8		
	Cedar Bayou Above Tidal	0902	82.7	82.7		17.3		82.7	
San Jacinto River	Buffalo Bayou Above Tidal	1014	6.3	77.9		69		0.7	
	Buffalo Bayou Tidal	1013	34.2	77.8		47.9		29.9	
	Caney Creek	1010		69.2					
	Cypress Creek	1009		80.3	9.3	80.3		10.3	
	East Fork San Jacinto River	1003		94.1					
	Greens Bayou Above Tidal	1016	6.4	95.8		85.3			
	Houston Ship Channel	1006	5.3	44.7	3.4	80.2	39.8	22.2	
	Houston Ship Channel Buffalo Bayou Tidal	1007	16.7	70.2		85.6	28.7	0.9	
	Houston Ship Channel/San Jacinto River Tidal	1005				82.3	100		
	Lake Conroe	1012							
	Lake Creek	1015	40.1	12.1				30.7	
	Lake Houston	1002	9.8	9.8		9.8			
	Peach Creek	1011		100				15.4	
	San Jacinto River Tidal	1001					47.3		
	Spring Creek	1008	8.2	77.8		39.2		11.0	
	West Fork San Jacinto River	1004		53.6	16.6			16.6	
	White Oak Bayou Above Tidal	1017	11.7	87		79.6			
San Jacinto-Brazos Coastal	Armand Bayou Tidal	1113	61.7	69.6	28.6	17	23.4	12.1	
	Bastrop Bayou Tidal	1105	31.4	69.6					
	Chocolate Bayou Above Tidal	1108		100					
	Chocolate Bayou Tidal	1107		100	100		100		
	Clear Creek Above Tidal	1102	25	78.8		76.1	48.4	13.1	
	Clear Creek Tidal	1101	37.4	78		31.8	29.2		
	Dickinson Bayou Above Tidal	1104		54.5					
	Dickinson Bayou Tidal	1103	86.9	100			43.6		
	Old Brazos River Channel Tidal	1111							
	Oyster Creek Above Tidal	1110	96.8	64.5		37.5		96.8	
	Oyster Creek Tidal	1109	100	100					

Chart Key

The numbers in the chart represent the percent of total segment length that is impaired or of concern for each parameter.

STABLE

GETTING BETTER

GETTING WORSE

NO TREND ANALYSIS

Severe, multiple water quality impairment(s) or concern(s) exist in a majority of the water body.

Significant, multiple water quality impairment(s) or concerns exist in the water body.

Water quality impairment(s) or concern(s) exist in a substantial portion of the water body.

Water quality impairment(s) or concern(s) exist in the water body.

No significant water quality impairments or concerns exist in the water body.

* Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macroinvertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissues and fish consumption

** Frog Chart trend analysis differs from the TCEQ Integrated Report 2022 due to an updated period of record (12/31/2015 - 12/31/2022)

\+ This segment was not assessed due to insufficient data

++This segment was not assessed for routine parameters, but was assessed for fecal coliform in Oyster Waters

DO = Dissolved Oxygen Bact = Bacteria Chl-a = Chlorophyll-a Nutr = Nutrients PCB = PCBs/Dioxins OTHER = See Chart

Basin	Watershed	Segment	DO	Bact	Chl-a	Nutr	PCB	Other*	Frogs
Brazos-Colorado Coastal	Caney Creek Above Tidal	1305	44.6	71.6		57.7		13.9	
	Caney Creek Tidal	1304	36.8	61					
	San Bernard River Above Tidal	1302	61.5	68.2		20.9		7.3	
	San Bernard River Tidal	1301		100					
Bays & Estuaries	Barbours Cut	2436				100	100		
	Bastrop Bay / Oyster Lake ++	2433							
	Bayport Ship Channel	2438			100	100	100	100	
	Black Duck Bay	2428			100	100	100		
	Burnett Bay	2430			69.2	100	100		
	Cedar Lakes +	2442							
	Chocolate Bay	2432	51	86.3		18.8	33		
	Christmas Bay ++	2434							
	Clear Lake	2425		4.3	56.5	69.6	73.9	45.3	
	Drum Bay ++	2435							
	East Bay	2423	33.9		100		100		
	East Matagorda Bay	2441							
	Lower Galveston Bay	2439			92.8	13.6	92.8		
	Moses Lake	2431	12.2	19.7	52.8		56.8		
	San Jacinto Bay	2427			100	100	100		
	Scott Bay	2429				100	100		
	Tabbs Bay	2426				48.3	69.5		
	Texas City Ship Channel	2437			100	100	100		
	Trinity Bay	2422	29.1	29.1	72.7		88.5		
	Upper Galveston Bay	2421		7.1	96.9	88.7	87.9		
	West Bay	2424	9.1	7.4	10.6	5.7	91.1		
	Gulf of Mexico	2501		26.4					

Regional Water Quality Summaries

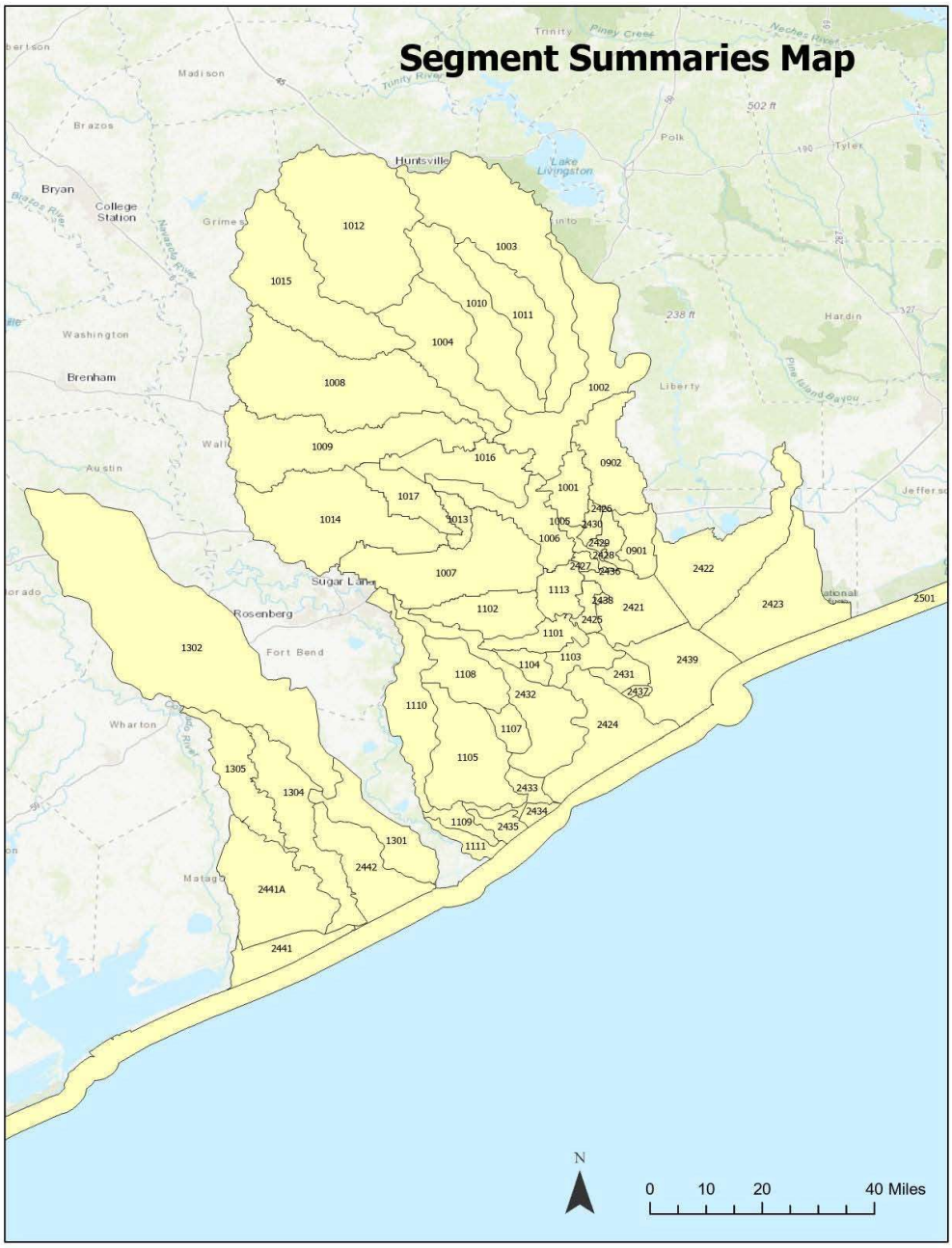
In addition to the 2024 Regional Water Quality Summary Chart, water quality information is provided as Regional Water Quality Summaries for each of the 56 segments.

The data provided on the Water Quality Summary Chart and Water Quality Summaries are derived from water quality monitoring data collected by H-GAC and Clean Rivers Program partners between December 2015 and December 2022.

Qualifiers are used to describe the portion of segments where water quality issues exist. A *few parts* means 33 percent or less of a segment; *some parts* means 34-66 percent of a segment; and *most parts* means 67 percent or greater of a segment. If only a single portion of a tributary is listed, it is the only portion with the concern.

Each segment summary contains information on the selected segment watershed, a list of associated tributaries, water quality impairments and concerns designated by the TCEQ, and any plans developed to address those issues. For more details about the segments' impairments and concerns, see the Water Quality Summary Chart. Information about watershed projects can be found in the Watershed Project Summaries section of this report.

For information on specific impairments or concerns for a segment down to the AU level, review the TCEQ 2022 Integrated Report of Surface Water Quality (https://www.tceq.texas.gov/waterquality/assessment/22twqi/22txir). Fish Consumption Advisories mentioned in the Water Quality Summary Map are issued by the Texas Department of State Health Services.



Map 11: Map of H-GAC Watershed Segments.

Trinity-San Jacinto Coastal Basin

Cedar Bayou Above Tidal (0902)
The Cedar Bayou Above Tidal segment watershed is largely used for agricultural purposes with small ranchettes scattered throughout. Residential and industrial development is concentrated in the southern portion.

Major Tributaries
- Adlong Ditch, Buck Gully

Areas of Concern
- Cedar Bayou Above Tidal is impaired for dissolved oxygen in most parts.
- Contact recreation use is not supported due to high bacteria concentrations
- A nutrient concern (ammonia) exists in Adlong Ditch
- Concern exists for an impaired macrobenthic community in the segment per TCEQ's 2022 Texas Integrated Report

Plans
- H-GAC developed the Cedar Bayou watershed protection plan

For more details see the Water Quality Summary Chart.

Cedar Bayou Tidal (0901)
The Cedar Bayou Tidal segment watershed is dominated by residential development in the west and along State Highway 146 in Baytown and by industrial facilities along the eastern shoreline and in Mont Belvieu. Agriculture land use, such as cultivated crops, is found in the northern parts of the watershed.

Major Tributaries
- Cary Bayou, McGee Gully

Areas of Concern
- Dissolved oxygen is impaired in Cary Bayou
- Contact recreation use is not supported in any parts due to high bacteria concentrations
- A restricted fish consumption advisory exists for most parts due to elevated concentrations of PCBs/dioxin in edible fish tissue

Plans
- H-GAC developed the Cedar Bayou watershed protection plan

For more details see the Water Quality Summary Chart.

San Jacinto River Basin

Buffalo Bayou Above Tidal (1014)
The Buffalo Bayou Above Tidal segment watershed extends from the heavily developed areas of Houston's urban core west and north to rural and agricultural areas of western Harris County and southeastern Austin County. Addicks and Barker reservoirs, which serve as flood retention basins, are central to the watershed. Two major parks, Bear Creek Park and George Bush Park, occupy portions of the reservoirs, thus creating multi-use areas.

Major Tributaries
- Bear, Langham, Mason, Rummel, South Mayde, Spring Branch, and Turkey creeks; Neimans Bayou

Areas of Concern
- Dissolved oxygen impairments and concerns exist in a few parts
- Contact recreation use is not supported in most parts due to high bacteria concentrations
- Nutrient concerns (nitrate, ammonia, and total phosphorus) exist in most parts
- An impairment exists for fish and macrobenthic communities in Neimans Bayou per TCEQ's 2022 Texas Integrated Report

Plans
- The Buffalo Bayou Above Tidal segment is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Buffalo Bayou Tidal (1013)
The Buffalo Bayou Tidal segment watershed is completely urbanized, encompassing downtown Houston, the theater and entertainment districts, residential developments with high-volume, mixed-commercial development, and light industry. Several parks and natural areas are along the banks of Buffalo Bayou. A major portion of the Houston metropolitan area drains to or through this segment.

Major Tributaries
- Tidal portions of White Oak and Little White Oak bayous

Areas of Concern
- Dissolved oxygen impairments exist in some parts
- Contact recreation use is not supported in most parts due to high bacteria concentrations
- Nutrient concerns (nitrate and total phosphorus) exist in some parts

- A concern for impaired macrobenthic community exists in Little White Oak Bayou per TCEQ's 2022 Texas Integrated Report

Plans

- The Buffalo Bayou Tidal segment is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Caney Creek (1010)

The Caney Creek segment watershed is primarily forested, but small ranches, ranchettes, and hobby farms are common throughout. A few tracts of the Sam Houston National Forest lie in the northern portions of the watershed. Cleared lands for cattle grazing and hay production make up most of the agricultural activities. Timber harvesting is also found in the middle and upper portions of the watershed.

Major Tributaries

- Camp, White Oak, Little Caney, McRae and Dry creeks; Spring Branch, Hegar Branch, and West Fork Spring Branch

Areas of Concern

- Contact recreation use is not supported in most parts due to high bacteria concentrations

Plans

- The Caney Creek segment is part of the Bacteria Implementation Group
- H-GAC has worked with stakeholders to create a total maximum daily load implementation plan for Caney Creek

For more details see the Water Quality Summary Chart.

Cypress Creek (1009)

The Cypress Creek segment watershed is dominated by dense residential development within forested lands in the eastern portion. The western portion is dominated by crop lands and grasslands used for cattle grazing. The middle of the watershed has experienced rapid urbanization. Grasslands and cultivated fields were once the primary land cover/land use; however, subdivisions and commercial buildings now dominate the landscape.

Major Tributaries

- Dry, Little Cypress, Live Oak, Mound, Pillot, and Seals creeks; Dry, Faulkey, Lemm, and Spring gullies

Areas of Concern

- Contact recreation use is not supported in most parts due to high bacteria concentrations
- Concern for chlorophyll-*a* levels exists for a few parts of Cypress Creek
- Nutrient concerns (nitrate, ammonia, and total phosphorus) exist in most parts
- A concern for impaired macrobenthic community exists for a part of Cypress Creek
- A concern for an impaired habitat exists for a part of Cypress Creek

Plans

- The Cypress Creek segment is part of the Bacteria Implementation Group
- H-GAC has an approved watershed protection plan for Cypress Creek

For more details see the Water Quality Summary Chart.

East Fork San Jacinto River (1003)

The East Fork San Jacinto River segment watershed is primarily undeveloped forested land with scattered ranchettes or small homesteads, except for the lower portion which is populated by Plum Grove and Cleveland. Part of Huntsville is in the far northern portion along with a large part of the Sam Houston National Forest. Timber harvesting is a major industry in the upper watershed. Land has been cleared for grazing and hay production.

Major Tributaries

- Orange Branch, Miller Creek, Whiskey Branch, and Winters Bayou

Areas of Concern

- Contact recreation use is not supported in most parts due to high bacteria concentrations

Plans

- The East Fork San Jacinto River segment is part of the Bacteria Implementation Group
- The East Fork San Jacinto River segment is included in the total maximum daily load implementation plan for the East and West Fork of the San Jacinto River project
- H-GAC is working with stakeholders to develop the East Fork San Jacinto watershed protection plan

For more details see the Water Quality Summary Chart.

Greens Bayou Above Tidal (1016)
The Greens Bayou Above Tidal segment watershed is an urban watershed. Beltway 8 runs through the middle of the watershed with large, high-intensity residential, commercial, and industrial developments found adjacent to and at intersections with major highways: I-45, U.S. Highway 59, and State Highway 249. Bush Intercontinental Airport is in the north-central portion of the watershed.

Major Tributaries
- Garners Bayou and Williams Gully

Areas of Concern
- A dissolved oxygen concern and impairment exist in an unnamed tributary of Greens Bayou
- Contact recreation use is not supported in most parts due to high bacteria concentrations
- Nutrient concerns (nitrate, ammonia, and total phosphorus) exist in most parts

Plans
- The Greens Bayou Above Tidal segment is part of the Bacteria Implementation Group
- H-GAC is beginning a watershed protection plan project in FY2024

For more details see the Water Quality Summary Chart.

Houston Ship Channel (1006)
The Houston Ship Channel segment watershed is urbanized and receives discharges from many regulated wastewater and stormwater outfalls. The lower portion of the watershed includes heavy industrial complexes lining both sides of the Ship Channel, including Deer Park, Channelview, Houston, Pasadena, and parts of unincorporated Harris County.

Major Tributaries
- Boggy, Carpenters, Halls, and Patrick bayous, Goodyear Creek; Tidal portions of Greens Bayou

Areas of Concern
- Dissolved oxygen concerns exist for a few parts
- General Use criteria for bacteria is exceeded in one of the seven AUs of the navigable waters of the ship channel
- Contact recreation use is not supported in some parts of the tributaries due to high bacteria concentrations
- A concern for chlorophyll-*a* levels exists for a few parts
- Nutrient concerns (nitrate, ammonia, and total phosphorus) exist in most parts

- A few parts of the segment do not support general use provisions due to toxicity
- A restricted fish consumption advisory exists for some parts of the Houston Ship Channel due to elevated concentrations of PCBs/dioxin in edible fish tissue
- Concerns and impairments exist in a few parts of the Houston Ship Channel for concentrations of mercury and other toxins in the sediment and water

Plans

- The above tidal portions of the segment are part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Houston Ship Channel/Buffalo Bayou Tidal (1007)

The urbanized Houston Ship Channel/Buffalo Bayou Tidal segment watershed includes the Houston Ship Channel and more than 70 miles of tidal and above tidal tributary streams. The watershed includes Bellaire, Houston, Pasadena, Galena Park, and South Houston, as well as large petrochemical complexes along the shores of the Ship Channel. Numerous permitted wastewater and stormwater discharges are found throughout the watershed.

Major Tributaries

- Berry, Brays, Country Club, Hunting, Keegans, Little Vince, and Vince bayous, Plum and Berry creeks; Pine Gully

Areas of Concern

- Dissolved oxygen impairments and concerns exist in a few parts
- While not designated for contact recreation use, most parts have high bacteria concentrations
- Nutrient concerns (nitrate, ammonia, and total phosphorus) exist in most parts
- A restricted fish consumption advisory exists in a few parts due to elevated concentrations of PCBs/dioxin in edible fish tissue
- An impairment exists in Vince Bayou Tidal for toxicity in the sediment

Plans

- The above tidal parts of the segment are part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Houston Ship Channel/San Jacinto River (1005)

The Houston Ship Channel/San Jacinto River segment watershed includes Baytown and Highlands on the eastern shore of the Ship Channel and the San Jacinto River with the

heavily industrialized cities of Channelview, Deer Park, and La Porte along the western shoreline.

Major Tributaries

- Black Duck, Burnet, San Jacinto, Scott, and Tabbs bays; Goose Creek; Old River; Barbours Cut

Areas of Concern

- Nutrient concerns (nitrate) exist in most parts
- A restricted fish consumption advisory exists for all parts due to elevated concentrations of PCBs/dioxin in edible fish tissue

Plans

- No watershed plans exist for the Houston Ship Channel/San Jacinto River segment

For more details see the Water Quality Summary Chart.

Lake Conroe (1012)

Lake Conroe is a large reservoir in Montgomery and Walker counties. It is a primary source of drinking water for Houston and surrounding communities. The lake receives inflow from tributaries in the upper reaches of the San Jacinto River Basin. There is significant residential and commercial development around the lower half of its shoreline. The Sam Houston National Forest covers the middle to upper portion of the watershed with small ranchettes and hobby farms scattered throughout. The upper watershed is a mixture of cultivated lands, pastures, forests, and cleared land from timber harvesting.

Major Tributaries

- Caney, East Sandy, Lewis, Little Lake, McDonald, McGary, and West Sandy creeks; West Fork San Jacinto River

Areas of Concern

- There are no concerns that exist for this segment

Plans

- Lake Conroe is part of the Lake Conroe watershed protection plan

For more details see the Water Quality Summary Chart.

Lake Creek (1015)

The Lake Creek segment watershed is primarily rural and dominated by forest and grasslands with the major land cover/land use being pastureland or hay production. Limited row crop cultivation is scattered throughout the upper portion. Mixed

residential and commercial development including subdivisions, strip centers, and ranchettes or hobby farms is in the lower part of the watershed.

Major Tributaries

- Caney, Fish, Garretts, Landrum, Little Caney, and Mound creeks

Areas of Concern

- Dissolved oxygen concerns exist for some parts
- Contact recreation use is not supported in a few parts of Mound Creek due to high bacteria concentrations
- A concern for an impaired macrobenthic community exists in a few parts of segment per TCEQ's 2022 Texas Integrated Report

Plans

- The Lake Creek segment is part of the Bacteria Implementation Group
- The Lake Creek segment is part of the West Fork San Jacinto River and Lake Creek watershed protection plan

For more details see the Water Quality Summary Chart.

Lake Houston (1002)

Lake Houston is a large reservoir in northeast Harris County. It is the primary source of drinking water for Houston and surrounding communities. The lake receives inflow from the segment's major tributaries.

Major Tributaries

- East Fork San Jacinto River Arm, Luce Bayou, Marsh Branch, Tarkington Bayou, and West Fork San Jacinto River Arm

Areas of Concern

- A dissolved oxygen concern exists for Tarkington Bayou
- Contact recreation use is fully supported in Lake Houston but not supported in Tarkington Bayou due to high bacteria levels
- Nutrient concerns (nitrate and total phosphorus) exist in Tarkington Bayou
- A concern for pH exists in a few parts of Lake Houston
- A restricted fish consumption advisory exists in Lake Isabell (segment 1002C_01), which is an isolated water body in the Lake Houston watershed, due to elevated concentrations of mercury in edible fish tissue

Plans

- Lake Houston is part of the Bacteria Implementation Group
- Lake Houston is included in the total maximum daily load implementation plan for the East and West Fork of the San Jacinto River

For more details see the Water Quality Summary Chart.

Peach Creek (1011)
The Peach Creek segment watershed is dominated by forested land with the Sam Houston National Forest in the upper reach. Grass and pasture lands are scattered throughout the watershed along with cattle ranches and ranchettes or hobby farms. Several communities, including Splendora and Woodbranch, are in the lower reaches of the watershed.

Major Tributaries
- Boggy, Duck, Jayhawker, Lawrence, and Mare creeks; Gully, Gum, Waterhole, and Bee branches

Areas of Concern
- Contact recreation use is not supported in all parts due to high bacteria concentrations
- A concern for an impaired habitat exists in a few parts of Peach Creek

Plans
- The Peach Creek segment is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

San Jacinto River Tidal (1001)
The San Jacinto River Tidal segment watershed is heavily developed in the lower portion, with industrial activity along the Houston Ship Channel as its major land use. The middle of the watershed is primarily forested wetlands, and the upper and eastern areas are primarily cultivated land and grasslands. The rural communities of Highlands, Barrett, and Crosby on the east side, and Sheldon is on the west side of the San Jacinto River.

Major Tributaries
- Gum Gully Creek

Areas of Concern
- A restricted fish consumption advisory exists for some parts due to elevated concentrations of PCBs/dioxin in edible fish tissue

Plans
The tidal segment of the San Jacinto River is not included in any watershed plan

For more details see the Water Quality Summary Chart.

Spring Creek (1008)
The Spring Creek segment watershed continues to experience rapid urban growth, especially around Tomball, The Woodlands, and the I-45 and State Highway 249 corridors. The western portion of the watershed is dominated by cultivated fields, grasslands, shrub lands, and forests.

Major Tributaries
- Three Mile, Walnut, Willow, Birch, Brushy, Dry, and Mill creeks; Bear, Mill, Mink, Panther, and Sulfur branches; and Lake Woodlands

Areas of Concern
- A concern for depressed dissolved oxygen exists for Brushy Creek
- Contact recreation use is not supported in most parts due to high bacteria levels
- Nutrient concerns (nitrate and total phosphorus) exist in some parts
- A concern for impaired fish community exists in a few parts
- A concern for cadmium in the water exists in a few parts of Upper Panther Branch

Plans
- The Spring Creek segment is a part of the Bacteria Implementation Group
- H-GAC has worked with stakeholders to develop the Spring Creek watershed protection plan

For more details see the Water Quality Summary Chart.

West Fork San Jacinto River (1004)
The West Fork San Jacinto segment watershed is primarily forested with residential and commercial development scattered throughout. Conroe is at the upper end of the watershed with several small communities in the lower area.

Major Tributaries
- Camp, Crystal, East Fork Crystal, Caney, Egypt, Lake, Little Caney, Stewarts, West Fork Crystal, and White Oak creeks; Woodsons Gully; Harpers, Horsepen, Rice, and Sand branches

Areas of Concern
- Contact recreation use is not supported in some parts due to high bacteria levels
- Concern for chlorophyll-*a* levels exists for a few parts
- A concern for an impaired macrobenthic community exists in a few parts per TCEQ's 2022 Texas Integrated Report

Plans
- The West Fork of the San Jacinto River is part of the Bacteria Implementation Group

- The West Fork of the San Jacinto River is included in the total maximum daily load implementation plan for the East and West Fork of the San Jacinto River project
- The West Fork of the San Jacinto River is included in the West Fork San Jacinto River watershed protection plan

For more details see the Water Quality Summary Chart.

White Oak Bayou Above Tidal (1017)
The White Oak Bayou Above Tidal segment watershed is almost entirely developed with pockets of parklands and wooded acreages scattered throughout. The most densely populated area is found in the lower reaches inside I-610. Heavy commercial development occurs along the US-290 corridor, with residential and mixed developments adjacent to the corridor.

Major Tributaries
- Brickhouse Gully, Cole Creek, Little White Oak Bayou, and Vogel Creek

Areas of Concern
- Dissolved oxygen impairments and concerns exist in a few parts
- Contact recreation use is not supported in most parts due to high bacteria levels
- Nutrient concerns (nitrate, ammonia, and total phosphorus) exist in most parts

Plans
- The White Oak Bayou Above Tidal segment is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

<u>San Jacinto-Brazos Coastal Basin</u>

Armand Bayou (1113)
The Armand Bayou segment watershed is densely developed, including Taylor Lake Village and La Porte and parts of Houston, Deer Park, and Pasadena. High-intensity and low-intensity residential and mixed commercial developments are the dominant land uses. Large industrial facilities are scattered in the north. Ellington Airport and the Armand Bayou Nature Center are in the watershed.

Major Tributaries
- Big Island Slough; Horsepen, Willows Spring, and Middle bayous; Mud Lake; Spring Gully

Areas of Concern

- Dissolved oxygen impairments or concerns exist in some parts
- Contact recreation use is not supported in most parts due to high bacteria levels
- Concerns exist for chlorophyll-*a* levels in a few parts
- Nutrient concerns (nitrates and total phosphorus) exist in the Horsepen Bayou Tidal part of the segment
- Ammonia is no longer a concern in Horsepen Bayou Tidal
- A restricted fish consumption advisory exists for Armand Bayou Tidal due to elevated concentrations of PCBs/dioxin in edible fish tissue
- A fish community impairment exists in parts for Armand Bayou Above Tidal

Plans

- The Armand Bayou segment is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Bastrop Bayou Tidal (1105)

The Bastrop Bayou Tidal segment watershed is mostly rural, with agriculture and cattle grazing as the primary land uses. Urban development is limited to Angleton and Danbury. The main stem of Bastrop Bayou originates near State Highway 288, south of Angleton and flows due east through forested wetlands and cultivated land to coastal prairies and wetlands.

Major Tributaries

- Austin, Brushy, and Flores bayous

Areas of Concern

- Dissolved oxygen concerns exist in a few parts; Brushy Bayou is impaired
- Contact recreation use is not supported in most parts due to high bacteria levels
- Nutrient concerns for ammonia no longer exist in Brushy Bayou

Plans

- The Bastrop Bayou Tidal segment is part of the Bastrop Bayou watershed protection plan

For more details see the Water Quality Summary Chart.

Chocolate Bayou Above Tidal (1108)

Chocolate Bayou Above Tidal segment watershed is primarily rural with agriculture as the dominant land use. Agricultural fields are concentrated in the middle portion with urban development in or near Manvel, Arcola, Iowa Colony, and Alvin. The segment terminates at a saltwater barrier downstream of the confluence with the Chocolate Bayou Rice Canal. The area continues to experience rapid growth.

Major Tributaries

- Hayes Creek and West Fork Chocolate Bayou

Areas of Concern

- Contact recreation use is not supported in any part due to high bacteria levels

Plans

- A TMDL is under review by the TCEQ. An implementation plan will be developed by stakeholders within the Chocolate Bay watershed, which includes the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds.

For more details see the Water Quality Summary Chart.

Chocolate Bayou Tidal (1107)

The Chocolate Bayou Tidal segment watershed is primarily rural, with Liverpool as the only urban area. Agriculture is the major land use, and a large system of irrigation canals crisscross the watershed. A large industrial complex composed of several major petrochemical plants is in the southeast sector and uses the bayou for barge traffic hauling raw materials and finished products to and from the complex.

Major Tributaries

- Corner, Cottonwood, Perry, Pleasant, and Salt bayous

Areas of Concern

- Contact recreation use is not supported in any part due to high levels of bacteria
- A concern for chlorophyll-*a* levels exists in all parts
- A restricted fish consumption advisory exists in all parts due to elevated concentrations of PCBs/dioxin in edible fish tissue

Plans

- A TMDL is under review by the TCEQ. An implementation plan will be developed by stakeholders within the Chocolate Bay watershed, which includes the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds.

For more details see the Water Quality Summary Chart.

Clear Creek Above Tidal (1102)

The Clear Creek Above Tidal segment watershed continues to experience rapid residential and commercial development, especially around the State Highway 288 corridor and FM 518 throughout Pearland and eastern Friendswood. Agricultural land use is found near the headwaters of Cowart Creek and in the far upper reaches. Medium and small farms occupy the nonresidential areas.

Major Tributaries

- Cowart, Mary's, and Turkey creeks; Hickory Slough; Mud Gully

Areas of Concern

- Dissolved oxygen concerns exist in a few parts
- Contact recreation use is not supported in most parts due to high bacteria levels
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in most parts
- A restricted fish consumption advisory exists for most parts due to elevated concentrations of PCBs/dioxin in edible fish tissue
- An impaired habitat concern exists for a few parts

Plans

- The Clear Creek Above Tidal segment is part of the Bacteria Implementation Group. Stakeholders have developed a draft Watershed Protection Plan and are waiting for TCEQ approval.

For more details see the Water Quality Summary Chart.

Clear Creek Tidal (1101)

The Clear Creek Tidal segment watershed continues to experience rapid growth with mixed residential and commercial development throughout. Most of the high-intensity development is near I-45 and the NASA/Johnson Space Center and Baybrook Mall complexes in the northeastern part of the watershed.

Major Tributaries

- Chigger and Magnolia creeks; Cow and Robinsons bayous

Areas of Concern

- Dissolved oxygen concerns exist in some parts and an impairment exists in Robinson Bayou and an unnamed tributary of Clear Creek Tidal
- Contact recreation use is not supported in most parts due to high bacteria levels
- Chlorophyll-*a* is no longer a concern
- Nutrient concerns (nitrates and total phosphorus) exist in a few parts
- A restricted fish consumption advisory exists due to elevated concentrations of PCBs/dioxin in edible fish tissue

Plans

- The Clear Creek Tidal segment is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Dickinson Bayou Above Tidal (1104)
The Dickinson Bayou Above Tidal segment watershed includes portions of Alvin, Friendswood, League City, and Santa Fe. Rapid growth is occurring throughout the watershed. Residential, mixed commercial development, and agriculture are the predominant land uses with high-intensity developments and business districts at the intersections of and along State Highway 6, State Highway 35, and FM 528. Ranchettes or hobby farms are common throughout this watershed.

Major Tributaries
- None

Areas of Concern
- Dissolved oxygen is no longer a concern
- Contact recreation use is not supported in some parts due to high bacteria levels

Plans
- A total maximum daily load implementation plan was developed for Dickinson Bayou
- A watershed protection plan was developed for Dickinson Bayou

For more details see the Water Quality Summary Chart.

Dickinson Bayou Tidal (1103)
The Dickinson Bayou Tidal segment watershed is heavily developed, including Dickinson, Santa Fe, and League City. Low to medium intensity residential and mixed commercial developments are the predominant land uses. There are agricultural activities in the western, southeastern and eastern portions of the watershed.

Major Tributaries
- Bordens Gully; Cedar Creek; Geisler, Gum, and Bensons bayous

Areas of Concern
- Dissolved oxygen impairments or concerns exist in most parts
- Contact recreation use is not supported due to high bacteria levels
- No concern for chlorophyll-*a* exists
- A restricted fish consumption advisory exists for a few parts due to elevated concentrations of PCBs/dioxin in edible fish tissue

Plans
- A total maximum daily load implementation plan was developed for Dickinson Bayou
- A watershed protection plan was developed for Dickinson Bayou

For more details see the Water Quality Summary Chart.

Old Brazos River Channel (1111)
The Old Brazos River Channel segment watershed comprises what was once the mouth of the Brazos River in southern Brazoria County. Beachfront residential development and water recreational activities are in the lower portions of the watershed, with large expanses of wetlands surrounding the watershed.

Major Tributaries
- None

Areas of Concern
- None

Plans
- The Old Brazos River Channel segment is not included in any watershed plans

For more details see the Water Quality Summary Chart.

Oyster Creek Above Tidal (1110)
The Oyster Creek Above Tidal segment watershed is largely undeveloped in the lower portions, with dense residential and commercial communities, including Missouri City and Stafford, in the upper portion. Smaller communities are scattered throughout. Oyster Creek is sinuous with numerous oxbow lakes. The greater portion of the watershed is bottomland forest, grassland, or wetland habitat.

Major Tributaries
- None

Areas of Concern
- Dissolved oxygen impairments exist in a most parts
- Contact recreation use is not supported in some parts due to high bacteria levels
- Nutrient concerns (total phosphorus) exist in some parts
- Chlorophyll-*a* is no longer a concern
- A concern for impaired habitat exists in most parts
- A concern for impaired macrobenthic community exists in a few parts

Plans
- Oyster Creek stakeholders, along with H-GAC, have completed a draft implementation plan, which is under review by TCEQ.

For more details see the Water Quality Summary Chart.

Oyster Creek Tidal (1109)
The Oyster Creek Tidal segment watershed is in a region which previously supported cotton and sugarcane plantations. Development is largely limited to the northwest portion, including Lake Jackson and Clute. Most of the watershed is covered by natural forests and grasslands, with large expanses of coastal wetlands at the southern and eastern edges. Oyster Creek is sinuous with numerous oxbow lakes.

Major Tributaries
- None

Areas of Concern
- A dissolved oxygen concern exists in all parts.
- Contact recreation use is not supported due to high bacteria levels

Plans
- Oyster Creek stakeholders along with H-GAC have completed a draft implementation plan, which is under review by TCEQ.

For more details see the Water Quality Summary Chart.

<u>Brazos-Colorado Coastal Basin</u>

Caney Creek Tidal (1304)
The Caney Creek Tidal segment watershed is primarily rural with the exceptions of Old Ocean in the northeast and Sargent near the mouth of the creek. A few farms are in the watershed, but the bulk of the agricultural activity consists of hay pastures concentrated along Caney Creek.

Major Tributaries
- Linnville, Red, Little Linnville, and Dance bayous; Dead Slough

Areas of Concern
- A dissolved oxygen concern exists in Linnville Bayou
- Contact recreation use is not supported in some parts due to high bacteria levels

Plans
- H-GAC worked with stakeholders to develop a total maximum daily load and implementation plan for Caney Creek and Linnville Bayou. An implementation plan is under review by TCEQ.

For more details see the Water Quality Summary Chart.

Caney Creek Above Tidal (1305)
The Caney Creek Above Tidal segment watershed is primarily rural except for Wharton, Bay City, and Van Vleck. Many large farms and hay pastures are throughout. A large area of forested wetlands is between the tributaries of Water Hole Creek and Snead Slough in the middle of the watershed.

Major Tributaries
- Hardeman, Quinine, Gardner, and Snead sloughs; Water Hole Creek

Areas of Concern
- Dissolved oxygen impairments or concerns exist in some parts
- A concern exists for contact recreation in most parts due to high bacteria levels
- Nutrient concerns (total phosphorus) exist in some parts
- An impaired habitat concern exists in a few parts

Plans

H-GAC worked with stakeholders to develop a total maximum daily load and implementation plan for Caney Creek and Linnville Bayou. The implementation plan is under review by TCEQ.

For more details see the Water Quality Summary Chart.

San Bernard River Above Tidal (1302)
The San Bernard River Above Tidal segment watershed is primarily agricultural with rice and cotton fields and grazing pastures dominating the landscape. East Bernard, Eagle Lake, Kendleton, and Hungerford are in the middle of the watershed, and riparian habitats crisscross the land.

Major Tributaries
- Coushatta, East Bernard, Little San Bernard, Peach, Mound, and West Bernard creeks, Gum Tree Branch; Middle Bernard River

Areas of Concern
- Dissolved oxygen impairments or concerns exist in some parts
- Contact recreation use is not supported in most parts due to high bacteria levels
- Nutrient concerns (ammonia, nitrate, and total phosphorus) exist in a few parts
- An impaired habitat concern exists in a few parts

Plans
- H-GAC facilitated the development a watershed protection plan for the San Bernard River

For more details see the Water Quality Summary Chart.

San Bernard River Tidal (1301)
The San Bernard River Tidal segment watershed is primarily undeveloped, with agriculture as the main activity around West Columbia and Brazoria. The landscape consists mostly of forests, woody wetlands, or grasslands, with large areas of coastal wetlands, including the San Bernard National Wildlife Refuge, throughout the southern end.

Major Tributaries
- Bell Creek

Areas of Concern
- Contact recreation use is not supported due to high bacteria levels

Plans
- H-GAC developed a watershed protection plan for the San Bernard River

For more details see the Water Quality Summary Chart.

<u>Bays and Estuaries</u>

Barbours Cut (2436)
The Barbours Cut segment watershed is in a heavily industrialized area off the southern end of the Houston Ship Channel. The area is surrounded by wetlands, a residential area, and the Port Houston container yard.

Major Tributaries
- None

Areas of Concern
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in all parts
- A restricted fish consumption advisory exists due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- No watershed plans currently exist for Barbours Cut

For more details see the Water Quality Summary Chart.

Bastrop Bay/Oyster Lake (2433)
The Bastrop Bay/Oyster Lake segment watershed is in an undeveloped estuarine environment and is part of the Christmas Bay system at the far west end of West Galveston Bay. Oyster Lake is on the southeast side of the Intercoastal Waterway and experiences complete water exchange with it. Bastrop Bay sits northeast of and adjoins

Christmas Bay, and its water can flow between the Intercoastal Waterway, Bastrop Bayou, West Galveston Bay, and Christmas Bay.

Major Tributaries
- None

Areas of Concern
- Oyster harvesting is not supported in parts due to high levels of bacteria

Plans
- Oyster Lake is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

Bayport Channel (2438)
The Bayport Channel segment watershed is in a heavily industrialized area between Pasadena and La Porte. The area is surrounded by residential development to the north, with the Port of Houston container yard and an industrial complex to the south. Wetlands can be found in the southern portion of the segment watershed.

Major Tributaries
- None

Areas of Concern
- A concern exists for chlorophyll-*a* levels
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist
- A restricted fish consumption advisory exists for Bayport Channel due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- The Bayport Channel segment is not included in any watershed plans

For more details see the Water Quality Summary Chart.

Black Duck Bay (2428)
The Black Duck Bay segment watershed is on the southwest side of Baytown. It is bordered by a residential area to the east, an industrial tank farm to the north, wastewater stabilization ponds to the west, and the Fred Hartman Bridge and causeway to the south.

Major Tributaries
- None

Areas of Concern
- A concern exists for chlorophyll-*a* levels in the segment

- Nutrient concerns (nitrates, total phosphorus) exist in the segment
- A restricted fish consumption advisory exists for all parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans

- The Black Duck Bay segment is not included in any watershed plans

For more details see the Water Quality Summary Chart.

Burnett Bay (2430) / Crystal Bay (2430A)

Burnett Bay segment watershed on the western shore of Baytown, with Crystal Bay to the south. The north and east shores are residential. The southern shore is also the location of Brownwood Park and the Baytown Nature Center.

Major Tributaries

- None

Areas of Concern

- A concern exists for chlorophyll-*a* levels in the segment
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in all parts
- A restricted fish consumption advisory exists in all parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans

- Burnett and Crystal Bays are not included in any watershed plans

For more details see the Water Quality Summary Chart.

Cedar Lakes (2442)

Cedar Lakes segment watershed is located along the Gulf Intracoastal Waterway down the coast from the San Bernard River. There was no assessment conducted on this segment because there has not been data collected in years. It has been monitored for oyster waters only and is part of the Department of State Health Services (DSHS) Shellfish Harvesting Restrictions Map.

Chocolate Bay (2432)

The Chocolate Bay segment watershed includes several unclassified bayous draining a large amount of land within Brazoria and Galveston counties. Mustang Bayou begins in Missouri City to the northwest and travels southeastward passing Fresno, Pearland, Alvin, and Hillcrest Village. Downstream of Alvin are large agricultural fields of rice and

row crops. The Halls Bayou watershed (a sub-segment of Chocolate Bay), including Willow Bayou, drains Santa Fe and Hitchcock south of State Highway 6. South of FM 2004 coastal marshes dominate the landscape, and upstream of 2004 ranches and small farms are common.

Major Tributaries

- Chocolate, Cloud, Halls, Mustang, New, Persimmon, and Willow bayous

Areas of Concern

- A dissolved oxygen concern exists for some parts of the segment
- Contact recreation use impairments or concerns exist for most parts due to high bacteria levels
- Nutrient concerns (ammonia and total phosphorus) exist in a few parts
- A restricted fish consumption advisory exists for Chocolate Bay and Halls Bayou due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- Oyster harvesting is not supported in most parts due to bacteria levels

Plans

- Chocolate Bay is part of the Galveston Bay Bacteria Reduction Plan. TMDLs are in development within the Bay's tributaries. An implementation plan will be developed for the Chocolate Bay watershed, which includes the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds.

For more details see the Water Quality Summary Chart.

Christmas Bay (2434)

The Christmas Bay segment watershed is a coastal preserve and is part of the Texas General Land Office/Texas Parks and Wildlife Department Coastal Preserves Program. Christmas Bay is one of the most pristine areas in the Galveston Bay watershed. The area is surrounded by undeveloped wetland habitat and is part of a larger system of smaller bays and lakes. Only a few small subdivisions are built with access to Christmas Bay, and all structures must rely upon on-site sewage systems to handle waste.

Major Tributaries

- None

Areas of Concern

- Oyster harvesting is not supported in parts of the segment due to bacteria levels

Plans

- The Christmas Bay segment is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

Clear Lake (2425)

The Clear Lake segment watershed is home to one of the most concentrated fleets of recreational boats in the United States. Numerous marinas around the lake provide easy access to Upper Galveston Bay. On the south shore, the watershed encompasses League City, Clear Lake Shores, and Kemah. The north shore includes Taylor Lake Village, El Lago, Seabrook, Shoreacres, and Pasadena.

Major Tributaries

- Harris County Flood Control District Ditch A; Jarbo and Taylor bayous; Taylor Lake

Areas of Concern

- Contact recreation use impairments exist for Jarbo Bayou due to high bacteria levels
- Concerns exist for chlorophyll-*a* levels in some parts
- Nutrient concerns (nitrates and total phosphorus) exist in most parts
- A restricted fish consumption advisory exists in most parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- An impairment for copper in the water exists for Clear Lake

Plans

- Jarbo Bayou is part of the Bacteria Implementation Group

For more details see the Water Quality Summary Chart.

Drum Bay (2435)

The Drum Bay segment watershed is a small bay down the coast from West Bay and immediately southwest of Christmas Bay. The Brazoria National Wildlife Refuge is to the north, and development is limited to a small subdivision on Follets Island.

Major Tributaries

- None

Areas of Concern

- Oyster harvesting is not supported in parts due to elevated bacteria levels

Plans

- The Drum Bay segment is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

East Bay (2423)
The East Bay segment watershed encompasses East Bay, the Upper Bolivar Peninsula, and portions of Chambers County that are predominantly undeveloped. Abundant wetlands, marshes, and coastal prairie cover most of the peninsula. Development consists mostly of residential buildings, permanent and vacation homes, fish and bait camps, and small businesses.

Major Tributaries
- Oyster Bayou

Areas of Concern
- A dissolved oxygen concern exists in Oyster Bayou
- Concerns exist for chlorophyll-*a* levels in all parts
- A restricted fish consumption advisory exists in all parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- Oyster harvesting is not supported in parts due to bacteria levels

Plans
- The East Bay segment is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

East Matagorda Bay (2441)
The East Matagorda Bay segment watershed is located in Matagorda County and lies east of the Colorado River channel which flows to the Gulf of Mexico. The segment stretches to the east where the bay receives flow from Big Boggy, Live Oak, and Caney creeks, and Live Oak Bayou. The segment is predominantly undeveloped with wetlands, marshes, and coastal prairie covering most of the watershed.

Major Tributaries
- Live Oak, Big Boggy, and Caney creeks; Live Oak Bayou;

Areas of Concern
- Dissolved oxygen is fully supported
- No concerns exist for pH, nutrients, chlorophyll-*a* levels in all parts of the segment
- Oyster harvesting is not supported in part due to bacteria levels

Plans
- No watershed plans exist for the East Matagorda Bay segment

Lower Galveston Bay (2439)
The Lower Galveston Bay segment watershed primarily receives flow from other water bodies, including Upper Galveston Bay, East Bay, and West Bay, and is influenced by tides from the Gulf of Mexico. The land portion of the watershed includes parts of Galveston and Texas City. The entire bay is a major recreational area with boating, recreational and commercial fishing, and birding.

Major Tributaries
- None

Areas of Concern
- Concerns exist for chlorophyll-*a* levels in all parts
- Nutrient concerns (nitrates) exist in a few parts
- A restricted fish consumption advisory exists in all parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- Oyster harvesting is not supported in parts due to elevated bacteria levels

Plans
- The Lower Galveston Bay segment is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

Moses Lake (2431)
The Moses Lake segment watershed is surrounded by large tracts of undisturbed wetland and marsh habitats. The northeastern and northwestern portions of the watershed consist mostly of grasslands and forested lands, while the southern section is highly urbanized, containing parts of Texas City and La Marque. Part of the Texas City petrochemical complex is included in the southern portion of the watershed.

Major Tributaries
- Moses Bayou

Areas of Concern
- A dissolved oxygen concern exists for a few parts
- Contact recreation use is not supported in a few parts due to high bacteria levels
- Concerns exist for chlorophyll-*a* levels in some parts
- A restricted fish consumption advisory exists in some parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- The Moses Lake segment is part of the Highland Bayou watershed protection plan

For more details see the Water Quality Summary Chart.

San Jacinto Bay (2427)
The San Jacinto Bay segment watershed contains the Upper and Lower San Jacinto Bays and is separated from the Houston Ship Channel by dredge spoil island/impoundments. Portions of the Pasadena petrochemical complex occupy the western and southern shores of the bays, with the Fred Hartman Bridge crossing the north end of Lower San Jacinto Bay.

Major Tributaries
- None

Areas of Concern
- A concern exists for chlorophyll-*a* levels
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in the entire segment
- A restricted fish consumption advisory exists in all parts of the bay due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- The San Jacinto Bay is not included in any watershed plans

For more details see the Water Quality Summary Chart.

Scott Bay (2429)
The Scott Bay segment watershed is along the Houston Ship Channel and off the west shore of the City of Baytown. Heavy industry is on the east shore of the bay with residential areas to the north and the Baytown Nature Center and Brownwood Park to the northwest.

Major Tributaries
- None

Areas of Concern
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in entire segment
- A restricted fish consumption advisory exists in all parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- Scott Bay is not included in any watershed plans

For more details see the Water Quality Summary Chart.

Tabbs Bay (2426)/Goose Creek Tidal (2426C)
The Tabbs Bay and Goose Creek Tidal segment watersheds are surrounded by heavily industrialized areas and dense residential and commercial areas in Baytown. Tabbs Bay is located south of State Highway 146.

Major Tributaries
- None

Areas of Concern
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in Tabbs Bay
- A restricted fish consumption advisory exists in most parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- The Tabbs Bay/Goose Creek Tidal segment is not included in any watershed plans

For more details see the Water Quality Summary Chart.

Texas City Ship Channel (2437)
The Texas City Ship Channel segment watershed supports regular heavy barge and ship traffic. The Texas City petrochemical complex occupies most of the watershed, and the entire northern shoreline and turning basin are occupied by docks for loading and unloading raw materials and finished products. The ship channel receives stormwater and wastewater discharges from industrial complexes.

Major Tributaries
- None

Areas of Concern
- A concern exists for chlorophyll-*a* levels in the entire segment
- Nutrient concerns (nitrates, ammonia) exist in all parts
- A restricted fish consumption advisory exists in all parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue

Plans
- The Texas City Ship Channel segment is part of the Highland Bayou watershed protection plan

For more details see the Water Quality Summary Chart.

Trinity Bay (2422)
The Trinity Bay segment watershed is in Liberty County. Coastal wetlands dominate the near shore area with agricultural activities, such as cattle grazing, with row crops throughout the east side of the bay. Anahuac is on the northeast shore. Double Bayou West and East forks drain significant crop pasture lands. Smith Point separates Trinity Bay from East Bay and Lower Galveston Bay.

Major Tributaries
- Double Bayou West Fork, Double Bayou East Fork, Red Bayou, Old River, Trinity River, Anahuac Channel, and Cotton Bayou

Areas of Concern
- Dissolved oxygen impairments exist in Double Bayou West Fork. Double Bayou East Fork Tidal has a dissolved oxygen concern.
- Contact recreation use is not supported in Double Bayou East and West forks due to high bacteria levels
- Concerns exist for chlorophyll-*a* levels in most parts
- A restricted fish consumption advisory exists in most parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- Oyster harvesting is not supported in parts of this segment due to bacteria levels

Plans
- Trinity Bay is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

Upper Galveston Bay (2421)
The Upper Galveston Bay segment watershed contains a significant amount of industrial activity with the majority derived from barge transportation and ocean-going vessels. The lower portion of the watershed is a mix of residential and commercial communities.

Major Tributaries
- Clear Lake Channel

Areas of Concern
- Contact recreation use is not supported in a few parts, specifically Little Cedar Bayou and Sylvan Beach Park, due to high bacteria levels
- Concerns exist for chlorophyll-*a* levels in most parts
- Nutrient concerns (nitrates, ammonia, total phosphorus) exist in most parts
- A restricted fish consumption advisory exists in most parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- Oyster harvesting is not supported in parts of this bay segment due to high bacteria levels

Plans

- Upper Galveston Bay is part of the Galveston Bay Bacteria Reduction Plan

For more details see the Water Quality Summary Chart.

West Galveston Bay (2424)

The West Galveston Bay segment watershed encompasses the bay side of Galveston Island and includes several small bays, lakes, and bayous. West Bay is between the Galveston causeway bridge and San Luis Pass to the west. Primary land uses in the watershed are related to agriculture, with residential development in the coastal communities of Galveston, Jamaica Beach, Tiki Island, Bayou Vista, Hitchcock, La Marque, and Santa Fe.

Major Tributaries

- Basford, English, Highland, Marchand, Offats, and Karankawa bayous; Greens Lake; Lake Madeline

Areas of Concern

- Dissolved oxygen impairments or concerns exist in a few parts
- Contact recreation use is not supported in a few parts due to high bacteria levels
- Concerns exist for chlorophyll-*a* levels in a few parts
- Nutrient concerns (ammonia & total phosphorus) exist in part Lake Madeline, English Bayou, and Offatts Bayou
- A restricted fish consumption advisory exists in most parts due to elevated concentrations of PCBs/dioxin in edible fish and/or crab tissue
- Oyster harvesting is not supported in parts of West Galveston Bay due to bacteria levels

Plans

- West Galveston Bay is part of the Galveston Bay Bacteria Reduction Plan
- Several tributaries are part of the Highland Bayou watershed protection plan

For more details see the Water Quality Summary Chart.

Gulf of Mexico (2501)

The Gulf of Mexico segment watershed is along the Texas Coast between Sabine Pass to the mouth of the Rio Grande. The sections within the H-GAC region stretch from the Jefferson-Chambers County line to between Freeport and Port Aransas.

Major Tributaries

- None

Areas of Concern

- Contact recreation use is not supported in a few parts due to high bacteria levels
- Recreational beaches have intermittent advisories due to high bacteria levels. For current information, please refer to Texas Beach Watch Program Advisories (https://cgis.glo.texas.gov/Beachwatch)
- A restricted fish consumption advisory exists in most parts due to elevated concentrations of mercury in edible fish and/or crab tissue

For more details see the Water Quality Summary Chart.

Water Quality Wrap Up

Elevated levels of bacteria continue to be the biggest water quality issue throughout the region. High bacteria levels can inhibit safe contact recreation and the harvest of oysters. With the guidance of local stakeholders, nearly two dozen watershed-based plans, completed or in progress, have been designed to reduce bacteria levels and bring those water bodies with elevated levels of bacteria into compliance with state standards.

Fish Consumption Advisories, a result of elevated levels of PCBs/dioxin in fish and crab tissue, continue to be an important issue in the region's bays and many tidal water bodies. Federal, state, and local agencies and organizations continue to identify major sources of these toxic chemical compounds and develop procedures to remediate them.

Low levels of dissolved oxygen and increasing levels of nutrients are tracked through routine monitoring. Many of the best management practices being put in place through watershed-based plans to reduce bacteria levels have a positive impact by raising dissolved oxygen levels and reducing nutrients.

The H-GAC Clean Rivers program generates approximately 70 percent of data used for water quality decision making for the region by TCEQ. The data are used to help with the development and implementation of TMDLs, watershed protection plans, and other local actions. The ability to understand the developing health of the water bodies throughout the region is paramount. H-GAC will continue to work with state and local stakeholders to find ways to do more systematic and focused monitoring in areas with elevated bacteria to locate and remove chronic sources.

WATERSHED PROJECT SUMMARIES

Every two years, TCEQ submits the Texas Integrated Report of Surface Water Quality to the EPA for approval. The report provides an assessment of existing water quality in the

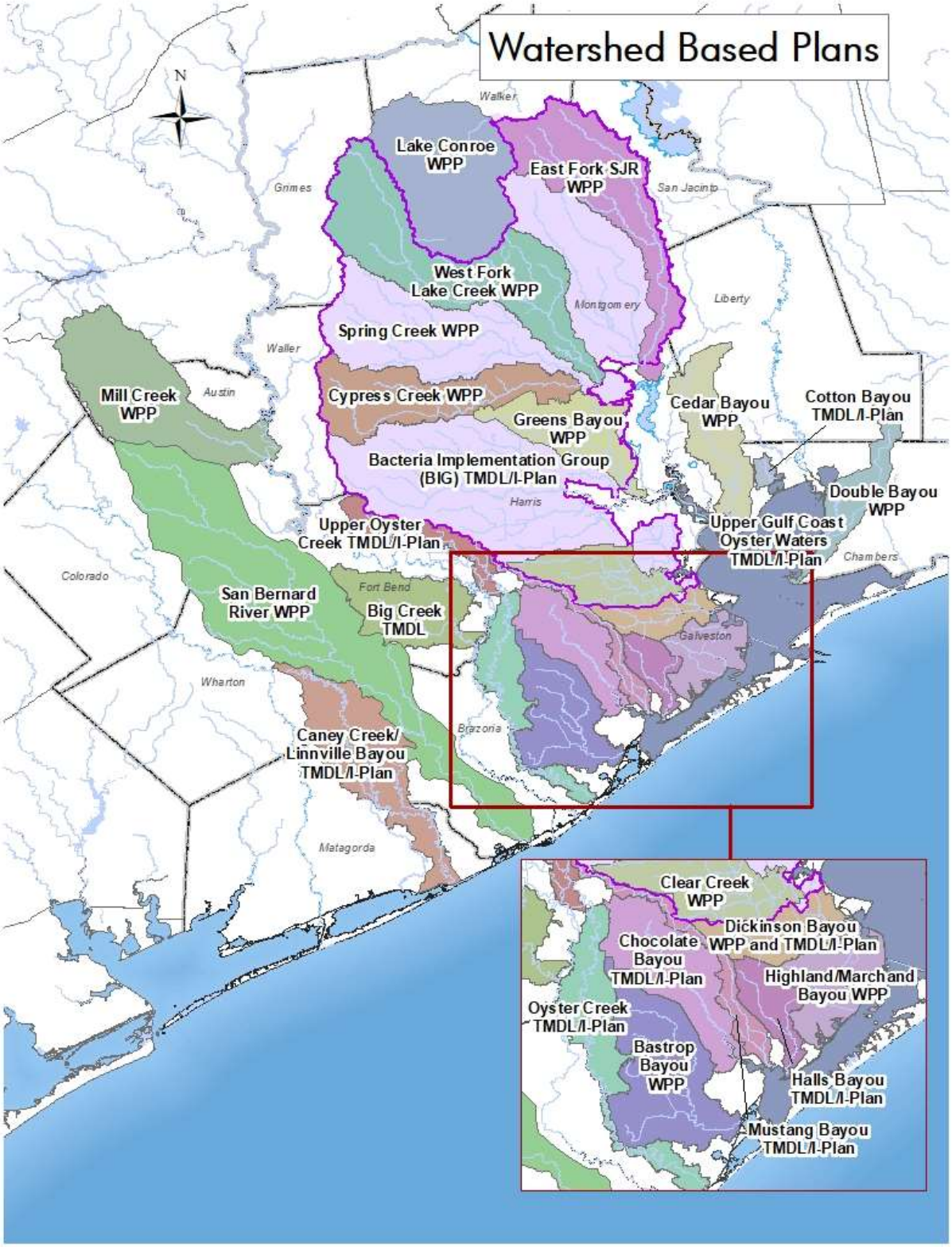
state and an overview of past and proposed water pollution reduction efforts. Clean Rivers Program monitoring data is included in the Integrated Report.

The Texas 303(d) List, part of the Integrated Report (www.tceq.texas.gov/waterquality/assessment), identifies water bodies that are impaired or threatened due to pollutant(s). The list may be used by planning agencies to prioritize watershed projects and acts as a catalyst for planning and mitigation strategies to address impairments and concerns, including bacteria, dissolved oxygen, nutrients, and PCBs/dioxin.

After a water body is added to the 303(d) List, there are two primary watershed-based planning paths for resolution available:

- developing a watershed protection plan, or
- determining a total maximum daily load and developing an implementation plan

H-GAC and other regional partners are actively involved in both types of watershed-based plans.



Map 12: Map of all Watershed Protection Plans and Total Maximum Daily Load Projects and Implementation Plans

Watershed Protection Plans

Watershed protection plans are developed with local stakeholders to address water quality issues in a community's water bodies. The plans are based on an EPA template to identify causes and sources of pollution, establish improvement goals, identify feasible and effective measures to address pollution sources, and establish ways to evaluate the effectiveness of the efforts. While the development of a watershed protection plan is usually due to a water body's inability to meet one or more state water quality standards, the plans can be implemented as a preventative measure. Watershed protection plans are not limited to a specific impairment and can consider a wide range of stakeholder concerns related to water. Implementation activities outlined by watershed protection plans are voluntary, contain no regulatory requirements, and generally focus on nonpoint sources of pollution such as urban, agricultural, and natural runoff. Watershed protection plans use Clean Rivers Program data to determine water quality priorities.

Watershed protection plans approved or in development for the H-GAC region are described below. More information about H-GAC watershed protection plans is available at Watershed-Based Plans | Houston-Galveston Area Council (H-GAC).

H-GAC Watershed Protection Plans

Bastrop Bayou

The Bastrop Bayou watershed drains a mix of land uses in rapidly growing eastern Brazoria County, including active agricultural production and small urban centers. Since 2004, TCEQ and H-GAC have worked with a diverse group of local stakeholders to develop and implement the Bastrop Bayou watershed protection plan (Bastrop Bayou Watershed Protection Plan) to address the bayou's elevated levels of bacteria. Potential sources of bacteria in the watershed include livestock, failing on-site sewage systems, pet waste, wildlife and feral hogs, urban runoff, and overflows from sanitary sewers.

Status

The watershed protection plan was approved by TCEQ, accepted by the EPA in August 2016, and is being implemented by H-GAC and local stakeholders. Implementation efforts include education and outreach activities, remediation of failing septic and aerobic wastewater systems, installation of pet waste management systems, and promotion of voluntary best management practices for agriculture.

Cedar Bayou

The Cedar Bayou watershed is at the junction of Harris, Liberty, and Chambers counties. It contains a mix of urban and rural land uses in a rapidly developing area. The

watershed spans approximately 173 square miles and drains into the Galveston Bay system. It has both tidal and above tidal (freshwater) segments.

Cedar Bayou has impairments for elevated levels of bacteria and PCBs/dioxin in fish tissue in its tidal segment. As recently as 2010, the above tidal segment was listed as impaired for macrobenthic communities by TCEQ. In subsequent reports, this segment has alternated between being listed as a use concern or fully supported for macrobenthic communities. Potential sources of bacteria in the watershed include failing on-site sewage systems, sanitary sewer overflows, wildlife and feral hogs, pet waste, urban runoff, land development activities, and farming and ranching activities.

Because of local concern for water quality, the Texas State Soil and Water Conservation Board, H-GAC, and local community stakeholders formed the Cedar Bayou Watershed Partnership (Cedar Bayou Watershed Protection Plan) to develop a watershed protection plan.

Status

The watershed protection plan was approved by the EPA in July 2016 and is in implementation, using voluntary activities such as reducing pet waste entering water bodies, improving sanitary sewer maintenance, remediating failing septic systems, and improving riparian corridors to address the bayou's water quality challenges.

San Bernard River

The San Bernard River watershed covers approximately 900 square miles in Austin, Colorado, Wharton, Fort Bend, and Brazoria counties. It is primarily rural and agricultural with a few small communities, including West Columbia, East Bernard, Sweeny, and Wharton. Contact recreation in the river is impaired by high bacteria levels, while excessive nutrients and low dissolved oxygen levels threaten fish and other aquatic life. Potential sources of bacteria include livestock, pet waste, wildlife and feral hogs, failing septic and aerobic systems, and sanitary sewer overflows. H-GAC, key community stakeholders, and TCEQ developed the San Bernard watershed protection plan (San Bernard River Watershed Protection Plan).

Status

The watershed protection plan was approved by the EPA in July 2017 and is in implementation. Local partners are implementing education and outreach efforts, dredging projects to restore hydrologic function, promotion of agricultural best management practices, and remediation of failing on-site sewage systems.

West Lake Houston Basin (West Fork San Jacinto River, Lake Creek, Spring Creek, and Cypress Creek)

The West Lake Houston Basin is made up of the drainage areas for the West Fork of the San Jacinto River, Lake Creek, Spring Creek, and Cypress Creek, which span approximately 1,250 square miles. The West Fork of the San Jacinto River is between the drinking water supply reservoirs of Lake Conroe to the north and Lake Houston to the south. It traverses the Interstate-45 corridor between Houston, The Woodlands, and Conroe, an area of robust growth and development. Lake Creek, Spring Creek, and Cypress Creek are the primary tributaries for the West Fork San Jacinto River. These watershed systems drain areas of Harris, Montgomery, Grimes, and Waller counties. Land use varies across the basin and includes undeveloped riparian forests and wetlands in the northern reaches, native grasslands and agricultural areas approaching the Katy Prairie to the west, and dense suburban communities adjacent to the Houston metropolitan area downstream.

Many water bodies within the Spring Creek watershed have elevated levels of bacteria, and some have shown levels of dissolved oxygen below the screening level. Potential sources of bacteria include livestock, pet waste, wildlife and feral hogs, failing septic and aerobic systems, and sanitary sewer overflows. Potential sources of low dissolved oxygen include fertilizers, livestock, pet waste, wildlife and feral hogs, failing septic and aerobic systems, and sanitary sewer overflows. There is also concern about sediment from development and sand and gravel mining operations in areas of the watershed near the confluence with Lake Houston.

<u>Status</u>

H-GAC worked with local stakeholders and TCEQ to develop projects for all watersheds within the basin. The watershed protection plan for the West Fork of the San Jacinto River and Lake Creek was approved by TCEQ and accepted by the EPA in January 2019. Watershed protection plans developed for Cypress Creek and Spring Creek were accepted by the EPA in 2021 and 2023, respectively. H-GAC and TCEQ are working with local stakeholders on implementation work, such as increasing the number of pet waste stations, installing storm drain markers, encouraging riparian conservation and tree plantings, remediating failing septic and aerobic systems, promoting agricultural best management practices, and conducting various outreach and education efforts.

Clear Creek

Clear Creek drains approximately 172 square miles of land covering portions of Fort Bend, Brazoria, Galveston, and Harris counties as it flows east toward its eventual confluence with Clear Lake. The creek connects many communities across a diverse

landscape of remnant undeveloped areas and the developed land uses that constitute most of its watershed.

Water quality issues, primarily high levels of fecal bacteria, are prevalent throughout the Clear Creek watershed. Elevated concentrations of fecal bacteria in area water bodies can be a result of human activities, such as overflow from sanitary sewers and on-site sewage facilities, pet waste and fertilizer runoff, as well as natural influences like waste from native wildlife or invasive feral hogs.

Status

Stakeholders in the Clear Creek Watershed Partnership worked with H-GAC and TCEQ to complete a draft watershed protection plan in 2023. The draft is available for download on the project website (www.clearcreekpartnership.weebly.com). The plan is currently under review by TCEQ and, pending approval, will be submitted to EPA for acceptance.

East Fork San Jacinto River

The East Fork San Jacinto River flows south from its headwaters in Walker County to a confluence with Lake Houston and is one of the primary tributaries of the San Jacinto River. This watershed area spans approximately 410 square miles and includes portions of Walker, Montgomery, San Jacinto, Liberty, and Harris counties. Land cover in the watershed area varies and is characterized by heavily wooded areas, especially in the portions of the watershed spanning Walker and San Jacinto counties. These areas are part of the Sam Houston National Forest. Pasture and woody wetlands are also common in these areas. The southern part of the watershed is more developed, especially in Liberty and Harris counties. Small cities, such as Cleveland, North Cleveland, Plum Grove, and Roman Forest, intersect or are completely contained within the watershed area. Large cities intersecting the watershed area include Huntsville and Houston.

Impairments due to elevated levels of fecal indicator bacteria are prevalent in East Fork San Jacinto River and its tributaries. Fecal bacteria in area water bodies can be a result of human activities, such as overflow from sanitary sewers and on-site sewage facilities, as well as natural influences like waste from native wildlife and invasive species. Other issues identified by stakeholders include sediment loading from development and bank erosion.

Status

H-GAC and TCEQ facilitated stakeholders in the East Fork San Jacinto River Partnership to develop a draft watershed protection plan in 2023. The plan was posted to the project website (www.eastforkpartnership.weebly.com) for a 30-day public comment

period. Comments are currently being incorporated before the plan is submitted to TCEQ for agency review.

Greens Bayou
The Greens Bayou watershed covers 208 square miles of densely developed area in Harris County. Much of the watershed area represents disadvantaged and underserved communities. Over 60 percent of the watershed population is considered low-to-moderate-income. Impairments due to elevated levels of fecal indicator bacteria are prevalent in Greens Bayou and its tributaries. Dissolved oxygen and nutrient concerns impede the water body's ability to support human and environmental uses. Flooding also presents issues in the watershed.

Status
H-GAC is working with TCEQ to begin characterizing the watershed through an assessment of Clean Rivers Program data. Local stakeholders will be brought together in the fall of 2024 to review these assessments and begin work on a watershed protection plan.

Other Area Watershed Protection Plans

In addition to H-GAC, other local entities are working with TCEQ and the Texas State Soil and Water Conservation Board to develop or implement watershed protection plans for local water bodies.

Dickinson Bayou
The Dickinson Bayou Watershed Protection Plan (www.agrilife.org/dickinsonbayou/watershed-information/) was developed by the Texas Coastal Watershed Program of Texas A&M University AgriLife. The plan addresses bacteria and nutrient issues in this coastal tributary to Galveston Bay in coastal Galveston, Harris, and Brazoria counties. This project will be extended through new funding in 2024.

Double Bayou
The watershed of the East and West Forks of Double Bayou drains 94 square miles of Liberty and Chambers counties before discharging to Trinity Bay. Local concern about elevated levels of bacteria and other water quality issues led to the formation of the Double Bayou Watershed Partnership (www.doublebayou.org/). The Houston Advanced Research Center, Galveston Bay Estuary Program, and Texas State Soil and Water Conservation Board supported local stakeholders of the Partnership in identifying

voluntary measures to address bacteria sources as part of the development of the Double Bayou watershed protection plan. The plan was approved by the EPA in July 2016. It is currently in implementation.

Highland and Marchand Bayous and Moses-Karankawa Bayous
The watershed protection plan effort for Highland and Marchand Bayous (www.agrilife.org/highlandbayou/) in coastal Galveston County was developed by the Texas Coastal Watershed Program of Texas A&M University AgriLife, the Galveston Bay Estuary Program, TCEQ, and local stakeholders to address elevated levels of bacteria and low levels of dissolved oxygen.

Based on preliminary work completed using Clean Rivers Program data in 2007, communities in Galveston County, coordinated by Texas A&M AgriLife Extension, established the Moses-Karankawa Bayous Alliance to begin addressing high bacteria levels and decreased levels of dissolved oxygen through a watershed characterization project and the development of a watershed protection plan. The watershed protection plan was accepted by the EPA in 2021, and implementation efforts are underway.

Lake Conroe
The Lake Conroe watershed protection plan (www.sjra.net/home/lake-conroe-watershed-protection-plan/) was developed by the San Jacinto River Authority and local stakeholders to address potential sources of contamination in lands immediately adjacent to the Lake Conroe reservoir. It is currently in implementation.

Total Maximum Daily Load/Implementation Plans

Total maximum daily load (TMDL) is a regulatory process triggered when a water body is placed on the 303(d) List. The total maximum daily load calculates the maximum amount of a single pollutant that a water body can receive and still meet water quality standards. To address the pollutant of concern, stakeholders complete an implementation plan that contains a series of recommended regulatory and/or nonregulatory best practices, identifies funding sources and implementing partners, and determines a project timeline. Clean Rivers Program data provides support for focusing water quality priorities.

More information about H-GAC total maximum daily loads and implementation plans is available at Watershed-Based Plans | Houston-Galveston Area Council (H-GAC).

H-GAC Implementation Plans

Bacteria Implementation Group

The Bacteria Implementation Group (Bacteria Implementation Group (BIG) | Houston-Galveston Area Council (H-GAC)) project area encompasses 125 approved total maximum daily loads, covering an area of 3,200 square miles (visually, this is about the area of Delaware and Rhode Island combined on a map). The project area spans parts of 10 counties: Brazoria, Galveston, Harris, Fort Bend, Grimes, Liberty, Montgomery, San Jacinto, Walker, and Waller.

Formed in 2008, the Bacteria Implementation Group is a 33-member stakeholder group that oversees an implementation plan to improve water quality in the greater Houston region and reduce bacteria levels. The implementation plan covers 11 management strategy areas with 38 activities.

The Bacteria Implementation Group's *Implementation Plan for 72 total maximum daily loads for Bacteria in the Houston-Galveston Region* received approval from TCEQ in January 2013. The plan is anticipated to be implemented over 25 years, with annual reviews to track success and make necessary course corrections. Four addendums to the plan have been made to update the number of total maximum daily loads completed within the project boundary and to expand the boundary to include Armand Bayou, East and West Forks of the San Jacinto River and Upper Lake Houston, and Jarbo Bayou.

To track success, the Bacteria Implementation Group produces an annual report using H-GAC Clean Rivers Program data to benchmark environmental progress toward implementation goals.

Status

Bacteria Implementation Group partners implementing plan activities have helped reduce bacteria levels overall by 32.1 percent between January 2005 and December 2022, including the expanded watersheds, though the trend has flattened in recent years. The partners have implemented elements of the plan for 10 years. The stakeholders are evaluating plan actions to determine changes that are needed to see the improvement trend continue over the next 10 years. These changes will be encapsulated in a revised implementation plan.

Upper Oyster Creek

The Upper Oyster Creek system begins near Fulshear, is greatly augmented by Brazos River water, and meanders downstream through impoundments in Sugar Land to rejoin the Brazos. Along the way, natural and human influences in the watershed contribute

pollutants to the water body. Total maximum daily load studies were completed by the Texas Environmental Institute for Applied Research for the system after data indicated it was unable to support the state water quality standards for contact recreation (due to elevated levels of bacteria) and aquatic life (based on low levels of dissolved oxygen). Two total maximum daily load reports were completed for the water body.

Status

The Upper Oyster Creek Implementation Plan (Upper Oyster Creek TMDL and Implementation Plan | Houston-Galveston Area Council (H-GAC)) for bacteria and aquatic life was approved by TCEQ in January 2014. There have been some improvements, with lower bacteria levels found within the watershed. A variety of local partners are implementing solutions which benefit water quality in the Upper Oyster Creek system. The progress made suggests the water body is benefitting from the continuation of Texas Pollutant Discharge Elimination System stormwater permits, good housekeeping for local utility systems, a robust set of public education efforts, and shared benefits from other unrelated local efforts. Continued rapid growth will require sustained support for these partner efforts in the watershed.

Chocolate Bayou

The water body was listed as impaired for bacteria on the 303(d) List in 2010. Chocolate Bayou begins in southeastern Fort Bend County near the town of Arcola and travels southeastward through eastern Brazoria County to Chocolate Bay. The watershed includes Iowa Colony, Manvel, Alvin, and Liverpool. While numerous subdivisions are being planned and developed, particularly near State Highway 6 and State Highway 288, open fields and pastures dedicated to ruminants and pockets of rice farming remain in the watershed.

Status

H-GAC has worked with watershed stakeholders since 2016 to complete two TMDLs (San Jacinto-Brazos Coastal Basin Bacteria Reduction Project | Houston-Galveston Area Council (H-GAC)). In 2024, local stakeholders will develop the Chocolate Bay Implementation Plan. The plan will include the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds.

Oyster Creek

The water body has been listed as impaired for bacteria on the 303(d) List since 2006. A portion of the above tidal segment has also been listed as impaired for dissolved oxygen since 1996. Oyster Creek begins in southern Fort Bend County in Sienna Plantation, a subdivision within Missouri City. The creek flows southward through the communities and cities in central Brazoria County, including Rosharon, Bonney, Holiday

Lakes, Angleton, Bailey's Prairie, Lake Jackson, and Clute. The upper and lower portions of the watershed are developed, while the middle remains under agriculture production. There are three Texas Department of Criminal Justice Prisons in the watershed's middle portion that are concentrated animal feeding operations.

Status
Two TMDLs to reduce fecal indicator bacteria were prepared by H-GAC and are under review by the TCEQ (San Jacinto-Brazos Coastal Basin Bacteria Reduction Project | Houston-Galveston Area Council (H-GAC)). A draft implementation plan to reduce bacteria has been created by stakeholders and is being reviewed by the TCEQ.

Halls Bayou Tidal
Halls Bayou, a tidal water body, has been listed as impaired for bacteria on the 303(d) List since 2012. Willow Bayou, a freshwater tributary, has been listed with an impairment for bacteria. The water bodies drain Santa Fe and Hitchcock southwest of State Highway 6, and the bayous flow southwestward toward Chocolate Bay. The watershed is sparsely populated, and most of the area is in rice production or pasturelands.

Status
Two TMDLs are being prepared by H-GAC and are expected to be finished in 2024 (San Jacinto-Brazos Coastal Basin Bacteria Reduction Project | Houston-Galveston Area Council (H-GAC)). In 2024, local stakeholders will develop the Chocolate Bay Implementation Plan. The plan will include the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds.

Mustang Bayou
Concerns for bacteria were first identified in 2010 within New and Persimmon bayous. A contact recreation impairment for bacteria was identified first in Mustang Bayou with the 2018 Texas Integrated Report, and New and Persimmon bayous in the 2020 Texas Integrated Report. Mustang Bayou begins in eastern Fort Bend County within the city limits of Missouri City. The bayou flows southeastward past Fresno, Pearland, and Manvel before flowing more southerly beginning at Alvin and Hillcrest Village. At this point, the bayou flows through agricultural fields and pastures before branching at Persimmon Bayou and terminating at New Bayou. Persimmon Bayou is mostly open habitat and marsh near Chocolate Bay, while New Bayou hosts numerous Chocolate Bay industrial refineries.

Status
Five TMDLs are being prepared and will be completed in 2024 (San Jacinto-Brazos Coastal Basin Bacteria Reduction Project | Houston-Galveston Area Council (H-GAC)).

Stakeholders will be developing the Chocolate Bay Implementation Plan in 2024. The plan will include the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds

Caney Creek
Bacteria impairments were first identified in 2002. Caney Creek drains the southern portion of Wharton and meanders southward past Boling-Lago, Lane City, Pledger Ashwood, Caney, Cedar Lane, and Sargent on its way to the Intra Coastal Waterway. Linnville Bayou is a major tributary east of Caney Creek that begins near Boling-lago and travels south past Danciger, Old Ocean, and Sweeny, before meeting up with Caney Creek near Cedar Lane. A smaller tributary, Hardeman Slough, begins northwest of Van Vleck and travels southeastward before it meets up with Caney Creek, north of Caney. Part of Caney Creek also demonstrates concerns for dissolved oxygen, poor aquatic habitat, and/or total phosphorus.

Status
Two TMDLs were approved by TCEQ in 2022 for Caney Creek for those impairments identified in 2002. Another portion of Caney Creek was found to be impaired with the 2020 Texas Integrated Report. An Addendum TMDL was prepared by H-GAC and is under review by the TCEQ (Brazos-Colorado Coastal Basin Bacteria Reduction Project | Houston-Galveston Area Council (H-GAC)). Caney Creek stakeholders submitted a draft implementation plan, which is waiting for approval by TCEQ.

Big Creek Segment
Two contact recreation impairments were first found by TCEQ in 2002. Big Creek falls within the Brazos River Authority's Clean Rivers Program region. Due to the creek's proximity to H-GAC and the watershed's location within H-GAC's service area, H-GAC prepared the TMDL and is facilitating meetings with the watershed's stakeholders. Big Creek drains the southern portions of Rosenberg, Richmond, and Sugar Land within Fort Bend County. Additionally, Beasley, Needville, Fairchilds, and Thompsons are located within Big Creek's watershed. For much of its length, Big Creek is a small- to- medium-sized stream that has been heavily modified in many areas to act as a drainage conveyance or as part of agricultural improvements (e.g., berms in riparian edges of fields). The creek's terminal end is at its confluence with the Brazos River at the eastern edge of Brazos Bend State Park.

Status
Two TMDLs have been prepared by H-GAC for Big Creek and are going through the TCEQ's approval process. A draft implementation plan prepared by stakeholders was submitted to TCEQ for review.

Cotton Bayou

The bacteria impairment was first identified in 2010. Cotton Bayou falls within the Trinity River Authority's Clean Rivers Program region. Due to the Bayou's location within the H-GAC Service Area, H-GAC prepared the TMDL and has supported watershed stakeholder involvement in the project. Cotton Bayou begins within the city limits of Mont Belvieu in Chamber County. Much of the stream network in the Cotton Bayou watershed consists of modified channels; however, Cotton Bayou itself, as well as its principal tributary, Hackberry Gully, are more natural water bodies flowing south to southeasterly both north and south of Interstate 10. The Cotton Bayou watershed drains into Cotton Lake, where the terminal end of Cotton Bayou forms a confluence with the lake. In turn, Cotton Lake receives tidal exchange that ultimately influences Cotton Bayou, through the connection with Trinity River Tidal.

Status

One bacteria TMDL has been completed by H-GAC and local stakeholders and submitted for TCEQ approval. A draft implementation plan has been prepared by stakeholders and is under TCEQ review.

Other Area Total Maximum Daily Load/Implementation Plans

Other total maximum daily load/implementation plan watershed projects, not led by H-GAC, are taking place in the H-GAC Clean Rivers Program region.

Dickinson Bayou

The Dickinson Bayou implementation plan development was led by Texas A&M AgriLife Extension (www.agrilife.org/dickinsonbayou/). The *Implementation Plan for Eight Total Maximum Daily Loads for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries* was approved by TCEQ in January 2014. The implementation plan addresses high levels of bacteria in Dickinson Bayou Tidal and its tributaries.

Texas A&M AgriLife is the managing stakeholder group facilitating the Dickinson Bayou Watershed Partnership. Focus areas address traditional sources of pollution, including on-site sewage facilities, wastewater treatment, and animal wastes, and recommend restoring natural buffering systems, such as riparian zones, preserving wetlands, and constructing wetlands.

Status

The implementation plan is complete, and a parallel watershed protection plan is being drafted. TCEQ is working with Texas A&M AgriLife Extension to complete the watershed protection plan. Texas A&M AgriLife continues to meet with stakeholders to develop the watershed protection plan and implement the bacteria reduction measures of the implementation plan.

Upper Gulf Coast Oyster Waters

The Upper Gulf Coast Oyster Waters implementation plan (www.tceq.texas.gov/waterquality/tmdl/25-oystercreek.html), led by the Galveston Bay Foundation with support from H-GAC, addresses 11 total maximum daily loads related to bacterial contamination of oyster fisheries in and around Galveston Bay. Eighteen stakeholder organizations and a group of concerned residents developed an implementation plan. The *Implementation Plan for 11 total maximum daily loads for Bacteria in Waters of the Upper Gulf Coast* was approved by TCEQ in August 2015. The implementation plan identifies likely bacteria sources, technical and financial needs, monitoring and outreach efforts, and a schedule of activities for each of the stakeholder-developed management measures that will be used to reduce bacteria levels.

Status

The Galveston Bay Foundation meets with stakeholders to implement activities through public education and outreach, including 'Cease the Grease', a regional campaign to reduce the impacts of fats, oils, and grease in sanitary sewers (www.CeasetheGrease.net). The program focuses on teaching proper disposal techniques to residents and establishing approved locations to recycle used cooking oil in the region. Funnels and pan scrapers are provided to residents at public events.

'Pump, Don't Dump', a boater waste education campaign focused on Galveston Bay (www.galvbay.org/how-we-protect-the-bay/in-our-communities/boater-waste-education/), has developed an interactive mapping application of all public, mobile, and private/member pump out stations and services to encourage use. Promotional materials (flags, key chains, whistles, cozies, etc.) with the "pump, don't dump" message on them are provided to boaters at public events.

Houston Ship Channel/Upper Galveston Bay

The Houston Ship Channel/Upper Galveston Bay Dioxin and PCB total maximum daily loads (https://www.tceq.texas.gov/waterquality/tmdl/78-hsc-pcbs.html) are in the southern portion of the San Jacinto River, Houston Ship Channel, Galveston Bay, and

several tidal tributaries to the bay system. Total maximum daily loads were developed in response to fish consumption advisories issued for the presence of PCBs/dioxin in edible fish and shellfish tissues.

The purpose of developing total maximum daily loads was to determine the necessary reductions in PCBs/dioxin in these watersheds to meet water quality standards. During the total maximum daily load development process, historic and legacy sources of the chemicals were identified by stakeholders, EPA, and TCEQ and considered likely causes for most of the sediment contamination in the San Jacinto River and Houston Ship Channel. The stakeholder group has not met since 2012. Focus shifted to cleanup of the legacy sources.

The San Jacinto River Waste Pits (www.epa.gov/tx/sjrwp) were identified as a primary contributor of dioxin to the Galveston Bay Estuary. In 2008, EPA Region 6 listed the San Jacinto River Waste Pits as a Superfund Site.

Status

The Galveston Bay Foundation places seafood consumption advisory signage at fishing locations and boat ramps throughout the San Jacinto River, Houston Ship Channel, and Upper Galveston Bay.

The EPA, TCEQ, responsible parties, and stakeholders continue to meet and work to address the Superfund Site. There is an agreed plan and work continues to remediate the site (SJRWP | US EPA).

Other Watershed Programs and Projects

On-site Sewage System Management

Regular maintenance and inspection of on-site sewage facilities protects public and environmental health, increases system longevity, and enhances private property use and value. In conjunction with the Clean Rivers Program, H-GAC offers programs (https://h-gac.com/on-site-sewage-facilities) to help reduce bacteria levels in water bodies near these facilities.

In the Homeowner Education Course, residents receive an overview of both types of on-site sewage systems (septic or aerobic), information on system maintenance and inspection, and details on available resources to maintain, repair, and replace aging systems. The course provides homeowners the basics of on-site sewage system

maintenance and visual inspection but does not provide for or allow homeowners to inspect their own aerobic system in place of professional inspections as part of a regular maintenance contract.

The Wastewater Assistance Program provides funding for the repair and replacement of failing on-site sewage systems (septic or aerobic). Funding is available to homeowners who meet certain income parameters. No matching funds are required. This program is funded through a Supplemental Environmental Project through TCEQ, with additional funding from the Harris County District Attorney's Office. Funding from corporate donations is also available for this project.

The On-Site Sewage Facility Information System Mapping Tool contains data on the locations of permitted on-site sewage facilities by age, authorized agent, permitting authority, number of permits per square mile, and likely locations of unpermitted systems. Updates to the mapping tool are conducted as part of the annual Water Quality Management Plan.

Water Quality Management Plan

H-GAC conducts water quality management planning as part of a Clean Water Act Section 604(b) grant program funded by the EPA through TCEQ. The annual Water Quality Management Plan Update (https://www.h-gac.com/water-quality-management-planning) describes a series of data collection, special study, and coordination activities completed through this project. The purpose of these activities is to provide data and analysis regarding wastewater infrastructure, watershed planning, and sources or nonpoint source pollution that affect water quality in the region.

Data acquired and assessed through this project include geospatial data for wastewater treatment plant outfalls and service area boundaries, self-reported effluent monitoring data, and occurrences of sanitary sewer overflows. Updates to the on-site sewage facility information system mapping tool are coordinated through this project.

The quality-assured data from this project are used extensively to inform decisions in multiple watershed projects and programs, such as the Clean Rivers Program, Bacteria Implementation Group, and numerous watershed protection plan and total maximum daily load projects. Data are also made available to project partners and H-GAC member entities for use in their water quality planning activities.

Coastal Communities Outreach Program

H-GAC's Coastal Communities Outreach and Education Program improves education and outreach about water pollution in Brazoria, Chambers, Galveston, and Matagorda counties by bridging the gap between the needs identified by communities and the implementation measures in watershed-based plans.

The program helps small communities without municipal separate storm sewer system permits engage residents in education and outreach that promotes behavior change to reduce the potential for water pollution. These communities typically lack financial and staff capacity to develop, launch, implement, and maintain public outreach campaigns.

The project focuses on four pillars of behavior change: pet waste management; fats, oils, and grease disposal; litter and illegal dumping; and on-site sewage facility repair and maintenance. H-GAC maintains a website for coastal communities (www.coastalcommunitiestx.com) that offers resources and tools for planning and implementing residential education and outreach campaigns. Local governments, utility districts, schools, civic organizations, homeowner associations, apartment managers, and other volunteers can use the tools to engage residents in positive behavior change. H-GAC also worked with local stakeholders to develop and pilot materials to specifically address fats, oils, and grease disposal in apartment complexes.

In 2023, H-GAC efforts in the program focused on identifying areas in communities where vulnerable populations overlap with high numbers of on-site sewage facilities and who may experience barriers to either receiving current program outreach materials or attending educational workshops. By working with local community partners already interacting with these residents, the program will pilot new materials and strategies to try and overcome identified barriers and more effectively engage the residents on the topic of on-site sewage facility repair and maintenance.

Galveston Bay Coalition of Watersheds

The Galveston Bay Coalition of Watersheds is an informal group of stakeholders from four watershed areas in Brazoria and Galveston counties: Bastrop, Dickinson, Highland, and Jarbo bayous. The Coalition serves as a long-term sustainable group that shares effort and cost of implementing watershed-based plans across multiple watersheds with similar identified pollution sources, easing the burden for individual communities. The Coalition is coordinated by the Texas Community Watershed Partners of Texas AgriLife.

OUTREACH ACTIVITIES

Public outreach is a cornerstone of the H-GAC Clean Rivers Program and is considered in all projects that staff implement. Outreach efforts seek to inform and educate local stakeholders about water quality issues and empower them to take an active role in the health of local water bodies.

Outreach Priorities

Stakeholder engagement, education, and outreach takes several forms in the H-GAC Clean Rivers Program. Outreach and education activities are often coordinated with other water resources programs and projects in the region. Coordination among these projects allows the Clean Rivers Program to reach a broad audience while tailoring information to the needs of a specific geographic or project boundary.

The following is an overview of key stakeholder engagement and outreach activities from 2023.

Outreach Projects and Programs

Texas Stream Team

The H-GAC Texas Stream Team program (www.h-gac.com/texas-stream-team), managed locally by the Clean Rivers Program, with support from the Galveston Bay Foundation, Bayou Preservation Association, and City of Sugar Land, trains and certifies volunteer water quality community scientists. There are 74 active monitoring stations in the four basins managed by H-GAC. Most sites collect the program's Standard Core parameters, but thanks to the help of partners, some sites also collect *E. coli* bacteria samples, Advanced parameters, or Riparian Evaluation data. In 2023, trainings in Brazoria, Fort Bend, Harris, and Montgomery counties certified 20 new monitors.

Texas Stream Team data is found on the Water Resources Information Map (www.h-gac.com/go/wrim/).

Texas Stream Team data are used to supplement professionally collected data and provide data in areas where professional monitoring does not take place. This monitoring is valuable to the Clean Rivers Program by helping identify areas with emerging water quality problems to determine where new professional monitoring might be needed.

H-GAC publishes a quarterly e-newsletter for monitors, interested governments, organizations, and residents.

Clean Waters Initiative

The Clean Waters Initiative (https://www.h-gac.com/clean-water-initiative-workshops), a workshop series facilitated by H-GAC Clean Rivers Program staff, offers education and information to local governments, nonprofit organizations, landowners, and residents to help develop effective strategies to reduce pollution in local water bodies. The workshops provide an opportunity for diverse stakeholder groups to network.

In 2023, three workshops focused on conservation and riparian areas, stormwater programs and impaired waters, and volunteer water quality monitoring programs.

Water Resources Information Map

The Water Resources Information Map (www.h-gac.com/go/wrim/) is an interactive mapping tool displaying all Clean Rivers Program professional and Texas Stream Team volunteer water quality monitoring sites in the region, with photos and data associated with each site. This tool, compatible with mobile devices, is available to anyone interested in current and historic water quality data, issues, and trends in the region.

Outreach Activities

River, Lakes, Bays 'N Bayous Trash Bash®

The Rivers, Lakes, Bays 'N Bayous Trash Bash® (www.TrashBash.org), established by the H-GAC Clean Rivers Program and the Texas Natural Resource Conservation Commission in 1993, is the largest single-day water body cleanup in Texas. Trash Bash is managed by the Texas Conservation Fund, with support from the Gulf Coast Authority and a volunteer steering committee. H-GAC staff provide regional coordination for the event.

Trash Bash® promotes environmental stewardship of the Galveston Bay watershed through public education by using hands-on educational tools and developing partnerships between environmental, governmental, and private organizations. Since its inception, more than 119,000 volunteers have removed over 2,400 tons of trash. In 2023, 2,456 volunteers at 14 locations collected 40.51 tons of trash, 219 tires, and almost a

half-ton of recyclable material while cleaning 108.2 miles of area shoreline. Approximately half the volunteers are under 18-years of age, and nearly a quarter participate in scouting.

In 2023, Trash Bash® held its 29th cleanup event and was a finalist in the Texas Environmental Excellence Awards in the Civic/Community category.

Other Education and Outreach Activities

H-GAC Clean Rivers Program staff attend public-facing education and outreach events to encourage residents of the region to adopt positive water pollution prevention behaviors in their daily lives.

For outreach events that have educational booths, staff select materials and messaging for each event from a collection of interactive exhibits H-GAC created with the help of grant funding from TCEQ and the Galveston Bay Estuary Program. Materials focus on common residential behaviors that can result in water pollution, with the primary focus on reducing bacterial levels in local water bodies. While Clean Rivers Program staff did not participate in many booth-style outreach events in 2023, they helped make sure the outreach materials still reached residents. All materials can be borrowed at no charge by groups wishing to talk about water quality in their communities, and seven complete sets of the materials are on long-term loan with partners for use at events throughout the year. The educational posters for the exhibits are available in English, Spanish, and Vietnamese.

Materials

- *Pitch the Poop* reinforces the need to pick up pet waste. Participants can win pet waste bag dispensers for dog leashes by playing the game;
- *Defeat the Grease Monster* demonstrates the effects of improper disposal of fats, oils, and grease on sanitary sewer pipes and on-site sewage facilities. Participants can win funnels and plate scrapers by playing the game;
- *Turn Your Yard into a Sponge* illustrates the pollutants contained in stormwater runoff from residential home surfaces (roof, yard, impervious surfaces). Participants can receive a brochure on how to prevent stormwater pollution at home; and
- *Fish Me from the Watershed* focuses on proper disposal of trash. Participants decide where to dispose of common types of trash (landfill, recycling bin, other recycling options, household hazardous waste) and if this is a viable item for reusing or reducing. Participants can receive a refrigerator magnet, donated by

the H-GAC Solid Waste Management program, to remind them to check www.Earth911.com for proper disposal or recycling options.

H-GAC staff

In addition to using the H-GAC outreach materials above, Clean Rivers Program staff participated in several outreach events in 2023 that were not in an outreach booth format.

- Provided educational support for a new Trash Bash cleanup site on Greens Bayou using the educational materials;
- Provided steering committee representation for the Trash Summit, a regional collaborative to develop a marine debris reduction action plan (www.donttrashagoodthing.org);
- Partnered on the Trash Free Texas Adopt-a-Spot project (www.trashfreetexas.org), a statewide collaborative through the EPA Trash Free Waters Program to consolidate litter adopt-a-spot programs into one interactive mapping application;
- Discussed bacteria in area bayous and related outreach opportunities at the Bayou Preservation Association watershed and subcommittee meetings; and
- Used Clean Rivers Program data for planning at Basin 11 and Basin 13 bacteria reduction project and regional watershed protection plan stakeholder meetings.

Online

H-GAC's water quality programs and activities are listed on the agency and program websites and social media. Water resources staff also monitor a dedicated e-mail account for questions and more information.

These sources include the following:

- Houston-Galveston Area Council website (www.H-GAC.com)
- Trash Bash Website (www.TrashBash.org)
- Coastal Communities Website (www.coastalcommunitiestx.com)
- Email (waterresources@h-gac.com)
- H-GAC Facebook (www.facebook.com/HouGalvAreaCog)
- H-GAC also has YouTube, X (formerly Twitter) and Instagram pages
- Trash Bash Facebook (www.facebook.com/TrashBash/)

APPENDICES

APPENDIX A: ACRONYMS & ABBREVIATIONS

Table of acronyms & abbreviations found in report

ALU	Aquatic Life Use	OSSF	On-Site Sewage Facility
AU	Assessment Unit	PCB	Polychlorinated biphenyl
BIG	Bacteria Implementation Group	PCR1	Primary Contact Recreation 1
BMP	Best Management Practices	PCR2	Primary Contact Recreation 2
CMS	Coordinated Monitoring Schedule	QAPP	Quality Assurance Project Plan
CN	Concern for near nonattainment	RUAA	Recreational use attainment analysis
CRP	Clean Rivers Program	SCR1	Secondary Contact Recreation 1
CS	Concern for screening levels	SCR2	Secondary Contact Recreation 2
DO	Dissolved Oxygen	SJRA	San Jacinto River Authority
E. coli	*Escherichia coli*	SWQM	Surface Water Quality Monitoring
EIH	Environmental Institute of Houston, University of Houston-Clear Lake	SWQMIS	Surface Water Quality Monitoring Information System
EPA	United States Environmental Protection Agency	TCEQ	Texas Commission on Environmental Quality
FY	Fiscal Year	TKN	Total Kjeldahl Nitrogen
H-GAC	Houston-Galveston Area Council	TMDL	Total Maximum Daily Load
I-Plan	Implementation Plan	TRIES	Texas Research Institute for Environmental Studies
mg	milligram	TSS	Total Suspended Solids
mg/L	milligram per liter	TSSWCB	Texas State Soil and Water Conservation Board
mL	milliliter	TSWQS	Texas Surface Water Quality Standards
MPN	Most Probable Number	UAA	Use Attainability Analysis
MT	Monitoring Type	USACE	United States Army Corps of Engineers
NC	No Concern	USGS	United States Geological Survey
NCR	Noncontact Recreation	WPP	Watershed Protection Plan
NPS	Nonpoint Source Pollution	WWTF	Wastewater treatment facility

APPENDIX B: Glossary of Water Quality Terms

A

Algae - Plants that lack true roots, stems and leaves. Algae consist of non-vascular plants that attach to rocks and debris or float freely in the water. Such plants may be green, blue-green, or olive-green and slimy to the touch. They usually have a coarse filamentous structure.

Ambient - The existing water quality in a particular water body (beyond the immediate influence of a discharge pipe).

Ammonia-Nitrogen (NH_3 -) - Ammonia, naturally occurring in surface and wastewaters, is produced by the breakdown of compounds containing organic nitrogen.

Aquatic Life Use (ALU) - A designation assigned to an individual water body segment based upon the potential to support aquatic life.

Assessment Unit (AU) - The smallest geographic areas of a water body that can support a designated or site-specific use.

Assessed Waters - Water bodies for which the State is able to make use-support decisions based on actual information.

B

Bacteria – single-cell organisms that are neither plants nor animals. This report refers to a category of organisms that are potentially harmful due to their source being the gastrointestinal tract of warm-blooded animals. Bacteria may refer to fecal bacteria, fecal coliform, *E. coli* bacteria, or enterococci bacteria in general

Basin - Large geographic areas generally containing one or more watersheds.

Best Management Practices (BMPs) - Schedules of activities, maintenance procedures, and other management practices to prevent or reduce the pollution of water to the maximum extent practicable. Best management practices include treatment requirements, operating procedures, and practices to control facility site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Bloom - The accelerated growth of algae and/or higher aquatic plants in a body of water. Bloom is often related to pollutants that increase the rate of growth.

C

Chloride (Cl-) - One of the major inorganic ions in water and wastewater. Concentrations can be increased by industrial processes. High chloride concentrations can affect metallic objects and growing plants.

Chlorophyll-a - A photosynthetic pigment found in all green plants. The concentration of chlorophyll a is used to estimate phytoplankton biomass (all of the phytoplankton in a given area) in surface water.

Classified - Refers to a water body that is listed and described in Appendix A or Appendix C of the Texas Surface Water Quality Standards.

Coastal Basin - A collection of watersheds adjacent to the coastline that water flows through on its way to the ocean. Typically, coastal basins are between and bound by two major river basins and a bay or other outlet to the ocean.

Concentration - The amount or mass of a substance present in a given volume or mass of samples.

Confluence - The flowing together of two or more streams, including where a tributary join another, usually larger, stream segment.

Contact Recreation - Recreational activities involving a significant risk of ingestion of water, including wading by children, swimming, water skiing, diving, and surfing. See also noncontact recreation.

Contamination - Degradation of water quality due to human activity (as compared to the original or natural conditions).

Conventional Parameters - A list of basic parameters that require laboratory analyses. The parameters frequently include, but are not limited to, total suspended solids (TSS) and total dissolved solids (TDS), nutrients (nitrogen and phosphorus compounds), chlorides, and sulfates.

Criteria - Water quality conditions that are to be met to support and protect desired uses. Some criteria are numeric and some are narrative (generally descriptive in nature).

D

Designated Use - A use that is assigned to specific water bodies in Appendix A or in Appendix D of the Texas Surface Water Quality Standards. Typical uses that may be

designated for specific water bodies include domestic water supply, categories of aquatic-life use, kinds of recreation, and aquifer protection.

Dioxin - A family of polychlorinated chemicals found in waste from the paper bleaching processes and the combustion of chlorinated compounds. It is considered carcinogenic and can disrupt the reproductive and immune systems in humans.

Discharge - The rate of fluid flowing past a given point at a given time.

Dissolved Oxygen (DO) - The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life.

Dissolved Oxygen (DO) Measurements, 24-hour - The measurement of dissolved oxygen over a 24-hour period using deployed, unattended, automated equipment preset to record and store field measurements. These measurements are used to assess Aquatic Life Use.

E

E. coli - *Escherichia coli*, a member of the total coliform group of bacteria found in feces. It indicates fecal contamination and the possible presence of enteric pathogens (viral, protozoan, and bacterial pathogens of the gastrointestinal route).

Effluent - Wastewater (treated or untreated) that flows out of a treatment plant or industrial outfall (point source) prior to entering a water body.

Enterococci - A subgroup of fecal streptococcal bacteria (mainly Streptococcus faecalis and Streptococcus faecium) found in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens.

Estuary - Regions of interaction between rivers and near shore ocean waters where tidal action and river flow create a mixing of fresh and salt water.

Eutrophication - The process by which water becomes enriched with nutrients (particularly phosphorus and nitrogen).

F

Fecal Coliform - A subset of the coliform bacteria group that is found in the intestinal tracts and feces of warm-blooded animals. Heat-tolerant bacteria from other sources can sometimes be included. It is used as an indicator of the potential presence of pathogens.

Field Parameters - A list of basic tests generally collected in the field using equipment and meters. The list also includes visual observations.

Flood - A relatively high streamflow that overtops the banks of a stream.

Fully Supporting (FS) - The water body meets Texas Surface Water Quality Standards (TSWQS) or supports its designated uses.

H

Habitat - The area in which an organism lives.

Headwaters - The source and upper part of a stream.

I

Impaired - A designation for an associated use (aquatic life, contact recreation, etc.) where a water quality standard is not attained.

Impairment - A detrimental effect on the integrity of a water body caused by a change in the chemical, physical, or biological quality or condition of a water body that prevents attainment of the designated use.

Implementation Plan (I-Plan) - A formalized written plan developed by stakeholders to address specific concerns (e.g., bacteria) and contain policy recommendations to bring water bodies into compliance.

Impoundment - A body of water confined by a dam, dike, floodgate, or other barrier.

Indicator Organism - An organism, species, or community that indicates the presence of a certain environmental condition or conditions.

M

Macrobenthic Invertebrate - Aquatic bottom-dwelling fauna. Common types are flat worms, leeches, snails, and various insect species.

Monitoring - The process of sampling and analyzing water quality parameters over time.

Municipal Separate Storm Sewer System (MS4)- A conveyance (or system of conveyances) that is owned by a state, city, town, village, or other public entity that discharges to waters of the United States., is designed to collect or convey stormwater (e.g., storm drains, pipes, ditches), is not a combined sewer, and is not part of a sewage treatment plant or publicly owned treatment works.

N

Nitrate-Nitrogen (NO_3-N) - A compound containing nitrogen that can exist as a dissolved solid in water. Excessive amounts can have harmful effects on humans and animals (>10 mg/L).

Nitrite-Nitrogen (NO_2-N) - An intermediate oxidation state in the nitrification process (ammonia, nitrite, and nitrate).

Noncontact Recreation - Aquatic recreational pursuits not involving a significant risk of water ingestion and limited body contact incidental to shoreline activity; including fishing, and commercial and recreational boating. See also contact recreation.

Nonpoint Source (NPS) Pollution - A pollution source that is not subject to regulation, that is diffuse and does not have a single point of origin or is not introduced into a receiving stream from a specific outfall. NPS pollution typically results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

Nutrient - Any substance used by living things to promote growth. The term is generally applied to nitrogen and phosphorus in water and wastewater but is also applied to other essential and trace elements.

O

Outfall - A designated point of effluent discharge.

Oyster Waters - Waters producing edible species of clams, oysters, or mussels.

P

Permit - A legally binding document issued by a state or federal permitting authority to the owner or manager of a point source discharge. The permit document contains a schedule of compliance and specifies monitoring and reporting requirements.

pH - The hydrogen-ion activity of water caused by the breakdown of water molecules and presence of dissolved acids and bases.

Phosphorus - A nutrient essential to the growth of organisms. It can be the nutrient that limits the primary productivity of water. In excessive amounts from wastewater, agricultural drainage, and certain industrial waste it also contributes to the eutrophication (the natural aging progression) of lakes and other water bodies.

Pollution - The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water that renders it harmful, detrimental, or injurious to humans, animal life, vegetation, property, or the public health, safety, or welfare. Pollution may impair the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

Point Source Pollution - Any source of pollution that is subject to regulation and is permitted. An example of a point source is a permitted wastewater treatment facility effluent discharge.

Polychlorinated Biphenyls (PCBs) - A class of organic compounds used in dielectric fluids in transformers, capacitors, and coolants. PCBs are highly toxic and are associated with endocrine disruption and neural toxicity in humans.

Precipitation - Any or all forms of water particles that fall from the atmosphere (such as rain, snow, hail, etc.).

Public Water Supply (PWS) Use - A water body designated to provide water to a public water system.

Q

Quality Assurance Project Plan (QAPP) - A written document outlining the procedures a monitoring project will use to ensure the data it collects and analyzes meets project requirements.

R

Recreational Use Attainment Analysis (RUAA) - A Use Attainment Analysis that is designed to determine if contact recreation is an appropriate use of a water body.

Reservoir - Any natural or artificial holding area used to store, regulate, or control water.

Riparian - Areas adjacent to streams or rivers with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

River Basin - A collection of watersheds drained by a major river and its tributaries.

Routine Monitoring - Monitoring that is scheduled in advance without intentionally trying to target a certain environmental condition. Routine monitoring typically consists of field measurements, conventional chemical parameters, bacteria, and flow measurements.

Runoff - The part of precipitation or irrigation water that runs off land into streams and other surface water.

S

Screening Level - Instream concentrations for parameters that establish targets that can be directly compared to monitoring data. Screening levels are derived from long-term monitoring data or published levels of concern.

Sediment - Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water and deposited in reservoirs and slow-moving areas of streams and rivers.

Segment - A water body or portion of a water body that is individually defined and classified in the Texas Surface Water Quality Standards. A segment is intended to have relatively homogeneous chemical, physical, and hydrological characteristics. A segment provides a basic unit for assigning site-specific standards and for applying water quality management programs. Classified segments may include streams, rivers, bays, estuaries, wetlands, lakes, and reservoirs.

Sonde - A multi-parameter water quality monitoring device that calculates and records field parameters.

Specific Conductance - A measure of the ability of a liquid to conduct an electrical current.

Standards - The designation of water bodies for desirable uses and the narrative and numerical criteria deemed necessary to protect those uses.

Stormwater - Rainfall runoff, snow-melt runoff, surface runoff, and drainage.

Stream Mile - A distance of one mile along a line connecting the midpoints of the channel of a stream.

Sulfate (SO_{2-4}) - An ion derived from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Sulfates are widely distributed in nature.

Surface Water - An open body of water, such as a lake, river, or stream.

Surface Water Quality Monitoring Information System (SWQMIS) - A database that serves as a repository for surface water quality monitoring data for Texas. SWQMIS also provides data validation and reporting tools, a mapping interface, and modules for tracking information about projects and quality assurance documents.

T

Texas Surface Water Quality Standards (TSWQS) - Standards that establish explicit goals for the water quality of streams, rivers, lakes, and bays throughout the state. The Standards are developed to maintain the quality of surface waters in Texas so that it supports public health and enjoyment and protects aquatic life, consistent with the sustainable economic development of the state. Water quality standards identify appropriate uses for the state's surface waters, including aquatic life, recreation, and sources of public water supply. The TSWQS are codified in Title 30, Chapter 307 of the Texas Administrative Code.

Tidal - Descriptive of coastal waters subject to the ebb and flow of tides. For purposes of standards applicability, tidal waters are saltwater. Classified tidal waters include all bays and estuaries with a segment number that begins with 24xx, all streams with the word tidal in the segment name, and the Gulf of Mexico.

Total Dissolved Solids (TDS) - The amount of material (inorganic salts and small amounts of organic material) dissolved in water and commonly expressed as a concentration in terms of milligrams per liter.

Total Maximum Daily Load (TMDL) - The total amount of a substance that a water body can assimilate and still meet the Texas Surface Water Quality Standards.

Total Suspended Solids (TSS) - The amount of organic and inorganic suspended particles in water.

Toxicity - The occurrence of adverse effects to living organisms due to exposure to toxic material. Adverse effects caused by conditions of temperature and dissolved oxygen are excluded from the definition of toxicity.

Tributary - A stream or river that flows into a larger one.

U

Use Attainability Analysis (UAA) - A structured scientific assessment of the factors affecting a water body's attainment of specified uses.

W

Water body or Body of Water - Refers to any mass of water (lake, bay, river, creek, bayou, etc.).

Water Quality - The chemical, physical, and biological characteristics of water.

Watershed - The area of land from which precipitation drains to a single point. Watersheds are sometimes referred to as drainage basins or drainage areas.

Watershed Protection Plan (WPP) - A voluntary, locally led approach to address state water quality standard impairments along with other water-related concerns.

Wastewater Treatment Facility (WWTF) – is a place where wastewater from homes, businesses, and other buildings is collected and processed to remove contaminants and make it significantly cleaner and safer before being released into water bodies or reused.

APPENDIX C: Water Quality Parameters

FIELD PARAMETERS

- Dissolved Oxygen (DO)
- Instantaneous Flow
- pH
- Salinity
- Secchi Transparency
- Specific Conductance (SpCond)
- Temperature

CONVENTIONAL PARAMETERS

- Ammonia-Nitrogen (NH3-N)
- Chloride (Cl-)
- Chlorophyll-*a* (Chl-*a*)
- Nitrate-Nitrogen (NO_3-N)
- Nitrite-Nitrogen (NO_2-N)
- Total Phosphorus (TP)
- Sulfate (S_2O_4)
- Total Kjeldahl Nitrogen (TKN)
- Total Suspended Solids (TSS)

BACTERIA PARAMETERS

- *Escherichia coli* (*E. coli*)
- Enterococci

ORGANIC PARAMETERS

- Dioxin
- Polychlorinated Biphenyls (PCBs)

Table XX: Water Quality Parameters, Potential Impacts, and Sources

Parameter	Potential Impacts	Potential Causes
Ammonia-Nitrogen (NH_3-N)	Elevated levels of ammonia can injure or kill aquatic life, such as fish and invertebrates. In fish, even low concentrations of ammonia can damage sensitive tissues (such as gills), can deplete natural resistances to bacterial infections, and can hinder reproductive capacities and growth.	Ammonia occurs naturally as a by-product of protein metabolism and decomposition. Ammonia can also enter a water body from runoff of fertilizers, livestock waste, and from discharges of untreated sewage and industrial wastewater.
Chloride (Cl^-)	Although small amounts of chlorides are essential to proper cell function in plants and animals, large concentrations of chlorides can damage aquatic life physiology and hinder reproductive fertility and growth.	Chlorides occur naturally from the weathering and erosion of sedimentary rocks. Agricultural runoff, industrial wastewater, petroleum industrial activities, saltwater intrusions, and effluent from wastewater treatment facilities (WWTF) are sources of chlorides.
Chlorophyll-*a*	Chlorophyll-a is a photosynthetic pigment found in green plants and is an indicator of the presence of algae in the water. It is used to monitor the trophic status of lakes or the primary productivity of ecosystems.	Elevated levels of nutrients could result in high concentrations of algal biomass.
Dioxin	Dioxin is a family of polychlorinated chemicals. It is carcinogenic and is detrimental to animal and human health.	Dioxin is present in the waste from the paper bleaching process and from the combustion of chlorinated compounds.
Dissolved Oxygen (DO)	The most important component for the survival of aquatic life is oxygen. Dissolved oxygen is essentially the amount of oxygen available in water. Low dissolved oxygen will suffocate aquatic species, and a high amount of dissolved oxygen will reduce water odors.	Elevated levels of organic nutrients can cause an overabundance of bacteria and algae, which depletes oxygen from water. Increases in water temperature will also lower the capacity for water to hold oxygen.

Bacteria *Escherichia coli (E. coli*) Enterococci	*Escherichia coli* and Enterococci are bacterial indicator species for the presence of fecal matter, pathogenic bacteria, and viruses. The presence of these indicators can cause cloudy water, unpleasant odors, and decreased levels of dissolved oxygen.	Malfunctioning or failing on-site sewage facilities, untreated domestic sewage, improper disposal of grease, and runoff from agricultural and livestock activities can cause an overabundance of bacteria and other pathogens.
Nitrate-Nitrogen (NO_3-N) Nitrite-Nitrogen (NO_2-N)	An abundance of nutrients can increase plant and algal growth. Bacteria use oxygen in the decomposition of plant matter, which can reduce dissolved oxygen. Nitrites are an intermediate form of Nitrogen that can cause brown blood disease in fish by preventing the transfer of oxygen by hemoglobin. Nitrites can also adversely affect human health, especially children under the age of three.	Nutrient sources are usually found in runoff from fertilizers and livestock facilities. They are also present in the effluent of WWTFs.
Polychlorinated Biphenyls (PCBs)	Polychlorinated biphenyls are acutely toxic and can disrupt endocrine and neural processes in aquatic life and humans.	PCBs are found in dielectric fluids used in transformers, capacitors, and coolants.
pH	Aquatic organisms have evolved to live in a specific range of pH. Biological and chemical processes can be altered or affected if the pH drops or rises over certain thresholds. Fish species cannot survive if the pH drops below 4 or rises above 12.	Runoff from mining operations and discharges of industrial wastewater can alter the pH of a water body.
Phosphorus Total Phosphate-P	Most phosphorus compounds found in water are phosphates. Orthophosphate is consumed by aquatic plants and organisms and is considered the limiting factor for aquatic plant growth. High or excessive levels of orthophosphate results in higher yield	Phosphates occur naturally from the decomposition of organisms. Sources also include the weathering of rock material and runoff from fertilizers.

	in growth. Excessive plant growth can cause eutrophication, (the natural aging progression of a water body) which will decrease dissolved oxygen levels.	
Salinity	Salinity is the measurement of conductive ions in the water. High levels of sodium sulfate and magnesium sulfate produce a laxative effect in drinking water. High levels of total dissolved solids can cause an unpleasant taste in potable water.	Weathering or erosion of rocks, salt mining, and saltwater intrusions are sources of increased salinity.
Secchi Transparency	Secchi transparency is used to calculate the depth at which natural light can penetrate the water column. It is also used as a measurement of eutrophication, the natural aging progression of a water body.	An abundance of algae and plants or excessive levels of total suspended solids will decrease the ability for light to transmit through the water column.
Sulfate ($S_2O_4^-$)	In the absence of oxygen and with a pH below 8, bacteria will reduce sulfate ions to sulfide ions. Sulfide ions will cause serious and unpleasant odor problems. Sulfates in sediment can also alter soil composition and hinder or prevent growth of native plants.	Sulfate is derived from rocks and soils containing gypsum, iron sulfides, and organic compounds. Sulfur containing fossil fuels, heavy industrial activities, and some fertilizers are also potential sources for sulfates.
Temperature	The types of aquatic life that can survive in a water body are dependent upon the water temperature. Water temperature can affect levels of dissolved oxygen. Water with a high temperature has less capacity to hold oxygen. As the water temperature drops, cold-blooded animals, such as fish, can become more susceptible to pathogenic stress or shock, which can lead to infections or death.	Releases of water from reservoirs can contribute to drops in temperature. Temperatures will increase with the removal of flora from riparian areas or from the release of heated water from industrial activities.

Total Suspended Solids (TSS)	An increase in the amount of total suspended solids will decrease the ability for light to penetrate through the water column. This can decrease the productivity of aquatic plants. As excessive amounts of TSS settle and become sediment, benthic habitats can be altered or destroyed.	High erosion events, usually coinciding with the removal of riparian floral species, and severe flow events will create excess levels of TSS. Unsound agricultural practices can also contribute to soil erosion into water bodies.

APPENDIX D: Water Quality Technical Primer

The Water Quality Technical Primer is provided as an overview of general water quality terminology. In combination with the Glossary, the Technical Primer provides background and defines terminologies and methodologies used to acquire, analyze, and report the data that is presented in the Basin Highlights Report.

THE FEDERAL CLEAN WATER ACT

The US Clean Water Act establishes the basic structure for regulating pollutant discharges, pollutant loadings in water, and regulating surface water quality standards. The goal of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. §1251(a)).

Amendments to The Clean Water Act in 1977:

- Established the basic structure for regulating pollutant discharges into the waters of the United States;
- Gave the US Environmental Protection Agency (EPA) the authority to implement pollution control programs, such as setting wastewater standards for industry;
- Maintained existing requirements to set water quality standards for all contaminants in surface waters;
- Made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions;
- Funded the construction of sewage treatment plants under the construction grants program; and
- Recognized the need for planning to address the critical problems posed by nonpoint source pollution.

POLLUTION

The Texas Administrative Code defines pollution as "the alteration of the physical, thermal, chemical, or biological quantity of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose."

There are two categories of pollution: Point Source and Nonpoint Source Pollution.

Point Source pollution is any source of pollution that is subject to regulation and is permitted. An example of a point source is a permitted wastewater treatment facility effluent discharge.

Nonpoint Source (NPS) pollution is any source not subject to regulation, diffuse, and does not have a single point of origin or is not introduced into a receiving stream from a specific outfall. NPS pollution typically results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

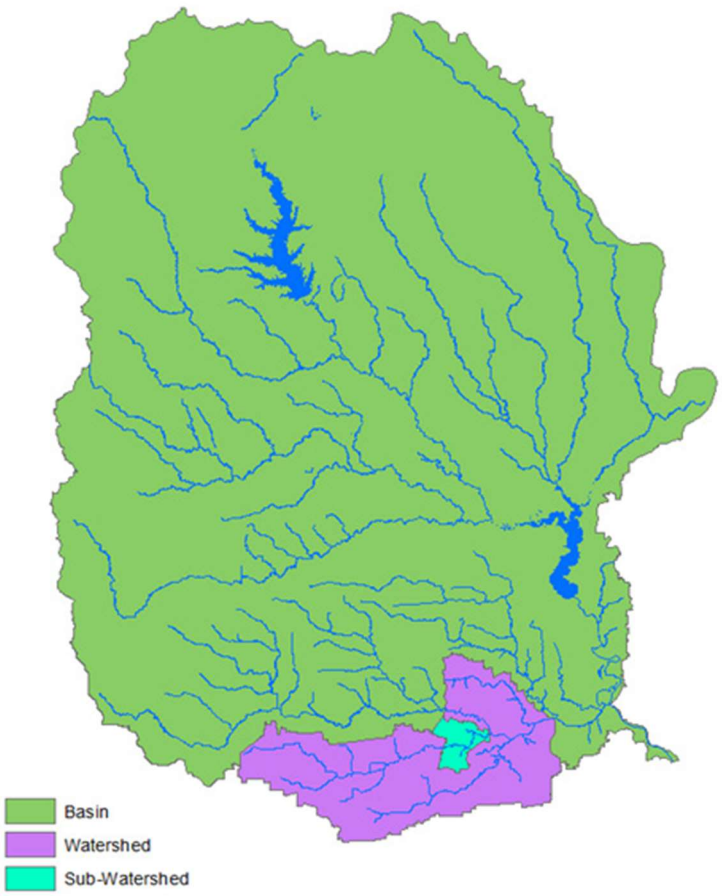
TEXAS SURFACE WATER QUALITY STANDARDS

The Texas Surface Water Quality Standards (TSWQS) establish numerical and narrative goals to maintain the quality of streams, rivers, lakes, and bays throughout the state. Appendix A and Appendix D of the TSWQS establish the geographic boundaries and the appropriate standards for each body of water. The standards are developed to maintain the quality of surface waters. Standards ensure public health and enjoyment, protect aquatic life, and remain consistent with the sustainable economic development of the state. The Texas Commission on Environmental Quality (TCEQ) develops the TSWQS under the authorization of the US Clean Water Act and Texas Water Code. The TSWQS are codified in Title 30, Chapter 307 of the Texas Administrative Code. The standards are approved by the EPA.

The TSWQS are designed to:

- Designate the uses, or purposes, for which the state's water bodies should be suitable;
- Establish numerical and narrative goals for water quality throughout the state; and
- Provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals for water quality.

The criteria adopted and incorporated into the standards are the allowable concentrations of pollutants in State, Territory, and authorized Tribal waters and are developed for the protection of aquatic life and human health. Impairments occur when water quality conditions do not meet the assigned uses or criteria as defined in the TSWQS.



DRAINAGE AREAS — BASINS, WATERSHEDS, AND SUB-WATERSHEDS

A watershed is a defined geographic area that water bodies flow through on the way to a common body of water. Basins are larger geographic areas generally containing one or more watersheds. A river basin is a collection of watersheds drained by a major river and tributaries. A coastal basin is a collection of watersheds adjacent to the coastline that water flows through on its way to the ocean. Typically, coastal basins are between and bound by two major river basins and a bay or other outlet to the ocean.

Watersheds can be broken down into even smaller drainage areas, which are referred to as sub-watersheds. For example, a sub-watershed could be defined as the drainage area of a small creek, stream, or portion of a stream that is part of the drainage area for a tributary, which is part of a major river drainage basin.

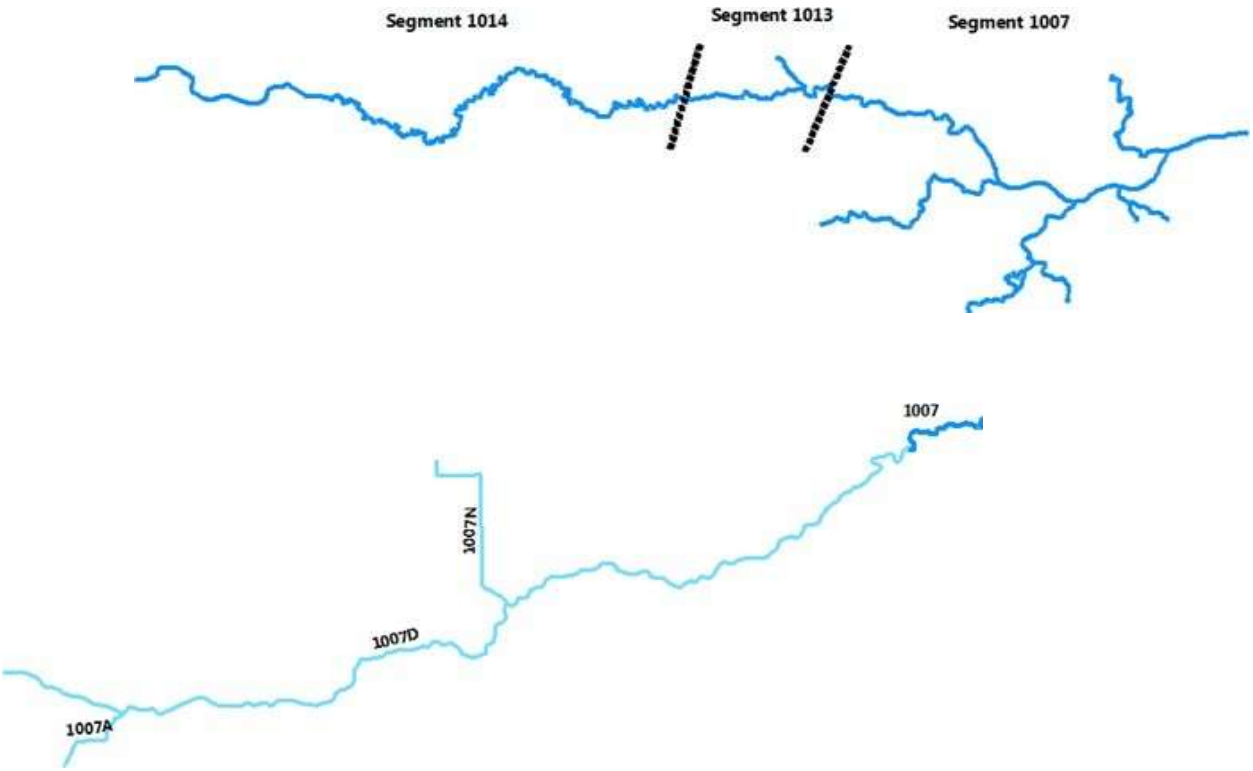
WATER BODIES, SEGMENTS, AND ASSESSMENT UNITS

The term water body is used to refer to any mass of water. A water body can be contained in a lake or a bay, or flow, such as a river, creek, or bayou. TCEQ divides water bodies in the state

into distinct segments that generally represent natural watersheds and are intended to have similar chemical, physical, and hydrological characteristics. Each segment is assigned a four-digit code. The first two digits identify the river basin, and the last two digits identify the segment. Segments can be either classified or unclassified.

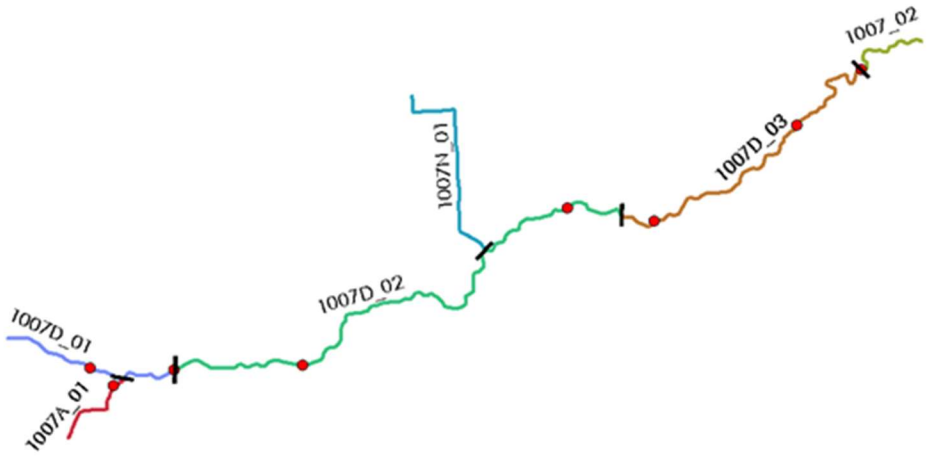
Classified Segments

A classified segment is a water body (or portion of a water body) that is individually defined in the TSWQS. Typically, classified segments are major waterways. Site specific numerical criteria are developed to evaluate the use and overall water quality of a classified segment. The parameters evaluated include bacteria, nutrients, and dissolved oxygen. Uses include aquatic life use and recreations use (discussion later in the primer).



Unclassified Segments

Unclassified segments are often tributaries of classified segments. These segments are usually assessed based on the criteria of the classified segment into which they flow. However, some unclassified segments have been assigned specific water quality standards in the TSWQS. Unclassified segments are assigned the same four-digit code as the classified segment and a letter that is specific to that water body.



Assessment Units (AUs)

For assessment purposes, each segment is subdivided into hydrologically distinct units, or assessment units (AUs). AUs are the smallest geographic areas of a water body that can support a designated or site-specific use. A segment may have one or multiple AUs, depending on water quality conditions or flow in different sections of the water body. Each AU has the same four or five-digit code as the segment followed by an AU identifier (e.g., _01, _02, etc.). If there are multiple AUs, the assessment units will generally be in sequential order (e.g., 1007D_01, 1007D_02, etc.). Each AU is evaluated separately as part of the assessment.

For example, Sims Bayou Above Tidal (1007D) is divided into three AUs. The red dots represent monitoring stations. Monitoring stations have been placed on the downstream and upstream ends of each AU in 1007D. Tributary 1007A has one monitoring station close to the confluence with the parent stream 1007D.

WATER QUALITY AND DESIGNATED USES

As defined in the TSWQS, a water body can be assigned specific uses including aquatic life, public water supply, and contact recreation use. Designated uses typically have corresponding numeric criteria listed in the TSWQS. General criteria apply across the entire state, but if sufficient information is available for a specific water body, the site-specific standards may be developed.

Aquatic Life Use

Aquatic life use (ALU) is determined by the amount of dissolved oxygen and the abundance and diversity of species. Aquatic life use consists of five categories: minimal,

limited, intermediate, high, and exceptional. In Texas, water bodies not specifically listed in Appendix A or D of the TSWQS are presumed to have a high aquatic life use and corresponding dissolved oxygen criteria. This use is assessed using 24-hour dissolved oxygen data along with nekton and macrobenthic invertebrate community evaluations.

Public Water Supply Use

Public water supply (PWS) use includes an evaluation of chloride, sulfates, and total dissolved solids in the water body. Criteria for these parameters are set so that public water supplies can treat and deliver water of acceptable quality.

Recreational Use

Recreational use refers to how safely a water body can support activities that involve the possibility of ingesting or coming into contact with water. If activities are likely to result in ingestion of water (wading, swimming, diving, tubing, surfing), bacteria levels need to be lower than the water quality standard to minimize risk. The TSWQS protects human health by setting numeric criteria in a water body relative to the types of recreational activity occurring on that water body. Fecal indicator bacteria levels are measured to determine risk. Criteria are expressed as the number of bacteria per 100 milliliters (mL) of water in terms of colony-forming units (CFU), most probable number (MPN), or other applicable reporting measures. The presence of fecal indicator bacteria in waters suggests that human and animal wastes may be reaching the assessed waters. In freshwater, the indicator organism is *Escherichia coli* (*E. coli*). Enterococci bacteria are the indicator for tidal water bodies.

There are five categories of recreational use, which are based on the type and frequency of recreation.

- Primary Contact Recreation 1 (PCR1) – Activities that are presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing, and whitewater kayaking, canoeing, and rafting).
- Primary Contact Recreation 2 (PCR2) – Water recreation activities, such as wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing, and whitewater kayaking, canoeing, and rafting, that involve a significant risk of ingestion of water but that occur less frequently than for PCR1 due to physical characteristics of the water body or limited public access.

- Secondary Contact Recreation 1 (SCR1) – Activities that commonly occur but have limited body contact incidental to shoreline activity (e.g. fishing, canoeing, kayaking, rafting, and motor boating). These activities are presumed to pose a less significant risk of water ingestion than PCR1 or PCR2 but more than secondary contact recreation 2.
- Secondary Contact Recreation 2 (SCR2) – Activities with limited body contact incidental to shoreline activity (e.g. fishing, canoeing, kayaking, rafting, and motor boating) that are presumed to pose a less significant risk of water ingestion than SCR1. These activities occur less frequently than SCR1 due to physical characteristics of the water body or limited public access.
- Noncontact Recreation (NCR) – Activities that do not involve a significant risk of water ingestion, such as those with limited body contact incidental to shoreline activity, including birding, hiking, and biking. NCR use may also be assigned where primary and secondary contact recreation activities should not occur because of unsafe conditions, such as ship and barge traffic.

Primary contact recreation is the presumed recreational use in Texas water bodies unless there is evidence to show that the water body is not used for primary contact recreation. A Recreational Use Attainability Analysis (RUAA) is necessary to change the presumed use of a water body.

WATER QUALITY MONITORING

Surface Water Quality Monitoring (SWQM) Program

TCEQ's Surface Water Quality Monitoring (SWQM) Program evaluates the physical, chemical, and biological characteristics to ensure that it is suitable for general or designated uses. Water quality is monitored and evaluated in relation to human health concerns, ecological conditions, and designated uses. Data collected under the SWQM program are used by TCEQ to provide a basis for effective policies that promote the protection, restoration, and wise use of the state's surface water.

Surface water samples are collected for assessment purposes following the methodologies outlined in TCEQ's *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods* (TCEQ Publication RG-415) (colloquially referred to as "SWQM Procedures"). The guidelines outlined in the SWQM

Procedures manual document the methods and the quality assurance procedures that must be used to demonstrate that data collected by monitoring personnel across the state are of a known and adequate quality. All data collected by H-GAC and its partners are collected following SWQM procedures.

Water quality data, including data collected under SWQM and the Clean Rivers Program, are stored in the Surface Water Quality Monitoring Information System (SWQMIS). This database is used to enter, manage, track, and report on water quality-related data.

Coordinated Monitoring Schedule (CMS)

The Coordinated Monitoring Schedule (CMS) is the combined schedule for all surface water quality monitoring in Texas. Monitoring entities within a basin or region meet annually to establish and coordinate monitoring schedules to ensure appropriate coverage, reduce duplication of effort, and better use available resources.

The CMS lists:

- Monitoring stations
- Collecting Entities (CE)
- Submitting Entities (SE)
- Monitoring Type (MT)
- Parameters
- Monitoring frequency

The Coordinated Monitoring Schedule is available online at https://cms.lcra.org

Quality Assurance Project Plan (QAPP)

H-GAC's Clean Rivers Program Quality Assurance Project Plan (QAPP) describes H-GAC's quality assurance policies, management structure, and procedures used to implement the quality assurance requirements for the Clean Rivers Program. These policies and procedures are necessary to verify and validate data collected for the Clean Rivers Program. The QAPP is reviewed and approved by TCEQ to help ensure that all data generated are of known and documented quality, deemed acceptable for their intended use and that the data have been collected and managed in such a way as to guarantee its reliability. Only quality-assured data may be used for water quality assessments or

other regulatory purposes. H-GAC's QAPP documents are available on H-GAC's website at Multi-Basin Quality Assurance Project Plan | Houston-Galveston Area Council (H-GAC)

Monitoring Types

Monitoring activities may be divided into the following categories:

- Routine Monitoring
- Special-Study Monitoring
- Permit-Support Monitoring
- Systematic Monitoring

The type of monitoring conducted by the Clean Rivers Program is usually routine, meaning it is monitoring that is scheduled in advance without intentionally trying to target any certain environmental condition, with samples being collected regardless of the conditions encountered. Routine monitoring includes field measurements (DO, pH, specific conductance, temperature), conventional chemical parameters (nutrients, chloride, sulfate), bacterial measurements (*E. coli* or enterococci), and flow measurements (if applicable for that water body). Please see Appendix C: Water Quality Parameters for a list of the parameter.

Another monitoring type conducted by the Clean Rivers Program is biased monitoring (monitoring targeted to a season, time, or condition) measurements, such as 24-hour DO. In this procedure, a data sonde (a water quality monitoring device that calculates and records field parameters) is deployed to measure DO every 15 minutes for 24 hours. After the deployment period, the data is analyzed, and the 24-hour average and absolute minimum are calculated. The DO average and absolute minimum are used to assign an ALU category to a water body. For example, exceptional aquatic life use has a 24-hour average of 6.0 mg/L and an absolute minimum of 4.0 mg/L. Biased monitoring can be part of a special study or permit support monitoring.

ASSESSMENT OF WATER QUALITY DATA

The provisions of Sections 305(b) and 303(d) of the Clean Waters Act require TCEQ to provide the Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d) (Integrated Report) to the EPA every two years. The report contains a list of water bodies evaluated, water bodies assessed by basin, impaired water bodies (303(d) List), water

bodies of concern, water bodies either newly listed or removed from the 303(d) List, and other supporting information.

For the assessment, TCEQ evaluates data collected during a seven-year period. The time frame is extended to 10 years (if needed) to attain the minimum number of data points needed for the assessment. Each assessed water body is identified as:

- Fully Supporting – At least 10 data points (20 for bacteria) are available for an assessment, and the water body meets TSWQS or supports designated uses
- Of Concern – There are two levels of concern, CN and CS. CN means there is concern for near nonattainment of the TSWQS based on numeric criteria. A concern status of CN indicates that standards are not being met, but there is insufficient data to fully assess the water body. CS means that there is a concern for water quality based on screening levels. Screening levels are used when there is not a defined standard (as with nutrients) and are derived from statistical distributions of statewide water quality monitoring data, with the 85th percentile for each applicable parameter is used as the screening level criteria.
- Impaired – Data indicates that the water body does not meet standards. Impaired water bodies are placed on the 303(d) List.

When a water body is determined to be impaired, several things must happen:

- The water body must be listed on the 303(d) List:
- An evaluation must be undertaken to determine what is preventing the water body from supporting its designated use(s) or if the use(s) are appropriate.
- Steps must be taken to either remedy the problem, collect additional data, or evaluate which uses are appropriate for the water body. These steps may include additional monitoring, development of a Total Maximum Daily Load (TMDL) or Watershed Protection Plan (WPP), or a review of the water quality standards.

After assessment, water bodies are placed into one of five categories (with subcategories). These categories indicate the water quality status of the water body. These categories (as well as subcategories), and their descriptions, are:

1. Attaining all water quality standards and no use is threatened.
2. Attaining some water quality standards and no use is threatened; and insufficient data and information are available to determine if the remaining uses are attained or threatened.

3. Insufficient data and information are available to determine if any water quality standard is attained.
4. Water quality standard is not supported or is threatened for one or more designated uses but does not require the development of a TMDL.
    4a TMDL has been completed and approved by EPA.
    4b Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future.
    4c Nonsupport of the water quality standard is not caused by a pollutant.
5. The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants.
    5a A TMDL is underway, scheduled, or will be scheduled.
    5b A review of the water quality standards for the water body will be conducted before a management strategy is scheduled.
    5c Additional data and information will be collected before a management strategy is scheduled.
    5n Water body does not meet its applicable chlorophyll-*a* criterion for reservoirs, but additional study is needed to verify exceedance

A previously assessed AU with insufficient data available during the assessment period for the most recent Integrated Report results in a carry-forward of the impairment listing from the previous report.

MANAGEMENT MEASURES FOR IMPAIRED WATER BODIES

If sufficient data is available to determine that a water body is impaired and does not meet standards, a management measure can be implemented to address the impairment.

- A Total Maximum Daily Load (TMDL) is a method used to determine the amount (load) of a pollutant an impaired water body can receive daily and still meet water quality standards and designated uses. After a load is calculated for the pollutant sources, an implementation plan (I-Plan) is drafted by the water body's stakeholders outlining management measures to be used to return the target pollutant to the calculated load. An I-Plan's management measures are usually voluntary actions but can, if recommended by stakeholders, include regulatory actions.

- A Watershed Protection Plan (WPP) is a community- and stakeholder-driven framework that uses a holistic/watershed approach to address potential sources of impaired water bodies. The plan is developed with community involvement, and the measures to reduce pollutants are voluntary.
- A Use Attainability Analysis (UAA) determines if the natural characteristics of a water body cannot attain the currently designated uses and/or criteria. Natural characteristics include temperature, pH, DO, diversity of aquatic organisms, amount of streamflow, and physical conditions such as depth. If there is a consensus among stakeholders and resource agencies that a presumed or designated use may not be appropriate for a water body, a UAA may be conducted to determine the most appropriate use(s).
- A Recreational Use Attainment Analysis (RUAA) is used to determine if contact recreation use occurs in a water body. A water body may have physical characteristics or limited public access that would not warrant a contact recreation use designation.

APPENDIX E: STATISTICAL METHODOLOGY

The identification of long- and short-term trends is important to many stakeholders, and these trends are important components of H-GAC's work, particularly in relation to the evaluation and revision of regional monitoring efforts and priorities. H-GAC staff used several methods of analyses to characterize surface water quality in the H-GAC region. Trend analysis can identify cases where the value of a water quality parameter is changing over time. Statistical tests are performed to distinguish statistically significant trends from random and seasonal variation. While it might seem reasonable to use all the data available for these analyses, as the amount of data increases the likelihood of finding a statistically significant but unimportant trend also increases. To minimize this, H-GAC performed trend analysis on the most recent 7 years (December 31, 2015 – December 31, 2022) of Texas Commission on Environmental Quality (TCEQ)-validated data to highlight recent trends in water quality in the region.

All data management and statistical analysis were performed using Statistical Analysis System (SAS). Complete details of data selection, preparation, and analysis can be found in the SAS code, which is available upon request.

Data Selection and Processing

For analyses in this report, H-GAC staff selected water quality data collected between 12/31/2015 and 12/31/2022 from data downloaded from Surface Water Quality Monitoring Information System (SWQMIS). All data used for these analyses were collected under a TCEQ-approved Quality Assurance Project Plan (QAPP). Qualified data (data added to SWQMIS with qualifier codes that identify quality, sampling, or other problems that may render the data unsuitable) were excluded from the download.

Variables in each dataset were transformed as appropriate, and new variables were created to facilitate analysis and graphical display of results. In some cases, data from two or more STORET (method) codes were combined because the results obtained from each method can be considered equivalent. Any data collected at a depth greater than 0.3 meters, or not collected under a routine ambient monitoring program, were deleted.

Censored data (data reported as < [parameter limit of quantitation (LOQ)]) were transformed to a value of one-half the parameter LOQ associated with the data, with some important exceptions. Because nutrient LOQs have been lowered over time, the presence of data censored at many different LOQs in the same dataset poses several problems. If the data for a given parameter are censored at values well above a later, lower LOQ value, trend analysis could suggest a trend where no real water quality trend is present. There is no ideal solution to this problem. Editing the censored data alone would limit, but not eliminate, false trends. In cases where some of the data reflected use of a lower LOQ than the current H-GAC Clean Rivers Program LOQ, values were transformed to one-half of the H-GAC Clean Rivers Program

LOQ to minimize the identification of trends caused by changing analytical methods. H-GAC does not believe the impact from this transformation is significant. The impact of this analysis would be most pronounced for parameter trends typically found at concentrations at or near the LOQ in that specific water body.

Table 2: STORET Codes and Parameters for Trend Analysis

STORET Code	Parameter	Units
00061	Instantaneous Flow	cfs
00094	Specific Conductance	µmhos/cm @ 25ºC
00010	Temperature	ºC
00300	Dissolved Oxygen	mg/L
00078	Secchi Transparency	Meters
00400	pH	S.U.
31699	*E. coli*	MPN/100mL
31701	Enterococci	MPN/100mL
32211 70953	Chlorophyll-*a* (Spectrophotometric) Chlorophyll-*a* (Fluorometric)	µg/L
00665	Total Phosphorus	mg/L as P
00610	Ammonia-Nitrogen	mg/L as N
00630 00620 00615	Nitrate+Nitrite* Nitrogen Nitrate Nitrogen Nitrite Nitrogen	mg/L as N
00625	Total Kjeldahl Nitrogen	mg/L as N
00530	Total Suspended Solids	mg/L
00940	Chloride	mg/L as Cl
00945	Sulfate	mg/L as SO_4

*Nitrate+Nitrite was selected when available, but some labs have reported nitrate rather than Nitrate+Nitrite. These three parameters were considered equivalent for the purpose of analysis.

Data Selection for Trend Analysis

H-GAC staff performed segment-level trend analysis on a 7-year data series (if available) from all data in the segment. Trends were also evaluated at the AU level to assess any changes and confirm results.

Trend Analysis Methodology

The first stage of trend analysis looked for temporal patterns for both segments and AUs. To identify these patterns, nonparametric correlation analysis (Kendall's tau-b) of the parameter value with the sample collection date was used to identify correlations that were significant at $p < 0.05$. These potential trends were then evaluated with up to four other methods. Simple linear regression of the natural log of the parameter value on the time variable was performed for all data in the subset selected by H-GAC for trend analysis. Flow-adjusted trends were obtained through correlation of residuals from LOESS (locally weighted least squares) regression in cases where instantaneous flow data were available. If there were no temporal gaps in the time-series (missing years, consistently

missing seasons), seasonal Kendall/Sen Slope estimation/Theil regression was run. If more than 15 percent of the data were censored at the analytical LOQ, survival analysis (Tobit analysis in SAS PROC LIFEREG) was performed.

Selected statistically significant trends were produced for segments and AUs for each watershed described in this report. If the trend is described as Increasing or Decreasing, the calculated p-value is below the threshold of 0.05 selected by H-GAC. Trends identified as Stable have a calculated p-value greater than 0.05. When evaluating the results of several trend analyses of a given parameter, H-GAC placed the most weight on the Kendall correlation because nonparametric methods are insensitive to outliers in the time series. However, if Kendall correlation differed from the results of seasonal trend analysis or flow-weighted analysis, the data were further evaluated. If no flow data were available, the flow-adjusted trend appears as Not Calculated (indicating no flow data is available) or Insufficient Data (indicating only one flow value exists and a correlation could not be calculated). If the seasonal Kendall/Sen Slope trend was not calculated due to gaps (missing seasons) in the time series, the seasonal Kendall trend appears as Not Calculated. Survival analysis was only applied in those cases where the amount of censored data could bias the results of the other methods. H-GAC set the threshold at 15 percent or more censored data. If fewer than 15 percent of the data were censored, survival analysis was not performed, and the trend appears as Not Applicable on output results.

Trend Analysis for the Regional Water Quality Summary ("Frog Chart")

The Regional Water Quality Summary, colloquially known as the "Frog Chart," is an index constructed by H-GAC to capture the degree of impairment/concerns for selected parameters (Dissolved Oxygen, bacteria, Chlorophyll-*a*, nutrients, PCBs/Dioxin, and a category for Other impairments) in each classified or unclassified segment. H-GAC's assessment of the health of these water bodies is a stream length-weighted summary of the impairments/concerns in each segment and is weighted based upon the percentage of the segment exhibiting the impairment or concern. This index is the basis for assigning a frog count to each segment. Segments are assigned from zero to five frogs, with the higher frog count indicating fewer impairments and concerns and better overall water quality.

In 2015, H-GAC staff compiled a subset of stations in classified segments believed to be most representative of segment water quality by selecting one to three stations that were statistically representative of a given parameter in a given segment. Means and standard deviations of parameter values are calculated for each station, and those stations with means and standard deviations closest to the overall mean and standard deviation for the segment and parameter combination were selected. Preference was given to stations where stream flow was measured, and final selections were reviewed for reasonableness. In most cases, the station, or stations at the most downstream location of the segment was the most statistically representative. Selection relied on SAS procedures PROC MEANS and PROC RANK. The same subset of stations has been used since 2015 to allow consistent comparisons across regional water quality summaries created for different years.

A conservative trend analysis was performed using seven years of recent data (12/31/2015 – 12/31/2022) at the selected representative monitoring stations in the classified portion of each watershed to detect trends at the watershed level for the H-GAC Regional Water Quality Summary

("Frog Chart"). Trends were identified by nonparametric correlation analysis and simple linear regression. Because nonparametric methods are less sensitive to extreme values in the data than parametric techniques like linear regression, trends that were suggested by linear regression analysis alone were not included in the chart.

Trends for the "Frog Chart" analysis were considered statistically significant if the p-value was below 0.05, which is the standard significance level used in most applications.

Some adjustments to the final frog count were made by H-GAC staff based on best professional judgment, in order to capture attributes not fully revealed by the SAS data analysis.

A Note on Statistical Significance

H-GAC feels that selecting all results with p-values ≤ 0.10 produces too many real, but unimportant, trends. In part, this is due to the large amount of data collected for our region; the more data one analyzes, the more likely it is that one will find a result and identify a "trend" that is statistically different from randomness ("no trend"). For example. 0.0545 rounds to 0.055, which in "arithmetic rounding" becomes 0.06 when expressed as one significant figure.

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