Plan Update No. 1
Date: May 20, 2026

Approved by the Bacteria Implementation Group: XXXX XX, 2026

Implementation Plan Update for One Hundred and Twenty-Five Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region

Segments[1]

Buffalo and White Oak Bayous: 1013, 1013A, 1013C, 1014, 1014A, 1014B, 1014C, 1014E, 1014H, 1014K, 1014L, 1014M, 1014N, 1014O, 1017, 1017A, 1017B, 1017C, 1017D, 1017E, and 1017F

Clear Creek: 1101, 1101A, 1101B, 1101C, 1101D, 1101E, 1102, 1102A, 1102B, 1102C, 1102D, 1102E, 1102F, and 1102G

Greens Bayou: 1016, 1016A, 1016B, 1016C, and 1016D

Eastern Houston: 1006F, 1006H, 1007F, 1007G, 1007H, 1007I, 1007K, 1007M, 1007O, 1007R, and 1007V

Halls Bayou: 1006D, 1006I, and 1006J

Brays Bayou: 1007B, 1007C, 1007E, 1007L, 1007S, 1007T, 1007U, and 1007W

Sims Bayou: 1007A, 1007D and 1007N

Lake Houston Upstream Watersheds: 1004E, 1008, 1008B, 1008C, 1008E, 1008H, 1008I, 1008J, 1009, 1009C, 1009D, 1009E, 1010, 1010C, and 1011

Armand Bayou: 1113, 1113A, 1113B, 1113C, 1113D, and 1113E

Lake Houston, East Fork San Jacinto River, West Fork San Jacinto River, and Crystal Creek: 1002, 1003, 1004, 1004D, and 1015A

Jarbo Bayou: 2425B

[1] TCEQ, 2022. Houston-Galveston Region: I-Plan and TMDLs. https://www.tceq.texas.gov/waterquality/tmdl/nav/42-houstonbacteria/42-houstonbig-tmdlplan

Distributed by the
Total Maximum Daily Load Team
Texas Commission on Environmental Quality
MC-203 P.O. Box 13087
Austin, Texas 78711-3087
E-mail: tmdl@tceq.texas.gov

TMDL implementation plans are also available on the TCEQ Web site at:
<www.tceq.texas.gov/implementation/water/tmdl/>

The preparation of this report was financed in part through grants from
the U.S. Environmental Protection Agency.

This plan update is prepared by
the Houston-Galveston Area Council
Community and Environmental Planning Department
in collaboration with the
Bacteria Implementation Group,
a stakeholder group appointed by the H-GAC Board of Directors and
charged with the Implementation Plan's development.

In compliance with the Americans with Disabilities Act, this document
may be requested in alternate formats by contacting the TCEQ at
512-239-0028, Fax 512-239-4488, or 1-800-RELAY-TX (TDD),
or by writing P.O. Box 13087, Austin, TX 78711-3087.

Table of Contents

Figures

Tables

Table of Acronyms and Abbreviations

Acknowledgements

Bacteria Implementation Group Members*

The 33-member Bacteria Implementation Group (BIG) consists of government, business, and community leaders working with other stakeholders to implement this Implementation Plan (I-Plan).

Lauren Boggs, Harris County (Urban County)
Rodger Brookes, City of Cleveland (Rural City)
Ralph Calvino, Terracon (Business/Industry)
Gordon Cranner, Schwartz, Page & Harding, LLP (Utility District)
Jesuina Chipindula, City of Houston (Large City)
Tom Douglas, Houston Sierra Club (Conservation)
Colleen Gilbert, Greens Bayou Coalition (Conservation)
Teague Harris, IDS Engineering Group (Utility District)
Sam Hill, Texas A&M Forest Service (Agriculture)
Andrew Isbell, Walker County (Rural County)
Courtney Klaus, Harris County (Urban County)
Michael Lee, US Geological Survey (Resource Agency/Academia)
Keith Miles, Montgomery County (Rural County)
Lisa Montemayor, City of Houston (Large City)
Bob Naeger, Houston Canoe Club (Recreation)
Paul Nelson, Bayou Preservation Association (Conservation)
Becky Olive, AECOM (Business/Industry)
Linda Pechacek, LDP Consultants, Inc. (Public)
Sonia Phillips, City of League City (Small City)
Jim Robertson, Cypress Creek Flood Control Coalition (Conservation)
Christine Santiny, City of Conroe (Small City)
Jamie Shakar, City of Houston (Large City)
Linda Shead, Texas Coastal Partners (Conservation)
Brian Shmaefsky, Lone Star College, Kingwood (Resource Agency/Academia)
Shane Simpson, San Jacinto River Authority (Business/Industry)
Robert Snoza, Harris County Flood Control District (Urban County)
Liz Stone, Quiddity Engineering (Business/Industry)
Michael Thornhill, SI Environmental (Utility District)
Scott Tuma, (Business/Industry)
Joanna Wilson, Gulf Coast Authority (Business/Industry)
Natasha Zarnstorff, Galveston Bay Foundation (Conservation)
Vacant, (Agriculture)
Vacant, (Agriculture - County)

** Member list effective as of June 3, 2025. Parenthetical indicates type of organization represented*

BIG Alternates*

Cody Arnold, City of Cleveland
Shaun Austin, Gulf Coast Authority
Paola Belloni, Terracon
Camila Biaggi, Quiddity Engineering
Matt Carpenter, SI Environmental (Utility District)
Nuguent Cotton, Harris County
Libby Decker, Terracon
Tom Douglas, Public
Robert Fiederlein, Greens Bayou Coalition
Brittani Flowers, Bayou Preservation Association
Arnelle Gonzalez, Quiddity Engineering
Wade Guy, Harris County
Greg Hall, City of Conroe
Forest Hartmann, City of Houston
Jody Hooks, City of League City
Steve Hupp, Cypress Creek Flood Control Coalition
Karen Kottke, AECOM
Leeanne Kincer, Montgomery County
Haile Leija, Galveston Bay Foundation
Avery Lewis, Harris County Flood Control District
Jeff Lu, Harris County
Zulimar Lucena, US Geological Survey
Reuben Martinez, Montgomery County
Carl Masterson, Texas Coastal Partners
Jonathan D. Mills, US Geological Survey
Mitchell Page, Schwartz, Page & Harding, LLP
Scott Saenger, Quiddity Engineering
Aaron Schindewolf, San Jacinto River Authority
Julia Schmidt, Texas A&M Forest Service
Lisa Scobel, Galveston Bay Foundation
Rose Sobel, Bayou Preservation Association
Desta Takie, City of Houston
Rachel Thorne, Galveston Bay Foundation
Lam Tran, City of Houston
Roberto Vega, Harris County Flood Control District
Jim Williams, Sierra Club
**Alternate list effective as of June 3, 2025.*

Texas Commission on Environmental Quality

This I-Plan Update was funded by TCEQ through the Total Maximum Daily Load (TMDL) Program. The TMDL Program provides support and coordination between TCEQ programs and the BIG.

Nicole Reed, TMDL Team Lead
Ms. Sophia Staska, Project Manager

Texas State Soil and Water Conservation Board

Brian Koch, Watershed Coordinator

Houston-Galveston Area Council

Community and Environment Department
Justin Bower, Director
Mr. Todd Running, Water Resources Program Manager
Steven Johnston, Principal Planner
Cornell Evans Jr., Planner
Jessica Casillas, GIS Specialist

Data Analytics and Research – Transportation Department
Megha Shrestha, Principal Data Analyst

Additional assistance was provided by many H-GAC employees, especially Stephanie Beckford, Kendall Guidroz, Andrea Tantillo, and Rachel Windham.

Work Groups

The BIG is supported by stakeholders who voluntarily participate in topic specific workgroups. For a complete list of participants, please review Appendix B. These people played an integral part in creating the implementation plan, carrying out implementation and in developing this I-Plan Update. The groups identify potential problems, activities and guide implementation described within the plan. The I-Plan does not necessarily reflect the views or opinions of individual workgroup members.

Note: Some of the workgroups were combined during the past ten years of implementation and are listed together.

Animals and Agriculture

Illicit Discharges and Dumping

On-site Sewage Facilities

Stormwater, Land Development, and Construction

Wastewater Treatment Facilities and Sanitary Sewer Systems

Coordination and Policy

Monitoring and Research

Executive Summary

The most common water quality impairment in the Houston-Galveston region is the presence of fecal bacteria, which can pose a health risk to those individuals engaged in contact recreation activities, e.g., swimming, water skiing, canoeing, fishing, and others.

Should levels of bacteria within a water body exceed the water quality standard set by the state, the water body is considered impaired. When a water body is designated as impaired, the Clean Water Act[2] requires a Total Maximum Daily Load (TMDL) be developed for each area of impairment within the body of water. A TMDL "is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards."[3]

Once a TMDL is completed, an Implementation Plan (I-Plan) is prepared by watershed stakeholders, which recommend voluntary best management practices designed to reduce the pollutant and restore the waterway to its designated use. An I-Plan, the Implementation Plan for Seventy-Two Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region,[4] was approved by the Bacteria Implementation Group (BIG) on October 16, 2012 and by the TCEQ on January 30, 2013 for the TMDL project area (Figure 1).

In Texas, I-Plans are developed with the understanding that each plan will be assessed by its implementors. From time-to-time the expectation is that each I-Plan will be revised or updated to consider improved understanding of pollutant sources; incorporate lessons learned since implementation began; reflect on enhanced opportunities available to implement specific actions or activities; and/or better strengthen buy-in by stakeholders.

[2] U.S. Code, 2020. Clean Water Act § 303(d), 33 U.S.C. § 1313. https://www.govinfo.gov/app/collection/uscode/2020/title33/chapter26/subchapterIII. Accessed October 1, 2022.

[3] EPA, 2022. Impaired Waters and Total Maximum Daily Loads. https://www.epa.gov/tmdl. Last modified September 15, 2022.

[4] H-GAC, 2013. Implementation Plan for Seventy-Two Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region. https://www.h-gac.com/bacteria-implementation-group/reports. Accessed October 1, 2022.

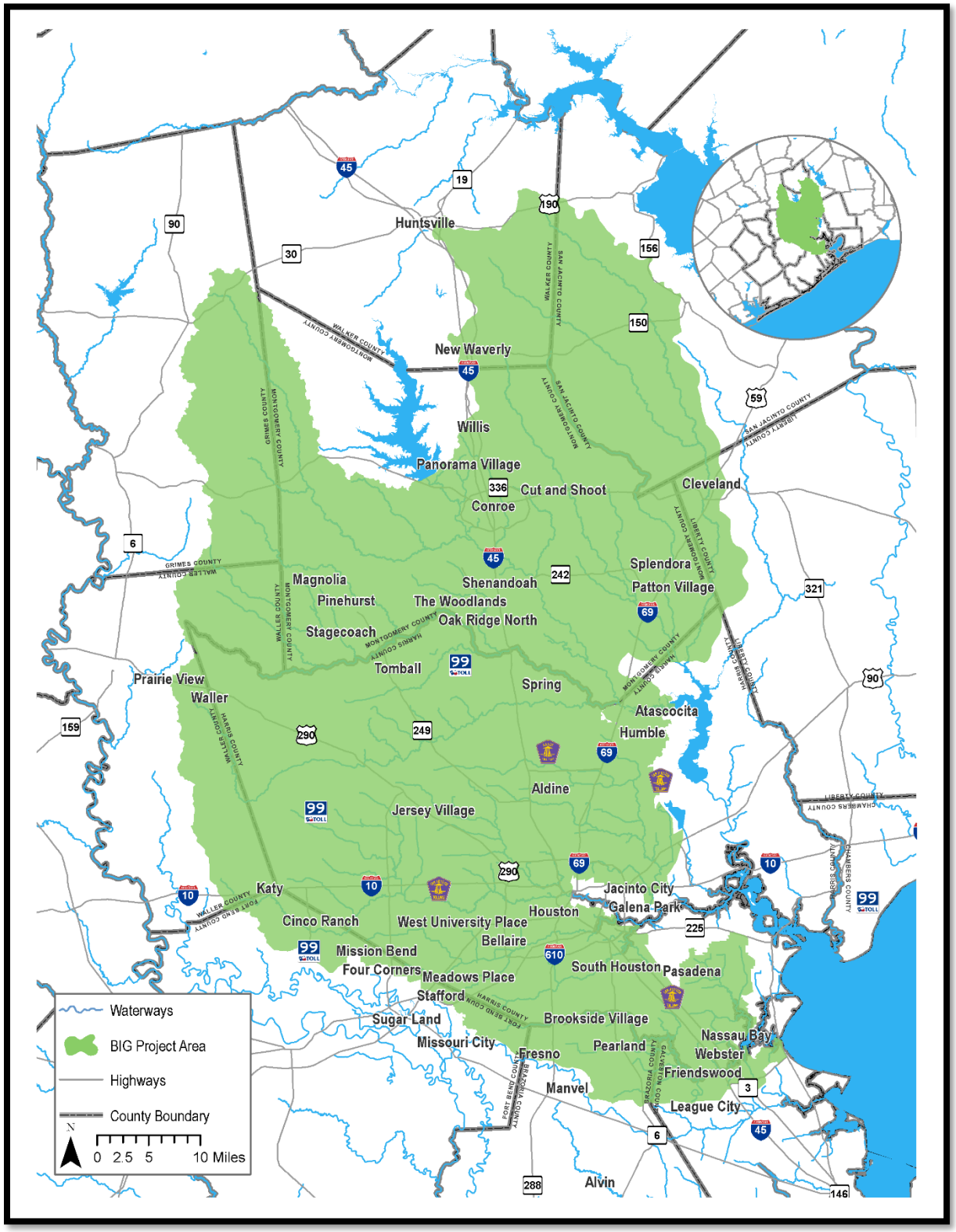

Figure 1. The BIG Project Area

Many of the strategies in the first I-Plan, referred to as the 2013 I-Plan going forward, were new to the region at the time and stakeholders were limited in terms of available local data to determine each management strategy's soundness, likelihood for implementation success, and cost-benefit effectiveness. Stakeholders determined which strategy to include based mostly on best professional judgment through a series of technical topic area work group meetings. Acknowledging this limitation, the BIG anticipated an iterative management approach. Data from early implementation would be used to refine strategies and enhance future implementation.

Applying this approach, the BIG and H-GAC staff were expected to track implementation activities and monitor water quality data to assess the validity of the various efforts to reduce bacteria. This update is driven by an understanding that some of the planned activities had not and would not be carried out and the updates included in this update are needed to better direct future actions.

Implementation to reduce bacteria began prior to completion of the 2013 I-Plan. Figure 2 shows the resulting reduction that stakeholders like the City of Houston, Harris County, and Harris County Flood Control District began in 2008 with efforts to reduce bacteria, first through a joint Phase I stormwater permit held by all three entities, and second through actions recommended by the BIG's I-Plan. The reductions took place by implementing key strategies, including addressing sanitary sewer overflows (SSOs), failing on-site sewage facilities (OSSFs), and installing water quality improvement practices in appropriate locations.

A review of Figure 2 suggest that bacteria reduction has since leveled out in recent years. Stakeholders were interested in evaluating what we have learned to date, what actions or activities have not been implemented, and expressing that understanding through an update to the I-Plan.

The BIG determined that the preference was to only update the I-Plan rather than to complete a full plan revision. For the BIG, an update would only seek to modestly change the I-Plan while retaining the backbone of the 2013 I-Plan. The BIG preferred this approach as most members were not interested in seeking endorsements and approvals from participating members or the TCEQ, seeing an update as one that the BIG can approve via committee.

This update preserves much of the language from the original text. However, added text, modified text and in some cases removal of text took place, though judiciously. The introduction to each activity has been updated to reflect new information and data that has become available since the 2013 I-Plan. Within each implementation activity the reader will

find Action, Background, Metric, Milestone, and Monitoring. The definitions for each is as follows:

- Action – reflects the overall goal of the activity
- Background – retains elements of the 2013 I-Plan
- Metric – how the activity will be measured
- Milestone – when the activity will be accomplished
- Monitoring – data used to programmatically and/or environmentally measure the Metric

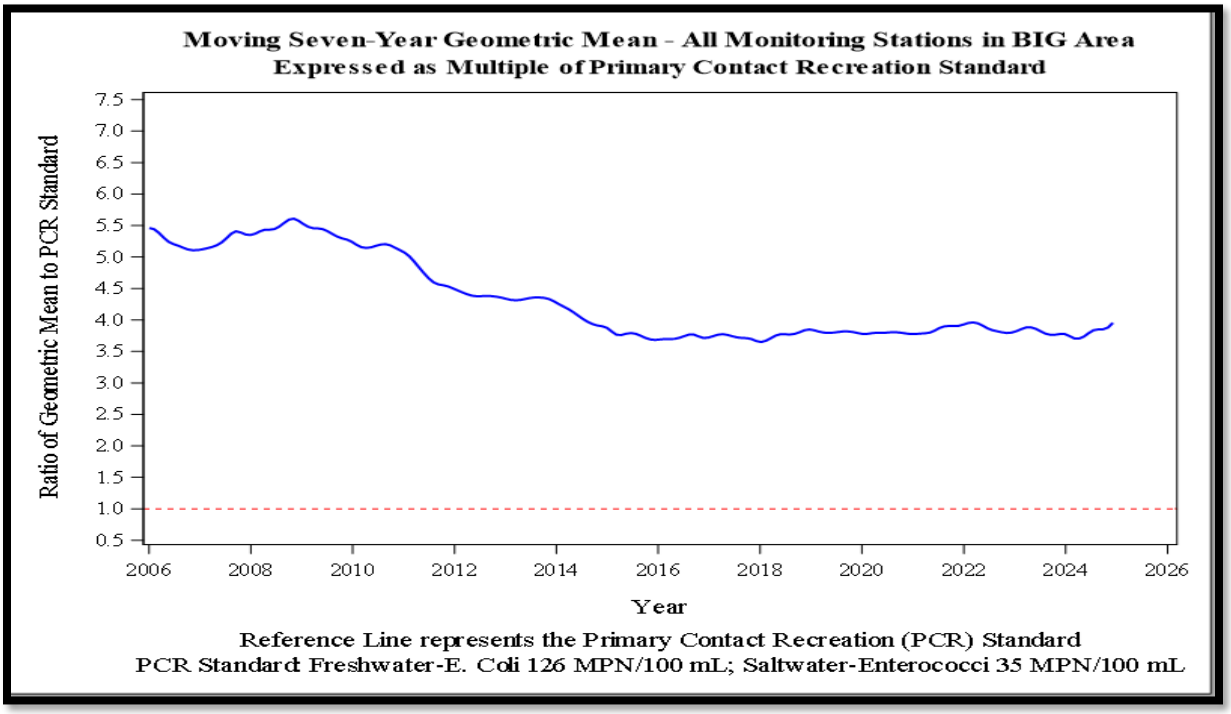

Figure 2. Bacteria geometric mean trends within the BIG Project Area, 2006 – 2025.

The goal of this I-Plan Update is to continue the reduction of bacteria concentrations in 89 segments containing 125 bacteria-impaired assessment units (AU) included in this I-Plan Update for which TMDLs have been adopted by the TCEQ.

Members of the BIG include representatives of city and county governments, resource agencies, business and agriculture interests, conservation and professional organizations, watershed groups, and the public. The recommendations in this I-Plan Update represent the work of the BIG and many additional stakeholders who actively participated in the process.

This I-Plan Update provides:

- The steps the BIG and its stakeholders will take to achieve the pollutant reductions identified in the TMDL reports,
- The schedule for implementation activities,
- A description of the legal authority under which the participating agencies may require implementation of the implementation activities,
- A tracking and monitoring plan to determine the effectiveness of the implementation activities,
- Measurable outcomes for assessing progress, and
- Communication strategies that will be used.

This document applies to waterways and their watersheds as shown in Figure 1. Additionally, any segments in the BIG project area that have TMDLs adopted by the TCEQ while implementation is underway may be incorporated into this I-Plan Update. Figure 2 denotes that since 2013 the BIG project area has expanded to include the Armand Bayou, Segment 1113 (2016); East and West Fork of the San Jacinto River, Lake Houston, and Crystal Creek, Segments 1003, 1004, 1002, and 1004D (2017); and Jarbo Bayou, Segment 2425B (2018) watersheds through three addendums to the 2013 I-Plan (Figure 1). This expanded the original project of 72 AU TMDLs to 125 AUs, including the addition TMDLs added to water bodies found within the original BIG Project Area.

Many of the implementation activities in this I-Plan Update are directed towards reducing bacteria loading from possible point and non-point sources that the TCEQ identified during development of the TMDLs. The activities are intended to achieve the reductions identified in the TMDL reports that are necessary to comply with established water quality standards. The sources of bacteria include wastewater treatment facilities, sanitary sewer systems, on-site sewage facilities, stormwater runoff, illicit discharges, agriculture, livestock, wildlife, pets, sediment resuspension, and bacterial regrowth.

Recommendations in this I-Plan Update are presented in sections describing the various sources of bacterial pollution identified through stakeholder and TMDL processes. The sections are the "backbone" of the 2013 I-Plan, and have been retained. These include a description of activities, identification of the parties responsible for implementing the activities, a schedule for implementation, the goals associated with the activities, and a process for tracking, evaluating, and reporting progress. A process of implementation, monitoring, analyses, adaptation, and review is also outlined so the 2013 I-Plan was regularly updated and could be more formally update and/or revised. This I-Plan Update provides the ongoing pragmatic and scientifically-based approach to meet water quality goals within a reasonable timeframe. The primary focus of the implementation activities in each section can be found in Table 1.

Table 1: Summary of Recommended Implementation Strategies

I-Plan Section	Activity Category	Focus of Implementation Activities
Implementation Strategy 1.0	Wastewater Treatment Facilities	Encourage increase monitoring requirements, track the use of stricter bacteria limits, encourage updates to facilities not able to comply with limits, and support increase enforcement.
Implementation Strategy 2.0	Sanitary Sewer Systems	Encourage all systems to develop and implement a utility asset management program and to protect against power outages at lift stations.
Implementation Strategy 3.0	On-site Sewage Facilities	Address failing systems and inadequate maintenance.
Implementation Strategy 4.0	Stormwater and Land Development	Expand stormwater management programs, develop a recognition program, and incentivize bacteria reduction measures.
Implementation Strategy 5.0	Construction	Improve compliance and enforcement of existing stormwater management permits.
Implementation Strategy 6.0	Illicit Discharges and Dumping	Increase efforts to address direct and dry-weather discharges, and encourage better control of waste hauler activities.
Implementation Strategy 7.0	Agriculture and Animal	Expand existing cost-share programs and the management of feral hog populations.
Implementation Strategy 8.0	Residential	Expand public education efforts.
Implementation Strategy 9.0	Monitoring and I-Plan Revision	Maintain databases of ambient and non-ambient water quality monitoring data and implementation activities, review I-Plan progress, and update I-Plan.
Implementation Strategy 10.0	Research	Examine effectiveness of stormwater activities, bacteria persistence and regrowth, and appropriate indicators for use in water quality monitoring.
Implementation Strategy 11.0	Geographic Priority Framework	Consider recommended criteria when selecting geographic locations for projects.

Introduction

The Clean Water Act requires that states establish standards that describe the ways that water bodies are used.[5] The standard associated with the contact recreation use is designed to ensure that water is safe for swimming, waterskiing, wading by children, or other activities that involve direct contact with the water.[6] Most water bodies in Texas and in the Houston-Galveston region must meet the standards for contact recreation set by the Texas Commission on Environmental Quality (TCEQ). The TCEQ determines whether water quality in a water body designated for contact recreation meets the contact recreation standard by measuring the levels of indicator bacteria—either *Escherichia coli (E. coli)* or *Enterococcus,* depending on waterway characteristics. High concentrations of indicator bacteria[7] have been associated with an increased risk of becoming ill from recreational activities.

In the Houston-Galveston region, bacteria are the most common water quality pollutant of concern. The 125 bacteria-impaired AUs covered by this Implementation Plan (I-Plan) Update represent 80 percent of assessed streams. Reducing this high number of bacteria impairments is the focus of this document (Figure 3).

When a waterway is designated as impaired, a TMDL must be developed. A TMDL "is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards."[8] Once a TMDL is completed, an I-Plan is developed. An I-Plan recommends implementation activities designed to reduce the pollutant of concern and restore the waterway to its designated use. An I-Plan,

[5] U.S. Code, 2020. Clean Water Act § 303(d), 33 U.S.C. § 1313. https://www.govinfo.gov/app/collection/uscode/2020/title33/chapter26/subchapterIII. Accessed October 1, 2022.

[6] TCEQ, 2022b. Texas Water Quality Standards. https://www.tceq.texas.gov/waterquality/standards/eq_swqs.html. Last modified August 24, 2022.

[7] Because of the complexity of terms used to describe pathogens and their indicators, the terms fecal bacteria, gut bacteria, indicator bacteria, and/or bacteria indicator may be used to include both *E. coli* and *Enterococcus* and for simplicity will be referred to as bacteria, throughout.

[8] TCEQ, 2022c. Total Maximum Daily Load Program: Communities Working Together to Improve Water Quality. https://www.tceq.texas.gov/waterquality/tmdl. Last modified June 17, 2022.

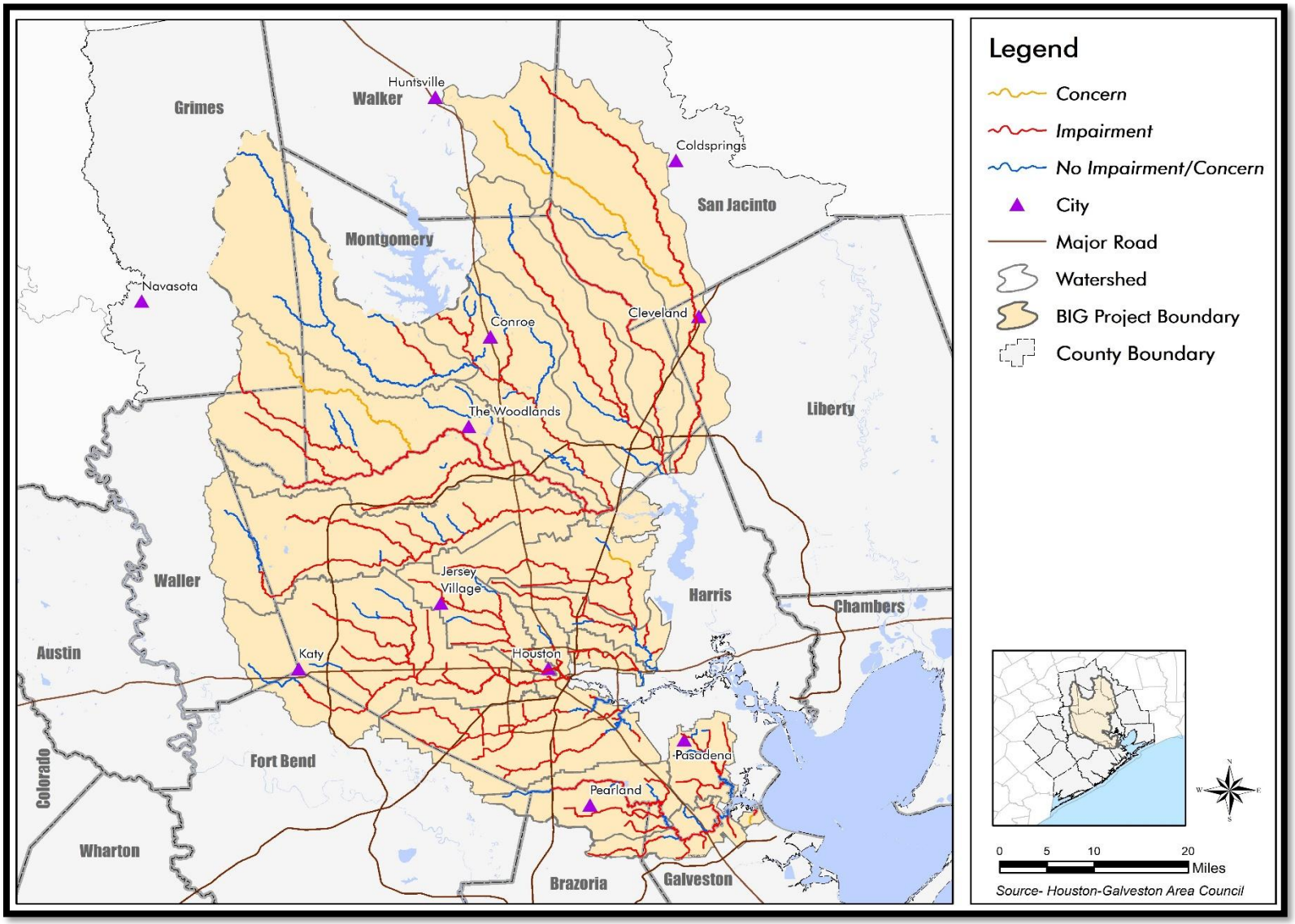

Figure 3. Bacteria impairments and concerns within the BIG Project Area

Implementation Plan for Seventy-Two Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region,[9] was approved by the Bacteria Implementation Group (BIG) on October 16, 2012 and by the TCEQ on January 30, 2013 for the TMDL project area.

This I-Plan Update is the result of work by the BIG[10], a stakeholder group that has routinely met to implement the first I-Plan, referred to as the 2013 I-Plan going forward. The BIG is composed of 33 members representing city and county governments, resource agencies, business and agriculture interests, conservation organizations, watershed groups, and the public. The BIG has meet since 2008, first to write the 2013 I-Plan and second to implement the plan.

Problem Definition

Impairments for the contact recreation use were identified, first in 1996 in the *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303 (d)* (previously the *Texas Water Quality Inventory and 303(d) Lists)* and in subsequent assessments produced every two years (Table 2)[11]. The TCEQ initiated TMDL projects to identify possible sources of bacteria and to determine appropriate reductions necessary to comply with water quality standards. The area encompassed by these project watersheds form the BIG's Project Area and area for implementation under this I-Plan Update (Figure 4).

Table 2: Segments Categorized by Year of First Listing for Bacteria Impairment

Year placed on the *Texas Integrated Report 303(d) List*	Segment ID
1996	1004, 1008, 1009, 1013, 1014, 1016, 1017, 1101, 1102
1998	1113A
2002	1006D, 1006F, 1006H, 1006I, 1006J, 1007B, 1007C, 1007D, 1007E, 1007F, 1007G, 1007H, 1007I, 1007K, 1007L, 1007M, 1007N, 1007O, 1007R, 1013A, 1013C, 1014H, 1014K, 1014M, 1014N, 1014O, 1016A, 1016B, 1016C, 1016D, 1017A, 1017B, 1017D, 1017E, 1101B, 1102A, 1102B, 4525B

[9] H-GAC, 2013. Implementation Plan for Seventy-Two Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region. https://www.h-gac.com/bacteria-implementation-group/reports. Accessed October 1, 2022.

[10] H-GAC, 2022a. Bacteria Implementation Group (BIG). https://www.h-gac.com/bacteria-implementation-group. Accessed October 1, 2022.

[11] TCEQ, 2022d. Texas Integrated Report of Surface Water Quality for Clean Water Act Section 305(b) and 303 (d) https://www.tceq.texas.gov/waterquality/assessment. Last modified August 24, 2022.

Year placed on the *Texas Integrated Report 303(d) List*	Segment ID
2006	1002, 1003, 1004D, 1004E, 1007A, 1008B, 1008H, 1009C, 1009D, 1009E, 1010, 1011, 1014A, 1014B, 1014E, 1014L, 1101D, 1102C, 1102D, 1102E, 1113, 1113B
2008	None
2010	1007S, 1007T, 1007U, 1007V, 1008C, 1008E, 1017C, 1101A, 1101C, 1101E, 1102G, 1113C, 1113D
2012	1017F, 1113E
2014	1015A, 1102F
2016	1007W, 1008I, 1008J, 1010C, 1014C
2018	None
2020	1004J*
2022	1002A*, 1003A*, 2425B*

***Potential future segment/AU TMDLs identified at time of writing**

The numeric criteria defined in the standards for support of the primary contact recreation use are as follows:

- The geometric mean of *E. coli* in freshwater should not exceed 126 colony forming units per 100 milliliters (mL).
- Single samples of *E. coli* in freshwater should not exceed 399 colony forming units per 100 mL.
- The geometric mean of enterococci in saltwater should not exceed 35 colony forming units per 100 mL.
- Single samples of enterococci in saltwater should not exceed 104 colony forming units per 100 mL.

Although these numbers represent the standards for primary contact recreation adopted by the TCEQ on February 7, 2018, and approved by the EPA on May 19, 2020,[12] other standards may have been in place prior to that date that led to a water body first being identified as impaired for bacteria.

This document applies to the 89 segments (Table 2) that contain bacteria impaired AUs and for which TMDLs have been adopted by the TCEQ, their tributaries, and associated watersheds. The map in Figure 4 presents the project area with major segments to which the

[12]TCEQ. 2018a. Texas Surface Water Quality Standards, 2018, 30 TAC 307.

https://www.tceq.texas.gov/waterquality/standards/2018-surface-water-quality-standards#fifthAnchor.

I-Plan Update applies. TMDLs are traditionally carried out on the smallest assessed portion of a water body called an AU, typically containing at minimum one ambient monitoring station and determined to host uniform water quality, aquatic life, and habitat parameters. A segment may be made up of one or more AUs and can therefore be made up of one or more TMDLs (Table 3). That said, the strategies and actions outlined in the I-Plan Update are expected to be carried out throughout the entire BIG Project area.

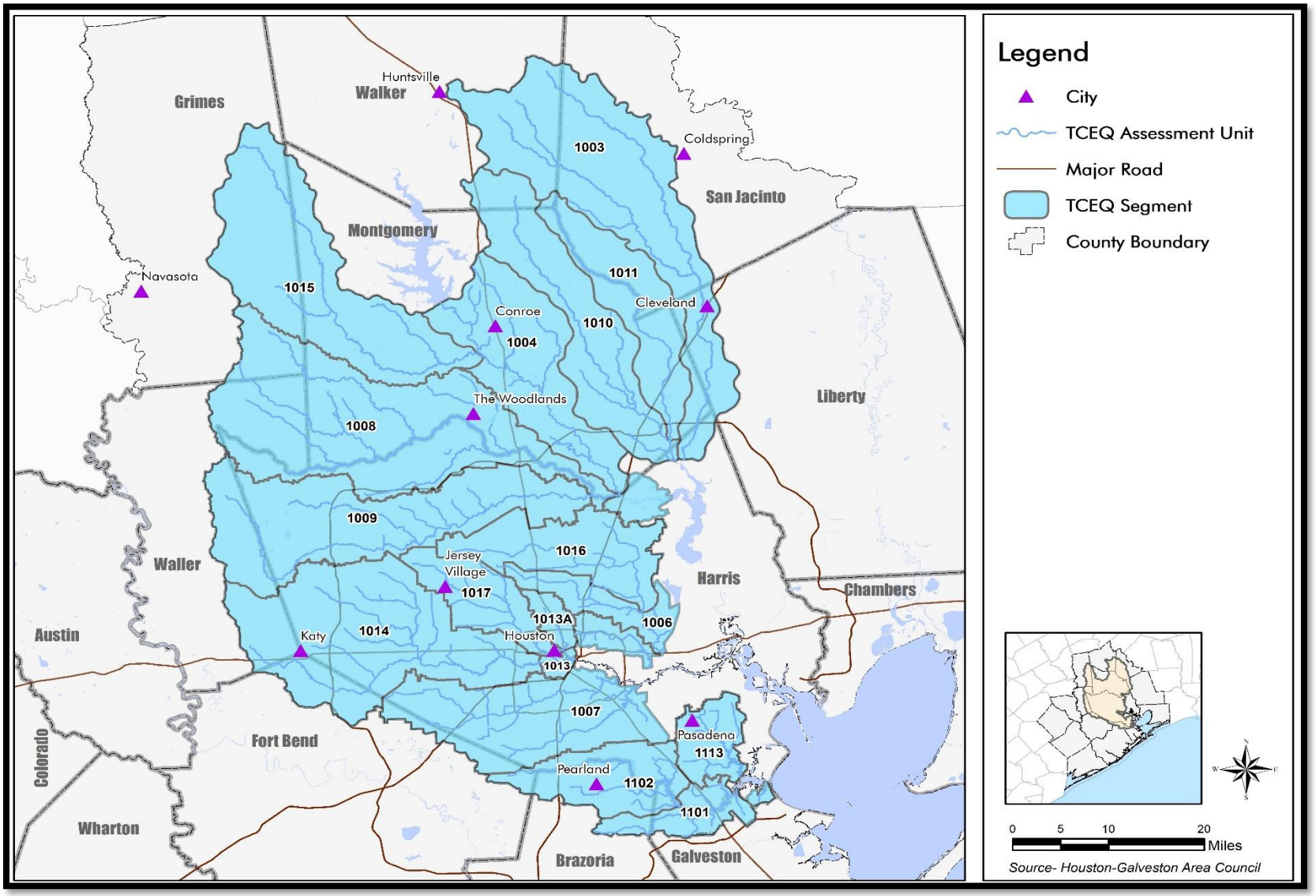

Figure 4. Principal watershed segments within the BIG Project Area

Table 3: TMDL Project and Approval Dates[13]

TMDL Project Name	Initial TMDLs	TMDL Addendum(s)[14]	TMDL Approval
Armand Bayou	**Six Total Maximum Daily Loads for Indicator Bacteria in Armand Bayou** *Segments: 1113, 1113A, 1113B, 1113C, 1113D, and 1113E* *Assessment Units: 1113_02, 1113A_01, 1113B_01, 1113C_01, 1113D_01, and 1113E_01*	**TMDL Addendum I: One TMDL for Indicator Bacteria in Armand Bayou** *Segment: 1113* *Assessment Unit: 1113_03*	**Initial TMDL: 2015** **Addendum I: 2019**
Brays Bayou	**Five Total Maximum Daily Loads for Indicator Bacteria in Brays Bayou and Tributaries** *Segments: 1007B, 1007C, 1007E, and 1007L* *Assessment Units: 1007B_01, 1007B_02, 1007C_01, 1007E_01, and 1007L_01*	**TMDL Addendum I: Three TMDLs for Brays Bayou Watershed** *Segments: 1007S, 1007T, and 1007U* *Assessment Units: 1007S_01, 1007T_01, and 1007U _01* **TMDL Addendum II: One TMDL for Harris County Flood Control Ditch D 138** *Segment: 1007W* *Assessment Unit: 1007W_01*	**Initial TMDL: 2010** **Addendum I: 2013** **Addendum II: 2021**

[13] TCEQ, 2022a. Houston-Galveston Region: I-Plan and TMDLs. https://www.tceq.texas.gov/waterquality/tmdl/nav/42-houstonbacteria/42-houstonbig-tmdlplan. Last modified September 9, 2022

[14] New TMDLs are addressed through addendums to the TCEQ's Water Quality Management Plan. TCEQ, 2022e. Water Quality Management Plan. https://www.tceq.texas.gov/permitting/wqmp/WQmanagement_comment.html. Last modified November 14, 2022.

TMDL Project Name	Initial TMDLs	TMDL Addendum(s)[14]	TMDL Approval
Buffalo and White Oak Bayous	**Eighteen Total Maximum Daily Loads for Bacteria in Buffalo and White Oak Bayous and Tributaries** *Segments: 1013, 1013A, 1013C, 1014, 1014A, 1014B, 1014E, 1014H, 1014K, 1014L, 1014M, 1014N, 1014O, 1017, 1017A, 1017B, 1017D, and 1017E Assessment Units: 1013_01, 1013A_01, 1013C_01, 1014_01, 1014A_01, 1014B_01, 1014E_01, 1014H_01, 1014H_02, 1014K_01, 1014K_02, 1014L_01, 1014M_01, 1014N_01, 1014O_01, 1017_01, 1017_02, 1017_03, 1017_04, 1017A_01, 1017B_02, 1017D_01, 1017E_01*	**TMDL Addendum I: One TMDL for Bacteria in Vogel Creek** *Segment: 1017C Assessment Unit: 1017C_01* **TMDL Addendum II: One TMDL for Bacteria in Rolling Fork Creek** *Segment: 1017F Assessment Unit: 1017F_01* ***TMDL* Addendum III: One TMDL for Bacteria in Horsepen Creek** *Segment: 1014C Assessment Unit: 1014C_01*	**Initial TMDL: 2009 Addendum I: 2013 Addendum II: 2015 Addendum III: 2021**
Clear Creek	**Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries** *Segments: 1101, 1101B, 1101D, 1102, 1102A, 1102B, 1102C, 1102D, and 1102E Assessment Units: 1101_01, 1101_02, 1101_03, 1101B_01, 1101B_02 1101D_01, 1101D_02, 1102_01, 1102_02, 1102_03, 1102_04 , 1102_05, 1102A_01,*	**TMDL Addendum I: Four TMDLs for Indicator Bacteria in Clear Creek Watershed** *Segments: 1101A, 1101C, 1101E, and 1102G Assessment Units: 1101A_01, 1101C_01, 1101E_01,and 1102G_01* ***TMDL Addendum II: One TMDL for Indicator Bacteria in Mary's Creek Bypass***	**Initial TMDL: 2009 Addendum I: 2013 Addendum II: 2019**

TMDL Project Name	Initial TMDLs	TMDL Addendum(s)[14]	TMDL Approval
	1102A_02, 1102B_01, 1102C_01, 1102D_01, 1102E_01	*Segment: 1102F* *Assessment Unit: 1102F_01*	
Eastern Houston Watersheds	**Thirteen Total Maximum Daily Loads for Indicator Bacteria in the Eastern Houston Bayous and Tributaries** *Segments: 1006F, 1006H, 1007F, 1007G, 1007H, 1007I, 1007K, 1007M, 1007O, and 1007R* *Assessment Units: 1006F_01, 1006H_01, 1007F_01, 1007G_01, 1007H_01, 1007I_01, 1007K_01, 1007M_01, 1007O_01, 1007R_01, 1007R_02, 1007R_03, and 1007R_04*	**TMDL Addendum I: One TMDL for Eastern Houston Watersheds** *Segment: 1007V* *Assessment Unit: 1007V_01*	**Initial TMDL: 2010** **Addendum I: 2013**
Greens Bayou	**Eight Total Maximum Daily Loads for Indicator Bacteria in Greens Bayou Above Tidal and Tributaries** *Segments: 1016, 1016A, 1016B, 1016C, and 1016D* *Assessment Units: 1016_01, 1016_02, 1016_03, 1016A_02, 1016A_03,*	**No Addendums**	**Initial TMDL: 2010**

TMDL Project Name	Initial TMDLs	TMDL Addendum(s)[14]	TMDL Approval
	1016B_01, 1016C_01, and 1016D_01		
Halls Bayou	**Four Total Maximum Daily Loads for Indicator Bacteria in Halls Bayou and Tributaries** *Segments: 1006D, 1006I, and 1006J* *Assessment Units: 1006D_01, 1006D_02, 1006I_01, and 1006J_01*	**No Addendums**	**Initial TMDL: 2010**
Jarbo Bayou	**One Total Maximum Daily Load for Indicator Bacteria in Jarbo Bayou** *Segment: 2425B* *Assessment Unit: 2425B_01*	**No Addendums**	**Initial TMDL: 2018**

TMDL Project Name	Initial TMDLs	TMDL Addendum(s)[14]	TMDL Approval
Lake Houston Upstream Watersheds	**Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston** *Segments: 1004E, 1008, 1008H, 1009, 1009C, 1009D, 1009E, 1010, and 1011 Assessment Units: 1004E_02, 1008_02, 1008_03, 1008_04, 1008H_01, 1009_01, 1009_02, 1009_03, 1009_04, 1009C_01, 1009D_01, 1009E_01, 1010_02, 1010_04, and 1011_02*	**TMDL Addendum I: Six TMDLs for Lake Houston Area Watersheds** *Segments: 1008B, 1008C, 1008E, and 1011 Assessment Units: 1008B_01, 1008B_02, 1008C _01, 1008C_02, 1008E_01, and 1011_01* **TMDL Addendum II: Two TMDLs for Brushy Creek and Spring Branch** *Segments: 1008J and 1010C Assessment Units: 1008J_01 and 1010C_01* **TMDL Addendum III: One TMDL for Walnut Creek** *Segment: 1008I Assessment Unit: 1008I_01* **TMDL Addendum IV: One TMDL for Caney Creek** *Segment: 1010 Assessment Unit: 1010_03*	**Initial TMDL: 2011 Addendum I: 2013 Addendum II: 2020 Addendum III: 2021 Addendum IV: 2022**
San Jacinto River, East and West Forks; Lake Houston; and Crystal Creek	**Seven Total Maximum Daily Loads for Indicator Bacteria in the East and West Forks of the San Jacinto River, Lake Houston, and Crystal Creek Watersheds** *Segments: 1002, 1003, 1004, and 1004D Assessment Units: 1002_06, 1003_01, 1003_02,*	**TMDL Addendum I: One TMDL for Indicator Bacteria in Mound Creek** *Segment: 1015A Assessment Unit: 1015A_01*	**Initial TMDL: 2016 Addendum I: 2019**

TMDL Project Name	Initial TMDLs	TMDL Addendum(s)[14]	TMDL Approval
	1003_03, 1004_01, 1004_02, and 1004D_01		
Sims Bayou and Tributaries	**Four Total Maximum Daily Loads for Indicator Bacteria in Sims Bayou and Tributaries** *Segments: 1007D and 1007N* *Assessment Units: 1007D_01, 1007D_02, 1007D_03, and 1007N_01*	**TMDL Addendum I: One TMDL for Sims Bayou Watershed** *Segment: 1007A* *Assessment Unit: 1007A_01*	**Initial TMDL: 2010** **Addendum I: 2013**

Project Area Description

The TCEQ developed TMDLs for the segments containing bacteria impaired AUs mentioned in the preceding text. The TMDL is a technical analysis that:

- Determines the amount of a particular pollutant that a water body can receive and still meet applicable water quality standards, and
- Estimates how much the pollutant load must be reduced to comply with water quality standards.

The TCEQ grouped several segments together based on geography to create TMDL projects. There are currently eleven TMDL projects within the BIG Project Area (Table 3). TMDL projects allow for evaluation and analysis of related water bodies to be considered together, both by scientists and by stakeholders. Stakeholders indicated that they wanted to develop the 2013 I-Plan for the adjacent TMDL project areas. The TMDL project areas often share political jurisdictions and communities.

Because many of the waterways within, near, or adjacent to the BIG Project Area were either listed or were expected to be listed on the 303(d) list for bacteria impairments, the 2013

I-Plan included provisions which allowed for the addition of future TMDLs adopted by the TCEQ via addendum, update, and/or revision.

BIG Project Area

The BIG Project Area is roughly 3,260 square miles and has a population of about five million people. The area encompasses much of the City of Houston and part or all of another 63 cities and 10 counties. It stretches from Galveston Bay and the Clear Creek/Jarbo Bayou watersheds in the south to the East Fork of the San Jacinto River in Walker County to the north; and to the cities of Waller and Katy in Waller County to the west to the City of Cleveland in Liberty County to the east. **Error! Reference source not found.**X lists all monitored stream segments in the BIG area, along with information about whether the waterway is impaired or tidally influenced.

The following are the TMDL projects addressed by this document (Table 3):

Armand Bayou[15]

The first six TMDLs were adopted by the TCEQ on August 5, 2015 and approved by the EPA on October 2, 2015. The BIG incorporated the project into the BIG Project Area by addendum on October 05, 2015[16]. The Armand Bayou Watershed encompasses approximately 60 square miles of land located just southeast of the City of Houston, Texas and lies within Harris County and the San Jacinto-Brazos Coastal Basin. Armand Bayou is one of the major tributaries within this basin along with Clear Creek, Dickinson Bayou, Chocolate Bayou, Bastrop Bayou, and Oyster Creek. The northern and southern portions of the watershed are heavily developed while the middle region is sparsely developed. Within the lower region of the watershed, Armand Bayou Nature Center owns and manages 2,500 acres as part of a wildlife and nature preserve. One additional TMDL was added by TCEQ through Addendum to the Water Quality Management Plan[17] on October 2018. The Water Quality Management Plan was approved by the EPA on February 22, 2019[18].

[15] TCEQ, 2015. Six Total Maximum Daily Loads for Indicator Bacteria in the Armand Bayou Watershed. Six Total Maximum Daily Loads for Bacteria in Armand Bayou; Segments 1113, 1113A, 1113B, 1113C, 1113D, and 1113E (texas.gov). Adopted August 5, 2015. Approved by the EPA October 2, 2015

[16] H-GAC, 2015. Implementation Plan Addendum 2. https://www.h-gac.com/getmedia/09bb4674-0400-4078-b748-630e144adc15/2Addendum82015.pdf

[17] TCEQ, 2022e. Water Quality Management Plan. https://www.tceq.texas.gov/permitting/wqmp/WQmanagement_comment.html. Last modified November 14, 2022.

[18] TCEQ, 2018b. One TMDL added by Addendum October 2018. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/89c-armand-bacteria-addendum-one.pdf

Brays Bayou[19]

The first five TMDLs were adopted by the TCEQ on September 15, 2010 and approved by the EPA on September 27, 2010. The heavily urbanized Brays Bayou Above Tidal watershed encompasses approximately 105 square miles of land located southwest of the City of Houston, Texas. It drains parts of the cities of Houston, Missouri City, Stafford, Bellaire, West University, Southside Place, and Meadows. Approximately 87 percent of the watershed lies within Harris County, while the remaining 13 percent is in Fort Bend County. There are about 121 miles of open streams within the watershed. Two addendums have since been completed covering four tributary segments, the last being approved by the EPA July 29, 2021[20].

Buffalo and Whiteoak Bayous TMDL Project Area[21]

The commission adopted these TMDLs on April 8, 2009. The EPA approved them on June 11, 2009. The 18 impaired segments of Buffalo and Whiteoak bayous, consisting of three main segments and 15 tributaries, are located within and to the west of Houston. The approximately 492 square miles are in Harris, Fort Bend, and Waller counties, with the majority being within Harris County. Buffalo Bayou flows from outlying, less-developed areas, joining Whiteoak Bayou Above Tidal in the highly urbanized central part of the Houston business district. A unique feature of the Buffalo Bayou watershed is that two flood control reservoirs are located in its upstream end. The U. S. Army Corps of Engineers operates the reservoirs to minimize flooding downstream. The EPA approved Addendum I to the TMDLs in August 2013. The EPA approved Addendum II to the TMDLs in July 2015. The EPA approved Addendum III to the TMDLs in July 2021[22].

[19] TCEQ, 2010a. Five Total Maximum Daily Loads for Indicator Bacteria in Brays Bayou Above Tidal and Tributaries. https://attains.epa.gov/attains-public/api/documents/actions/TCEQMAIN/39307/107419. Adopted September 15, 2010. Approved by the EPA September 27, 2010.

[20] TCEQ, 2021a. One TMDL for Harris County Flood Control Ditch D 138 Added by Addendum II, January 2021. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-brays-bayou-tmdl-addendum-two.pdf.

[21] TCEQ, 2009. Eighteen Total Maximum Daily Loads for Bacteria in Buffalo and Whiteoak Bayous and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/22-buffalo-whiteoak-bayous-tmdl-adopted.pdf

[22] TCEQ, 2021b. One TMDL for Horsepen Creek Added by Addendum III, January 2021. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/22-buffalo-whiteoak-bayous-tmdl-addendum-three.pdf

Clear Creek TMDL Project Area[23]

The commission adopted these TMDLs on September 10, 2008. The EPA approved them on March 6, 2009. The nine impaired segments of Clear Creek, consisting of two main segments and seven tributaries, are located in Houston and to its southeast. The Clear Creek watershed is approximately 180 square miles in area with approximately 40 percent within Brazoria County, 35 percent within Harris County, 20 percent within Galveston County, and 5 percent within Fort Bend County. The eastern and central portions of the watershed are primarily urban and residential, with some commercial and industrial uses. The western and southern parts of the watershed include rural and agricultural land uses, which continue to transition over time from cultivated and woody land to developed land. The EPA approved an Addendum I to the TMDLs in March 2013. The EPA approved Addendum II to the TMDLs on February 22, 2019[24].

Eastern Houston Watersheds TMDL Project Area[25]

The commission adopted these TMDLs on September 15, 2010. The EPA approved them on September 27, 2010. The heavily urbanized Eastern Houston watersheds encompass approximately 63 square miles of land located in central Harris County. They include portions of the Cities of Houston, South Houston, Pasadena, and Jacinto City as well as incorporated areas of Harris County. There are about 120 miles of open streams within the watershed. The EPA approved Addendum I to the TMDLs in August 2013[26].

Greens Bayou TMDL Project Area[27]

The commission adopted these TMDLs on June 2, 2010. The EPA approved them on August 12, 2010. Greens Bayou is located in north central Harris County, about 10 miles north of the central business district of the City of Houston. The Greens Bayou non-tidal watershed drains an area of about 140 square miles and encompasses the cities of Houston and

[23] TCEQ, 2008. Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/68a-clear-creek-tmdl-addendum-one.pdf

[24] TCEQ, 2018c. Two TMDLs added by Addendum October 2018.https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/68b-clear-creek-bacteria

[25] TCEQ, 2010b. Thirteen Total Maximum Daily Loads for Indicator Bacteria in Eastern Houston Watersheds. https://attains.epa.gov/attains-public/api/documents/actions/TCEQMAIN/39293/107417

[26] TCEQ, 2013a. One TMDL added by Addendum April 2013. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-eastern-houston-tmdl-addendum-one.pdf

[27] TCEQ, 2010c. Eight Total Maximum Daily Loads for Indicator Bacteria in Greens Bayou Above Tidal and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-greens-bayou-tmdl-adopted.pdf

Humble. Most of the watershed is highly developed, but some areas between U.S. Highway 59 and I-10 remain undeveloped. There are about 200 miles of open streams within the watershed.

Halls Bayou TMDL Project Area[28]

The commission adopted these TMDLs on September 15, 2010. The EPA approved them on September 27, 2010. The heavily urbanized Halls Bayou watershed encompasses approximately 44 square miles of land located in north central Harris County, Texas. There are about 74 miles of open streams within the watershed.

Jarbo Bayou TMDL Project Area[29]

The commission adopted this TMDL on January 24, 2018. The EPA approved the TMDL on March 29, 2018. The BIG incorporated the project into the BIG Project Area by addendum on June 5, 2018[30]. The Jarbo Bayou watershed encompasses approximately 4.8 square miles of land located on the southeast border of Clear Lake and lies entirely within Galveston County. The watershed is part of the San Jacinto-Brazos Coastal Basin, which covers the coastal portions of Galveston, Harris, and Brazoria counties located between the San Jacinto River and the Brazos River. Jarbo Bayou is an unclassified tributary within this basin, consisting of a single stream segment that feeds directly into Clear Lake. The regions of the Jarbo Bayou watershed bordering Clear Lake as well as the western section of the watershed are thoroughly developed, while the central and southeastern regions are less developed and include pasture land as well as pockets of wooded wetlands.

Lake Houston Upstream Watersheds TMDL Project Area

The commission adopted these TMDLs on April 6, 2011. The EPA approved them on June 29, 2011. The nine impaired segments of the Lake Houston project are located within the San Jacinto River Basin in East Texas. The project area encompasses approximately 1,100 square miles of land, primarily in Harris and Montgomery counties, but also in portions of Grimes, Liberty, San Jacinto, Walker, and Waller counties. The southern portion of the watershed includes portions of the City of Houston and its northern suburbs. The Woodlands and the City of Conroe join Houston as the largest communities located within the project area. The northern portions are relatively rural and include parts of the Sam Houston National Forest.

---

[28] TCEQ, 2010d. Four Total Maximum Daily Loads for Indicator Bacteria in Halls Bayou and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-halls-bayou-tmdl-adopted.pdf

[29] TCEQ, 2018d. One Total Maximum Daily Load for Indicator Bacteria in Jarbo Bayou. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/106-jarbo-bayou-bacteria-tmdl-adopted.pdf

[30] H-GAC, 2018. Implementation Plan Addendum 4. https://www.h-gac.com/getmedia/1645ceb1-8c6a-4a29-b2f6-2794dba062f6/4Addendum62018.pdf

The EPA approved Addendum I to the TMDLs in February 2014, Addendum II in March 2020, Addendum III in March 2021 and Addendum IV in August 2022[31].

San Jacinto River, East and West Forks; Lake Houston; and Crystal Creek TMDL Project Area[32]

The commission adopted these TMDLs on August 24, 2016. The EPA approved them on October 7, 2016. The BIG incorporated the project into the BIG Project Area by addendum on October 25, 2016[33]. The water bodies included in this study are all within the Lake Houston watershed. They are, however, outside the area covered by previous TMDLs for indicator bacteria in watersheds upstream of Lake Houston (TCEQ, 2011). Lake Houston AU 1002_06 is defined as the portion of the lake from the confluence with Spring Creek to the West Lake Houston Parkway crossing. The East Fork San Jacinto (Segment 1003) flows from US 190 in southeast Walker County to the confluence with Caney Creek in northeastern Harris County. The West Fork San Jacinto (Segment 1004) flows from the Lake Conroe dam in Montgomery County to the confluence with Spring Creek at the Montgomery-Harris county line. Crystal Creek (Segment 1004D) flows southwesterly from the confluence of the East and West Forks of Crystal Creek to the confluence of the West Fork San Jacinto River. With the exception of the East Fork San Jacinto River and Lake Houston, the TMDL segments are located entirely within Montgomery County. The EPA approved Addendum I to the TMDLs on February 22, 2019[34].

Sims Bayou TMDL Project Area[35]

The commission adopted these TMDLs on August 24, 2016. The EPA approved them on October 7, 2016. The heavily urbanized Sims Bayou Above Tidal watershed encompasses approximately 64 square miles of land located southwest of the City of Houston, Texas.

---

[31] TCEQ, 2022f. One Total Maximum Daily Load for Indicator Bacteria in Walnut Creek added by Addendum III, October 2020. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/82f-lakehouston-tmdl-addendum04-2022april.pdf

[32] TCEQ, 2016. Seven Total Maximum Daily Loads for Indicator Bacteria in the East and West Forks of the San Jacinto River, Lake Houston, and Crystal Creek Watersheds. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/82b-ewfsjr-tmdl-adopted.pdf

[33] H-GAC, 2016. Implementation Plan Addendum 3. https://www.h-gac.com/getmedia/aba91b96-8c6f-4df2-8307-8521cc833364/3Addendum52016.pdf

[34] TCEQ, 2018e. One TMDL added by Addendum October 2018. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/82c-ewfsj-bacteria-tmdl-addendum-one.pdf

[35] TCEQ, 2010e. Four Total Maximum Daily Loads for Indicator Bacteria in the Sims Bayou Above Tidal Watershed. Four Total Maximum Daily Loads for Indicator Bacteria in Sims Bayou Above Tidal and Tributary (texas.gov).

Approximately 83 percent of the watershed lies within Harris County, while the remaining 17 percent is in Fort Bend County. There are about 75 miles of open streams within the watershed. The EPA approved Addendum I to the TMDLs on February 22, 2019[36].

Methods for Estimating Bacteria Loads

In the development of the Houston-Galveston area bacteria TMDLs, the TCEQ and its consultants used a variety of methods to analyze indicator bacteria loads, in-stream water quality, and load reductions. Relating bacteria loading to in-stream bacteria levels is difficult because of the dynamics of bacteria populations. Bacteria populations can be affected by many factors, such as sunlight, water temperature, nutrients, and sediment.

The specific models for each project area were chosen based on available information about how various models work and characteristics of the water bodies. For the Clear Creek TMDL, load duration curve (LDC) analyses were used for the seven freshwater segments and a tidal prism method was used for the two tidal segments. Three methods of analysis were used to analyze bacteria loads for the Buffalo and Whiteoak bayous TMDLs: LDC analyses, a mass balance analysis using Bacteria Load Estimator Spreadsheet Tool (BLEST), and a Hydrologic Simulation Program Fortran (HSPF) analysis for simulation of watershed hydrology and water quality. Only LDC analyses were used for waterways in the Houston Metropolitan and Lake Houston project areas. Constructing LDCs has since become the standard practice by the TCEQ for TMDL development.

In LDCs, a line displays the maximum allowable load over the complete range of flow conditions based on the calculation of flow multiplied by the criterion. Using LDCs, a TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition. LDCs do not simulate the fate of contaminants; rather, they calculate allowable loading for a given flow and they show the distribution of bacteria exceedances during different flow levels.

A time-varying tidal prism modeling approach with a moderate level of spatial resolution allows for the calculation of bacteria loadings in tidal waterways. The tidal prism is the volume of water between low and high tide levels or between the high tide elevation and the bottom of the tidal waterway. The model incorporates the three mechanisms through which

[36] TCEQ, 2013b. One TMDL added by Addendum April 2013. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-sims-bayou-tmdl-addendum-one.pdf

bacteria loadings enter the impaired systems: runoff, direct point source discharges, and tidally influenced loadings.

BLEST is designed to calculate or estimate the indicator bacteria loads and load reductions for each segment needed to attain the water quality standard for the segment. It estimates load reductions for a fixed time interval and a given segment and does not incorporate the temporal variations associated with pathogen loads. However, it does allow an evaluation of loads by subwatershed.

The HSPF model is a continuous simulation model for watershed hydrology and water quality. The model can account for both point source and nonpoint source loadings in the watershed. It includes simulation of the receiving stream that receives mass loadings from the watershed.

For detailed review of the TMDL projects and specific methods used to develop the TMDLs links have been provided in the reference section for each TMDL project area.

TMDL Equation

The standard TMDL equation is TMDL = WLA + LA + MOS, where TMDL is the total maximum daily load, WLA is the waste load allocation, LA is the load allocation, and MOS is the margin of safety, a factor to account for uncertainty. The WLA includes a future growth component to address population growth over time. The equation is used to allocate loads among different sources of a pollutant.[37]

WLAs were determined for point sources of bacteria in each TMDL. These point sources include effluent discharges from permitted wastewater facilities, permitted stormwater runoff, and other point sources. LAs for nonpoint sources of bacteria generally include background loads, upstream loads, any stormwater runoff not subject to permit, e.g., on-site sewage facility loads, animal deposition, i.e., pets, livestock, feral hogs, and wildlife, and leaking wastewater infrastructure. For detailed review of the allocated loads for all TMDLs covered by this document links have been provided in the reference sections for each TMDL project area.

Potential Sources of Bacteria

Pollutants may come from both point and nonpoint sources. Potential sources include:

- non-compliant WWTF discharges,
- industrial and construction site discharges,

[37] (U.S. Environmental Protection Agency 2008)

- municipal separate storm sewer systems,
- unpermitted storm sewer systems,
- sanitary sewer overflows,
- leaking wastewater infrastructure,
- dry weather discharges/illicit discharges into and from storm sewers,
- sediment re-suspension,
- bacteria regrowth,
- failing on-site sewage facilities,
- agricultural activities and domesticated animals,
- wildlife
- feral hogs, and
- Pets.

Primary bacteria sources of concern include wastewater treatment facilities, sanitary sewer systems, on-site sewage facilities, and stormwater; however, loadings from the various sources cannot always be quantified. That said, the BIG identified three key implementation activities since the 2013 I-Plan:

1. owners of sanitary sewer systems should develop and implement an operations and maintenance program, including residential and commercial outreach, that target the reduction of sanitary sewer overflows,
2. owners of on-site sewage facilities should repair or replace of failing systems, and
3. stormwater management programs, particularly permitted programs, should enhance their programs to implement best management practices that aim to reduce bacteria.

Each of these activities along with other strategies, are more fully explored within sections of this plan.

Implementation Plan Overview

In order to keep Texas' commitment to restore and maintain water quality in impaired rivers, lakes, bayous, and bays, the TCEQ establishes implementation plans for each TMDL. This update to the 2013 I-Plan is designed to guide activities that will reduce bacteria in the 89 impaired segments and their watersheds. The ultimate goal of the I-Plan Update is to restore contact recreation use, where appropriate, by reducing concentrations of bacteria to levels that meet the criteria established in the water quality standards for contact recreation.

An I-Plan is a flexible tool that governmental and nongovernmental organizations will use to guide their program management. The participating organizations may accomplish the activities described in this I-Plan Update through voluntary or regulatory measures as

appropriate. Progress will be evaluated on a regular basis with updates and changes being made to the I-Plan Update as needed.

This I-Plan Update contains the following components:

- a description of implementation activities and management measures that will be implemented to achieve the water quality targets;
- a schedule for implementing activities;
- a description of the legal authority under which the participating agencies may require certain implementation activities;
- a follow-up tracking and monitoring the plan to determine the effectiveness of the implementation activities and management measures undertaken;
- identification of measurable outcomes and other considerations used to determine whether the I-Plan Update has been properly executed and water quality standards are being achieved, or whether this plan needs to be further modified; and
- identification of communication strategies used to disseminate information to stakeholders and other interested parties.

I-Plans are implemented through an adaptive management approach. The EPA describes adaptive implementation as a tool used to improve implementation strategies. Adaptive implementation may be appropriate when there is uncertainty regarding loading, necessary load reductions, and the effectiveness of implementation activities, as was the case for the 2013 I-Plan. Adaptive implementation allows for the implementation of practicable controls while additional data collection and analysis are conducted. Monitoring addresses the uncertainty in the efficacy of implementation actions and can provide assurance that implementation measures are succeeding in attaining water quality standards, as well as inform the ongoing TMDL implementation strategy. The cost-effectiveness of the recommendations in the 2013 I-Plan were expected to be tested early during implementation so the overall strategy can be adapted to emphasize those measures which are working best. The advantage of this approach is that it will avoid major up-front expenditures for untested strategies, but it will also require a sustained investment in monitoring and follow-up communication. This I-Plan Update is the result of this adaptive management approach, folding in ten years of implementation and lessons learned during that time.

Other Watershed Planning Efforts

The 2013 I-Plan had a goal to meet the Nine Minimum Element requirements of a watershed protection plan (WPP). By meeting those requirements it was hoped that future

incremental section 319 funding[38], see the Clean Water Act § 319(h), 33 U.S.C. 1329 (2006 & Supp. 2009) could be secured to assist implementation. However, during implementation it was found that the 2013 I-Plan was not recognized as a watershed-based plan meeting the necessary requirements. To address this, H-GAC began to fill in portions of the BIG Project Area with WPPs that do meet the requirements (Figure 5).

I-Plans differ from WPPs in two key ways. First, I-Plans typically address only one pollutant in a water body or water bodies while WPPs can address all sources and causes of watershed impairments and threats. Second, I-Plans, though typically containing voluntary measures, can be regulatory and state driven, while WPPs are voluntary and usually locally applied.

[38] EPA, 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. https://www.epa.gov/sites/default/files/2015-09/documents/2008_04_18_nps_watershed_handbook_handbook-2.pdf

Figure 5. Watershed protection plans within the BIG Project Area

Implementation Project Highlights

Annually, highlighting successful projects is an important part of assessing I-Plan implementation. The BIG, through its Annual Report focused on model bacteria reduction projects that were:

1. having an impact;
2. presenting cost saving opportunities for organizations on tight budgets;
3. increasing knowledge and understanding;
4. improving operation and maintenance; and/or
5. contributing unique and novel approaches.

The goal for sharing this highlights was to foster a sharing of information and lessons learned, that would ultimately result in the expanded use of bacteria reduction projects across the BIG project area. Each annual report included three to four example projects. A selection of these projects are provided below. For more detail on any of these or for other examples, review the annual reports[39].

On-the-Ground Structural Best Management Practices (2014 Annual Report)

In 2013, multiple jurisdictions in Harris and Galveston counties initiated Best Management Practice (BMP) projects to gauge effectiveness. An example is the Ghirardi WaterSmart Park in League City[40]. The city, TCEQ, and Texas Community Watershed Partners (TCWP), formerly the Texas Coastal Watershed Program, completed the 3.75- acre park highlighting Low-Impact Development (LID) BMPs (Figure 6). The park features pervious pavement, a cistern, a green roof, rain gardens, and bio-swales, and serves as a demonstration for residents, city staff, and local developers as to how these BMPs can be implemented into landscapes and developments around the area. TCWP monitored the BMPs until August 31, 2014, measuring nitrogen, phosphorus, and bacteria.

[39] H-GAC, 2022b. Bacteria Implementation Group Reports. https://www.h-gac.com/bacteria-implementation-group/reports.

[40] TCWP, 2022. Ghirardi Family WaterSmart Park. https://tcwp.tamu.edu/ghirardi-watersmart-park/

Figure 6. Green roof and rain barrel at Ghirardi Watersmart Park, League City, TX

Walker County Addressing Onsite Sewage Facility (OSSF) Compliance (2015 Annual Report)

Managing OSSFs presents a challenge for rural counties to adequately track residential compliance with maintenance and repairs. Walker County created a novel county OSSF program by contracted with 26 professional on-site wastewater companies to perform inspections, assist homeowners in determining repair issues, and completing and filing inspection reports. The county developed uniform inspection standards, requiring a processing fee for each report and implementing a late fee for overdue reports. The county maintains the list of approved wastewater companies by conducting random follow-up inspections to ensure reports are accurately completed. Walker County's example is being explored for use by other BIG Partners.

Whiteoak Bayou Bacteria Reduction (2015 Annual Report)

The annual *E. coli* geometric mean declined by almost 75% since 2008. While there is currently no means for correlating this decline with implementation efforts of BIG partners, the period of decline coincides with bacteria reduction activities carried out by the BIG. In 2008, the Joint Taskforce, consisting of the City of Houston, Harris County, Harris County Flood Control District (HCFCD) and the Texas Department of Transportation (a member at

the time), developed their Bacteria Reduction Plan (Reduction Plan) in response to the bacteria impairment and to address their MS4 Phase I permit requirements. The plan includes adaptive components for monitoring, assessment and best management practices. As part of the Reduction Plan, the City of Houston initiated a program to identify and fix illicit discharges. Additionally, HCFCD saw completion of five regional stormwater detention basins in White Oak Bayou's watershed that were designed with water quality enhancement features to treat stormwater. HCFCD also completed conveyance improvements and channel rehabilitation projects to remove excess sediment deposits, regrade and revegetate eroding channel slopes, and repair outfall pipe structures.

Bayou Preservation Association and the City of Houston (2016 Annual Report)

In the summer of 2015, the Bayou Preservation Association (BPA) and the City of Houston continued their successful public-private partnership. The organizations joined again to uncover illicit discharges with the hopes of eliminating them from the BIG's top ranked bayous based on elevated bacteria concentrations.

During a short period in the summer, BPA's interns visited Hunting, Brays, Sims, Whiteoak and Buffalo bayous. They identified several locations within the bayous with elevated *E. coli* bacteria concentrations. All locations are reported to local jurisdictions, including the cities of Houston and Bellaire, for thorough investigations to identify causes and remedial solutions. A site on Hunting Bayou with a leak identified in 2014 was revisited by BPA. BPA found that the City of Houston's temporary fix was leaking. The City of Houston corrected the leak and is currently working on a permanent fix. In Berry Gully, a Sims Bayou tributary in the City of South Houston, BPA found a hole in an exposed sewer main. The City of South Houston responded and is working to replace the sewer line.

Designing for Impact: A Regional Guide to Low Impact Development (2017 Annual Report)

In 2016, the Houston-Galveston Area Council (H-GAC) completed the Designing for Impact: A Regional Guide to Low Impact Development (LID)[41]. The guide will be used to encourage local governments to consider LID practices in public and private sector development and redevelopment projects. Over the next 20 years, population growth is expected to fuel development and redevelopment in the Houston-Galveston region including estimates of 6 million parking spaces, 680 million square feet of non-residential buildings and 3.5 billion square feet of residential buildings. LID is an alternative stormwater management method to

[41] H-GAC, 2022d. Designing For Impact. https://www.h-gac.com/low-impact-development

slow or capture stormwater across a project site, decrease impervious surfaces, which affords the opportunity to improve water quality, along with other benefits in the process.

H-GAC hosted a Designing for Impact Design workshop on May 20, 2016 to present the guidebook and discuss how to move LID forward. H-GAC also followed up the workshop with a bus tour to local LID projects on June 16, 2016. H-GAC invited LID project consultants to provide project breakdown on the LID case studies.

Additional outreach included development of an interactive webpage, www.h-gac.com/go/LID, to serve as a regional LID resource. Over fifty LID projects are highlighted. An information form was created that will allow organizations to submit LID projects to continuously update the webpage.

Fats, Oils, Grease (FOG) Sanitary Sewer System Reduction Efforts (2018 Annual Report)

The City of Houston and Galveston Bay Foundation have active programs seeking to reduce FOG. The Houston Health Department maintains a comprehensive FOG program under FOG Ordinance Chapter 47 Article XI, that focuses on reducing the impact of pollutants that may interfere with the function of the sanitary and storm sewer system. The department has an active community education and involvement presence and provides necessary enforcement through investigations and follow up remediation. In fiscal year 2017, staff conducted 37 public outreach initiatives educating on the importance of proper handling of used cooking oil and proper disposal of sanitary items such as so called "flushable" wipes. That same year, there were 3,017sanitary sewer overflows investigated by staff. These investigations confirmed 11,492 violations and lead to 923 citations.

In 2017, Galveston Bay Foundation promoted the Cease the Grease Program[42] at 18 outreach events, reaching 7,527 people. An additional 7 million people were reached through media promotions. The Galveston Bay Action Network[43] was used to file 9 sanitary sewer issue reports. The reports are sent on to the appropriate agency for response.

On-site Sewage Facility Repair and Replacement (2019 Annual Report)

On-site sewage facilities, often referred to as septic systems, when maintained and sited correctly, are an appropriate method to safely treat human wastes. One BIG priority is to address those systems that are not functioning properly within the project area (Figure 7).

[42] Galveston Bay Foundation, 2022a. Cease the Grease Campaign. http://ceasethegrease.net/

[43] Galveston Bay Foundation, 2022b. Galveston Bay Action Network. https://www.galvbaygrade.org/cover-stories/2023/07/galveston-bay-action-network/

There are approximately 46,000 permitted on-site sewage facilities and an estimated 172,000 unpermitted, those installed either illegally or prior to the establishment of permit requirements, within the project area. One study[44] conservatively estimates the rate of failing systems at 12 percent or 26,000 of the 218,000 systems are likely failing to properly treat human wastes.

Figure 7. Septic tank replacement

At least two programs are seeking to address those failing systems: The East Aldine Area and the H-GAC Waste Water Assistance Program.

The East Aldine Management District (District) and Harris County have made significant improvement in the East Aldine area's water and sanitary sewer infrastructure. A study in the 1990s found that there were over 4,500 single-family homes in East Aldine that relied on shallow water wells for drinking water and traditional septic tank systems for wastewater treatment. Utilizing $43 million in Community Development Block Grants received by Harris County, Texas Water Development Board grants and the District's general funds and District

[44] Reed, Stowe & Yanke, LLC. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas. Texas On-site Wastewater Treatment Council.

issued bonds, new water and wastewater service was and will be provided to 1,336 homes and an estimated 3,600 residents. The District and Harris County targeting Aldine communities with the highest septic tank failure rates, areas greater than 30 percent, and with a prevalence of private drinking wells[45].

Harris County and the District continued to install sewer service in 2018 using grant funding. Since 2014, Harris County and East Aldine Management District had made 811 connections to new sanitary sewer systems, abandoning a total of 1,413 OSSFs.

The H-GAC Wastewater Assistance Program is funded by directing environmental fines from water quality violations to two Supplemental Environmental Projects (SEP), one through TCEQ and the second through the Harris County District Attorney's Office. More information about the program is available on H-GAC's website[46].

H-GAC uses these SEP funds to assist homeowners with failing systems by providing holding tank pump outs, complete system repairs, and if necessary, replacement of the entire system. Homeowners must qualify based on income, must own the home, and live in the 13 county H-GAC Service Area.

H-GAC began addressing failing systems in 2018. In the BIG project area, 14 systems were identified either through a referral from the county or by the homeowner. Of those systems, five have been fixed, one is being scheduled for repair, and eight are on a wait list. The program is looking for additional funding to address those systems on the wait list. The average cost per system is $5,000 for repairs that range from the simple and least costly, water conservation kits and pump-outs, to the more complex and greater cost, major repairs, system replacement and in limited cases, tie-ins to centralized wastewater.

Exploration Green (2021 Annual Report)

Exploration Green[47] (EG) is a multi-use park serving the region and supporting the goals of the BIG. The project is the result of public and private partners, including the Clear Lake City Water Authority (CLCWA), civic organizations, consultants, and private citizens. One result has been the founding of the not-for-profit Exploration Green Conservancy which worked with the Galveston Bay Foundation to establish a perpetual conservation easement for EG.

[45] Presentation by East Aldine Management District, "East Aldine District Water-Sewer Capital Improvement Plan." Clean Water Initiative Workshop, Houston-Galveston Area Council May 22, 2019. Web access: http://www.h-gac.com/clean-water-initiative-workshops/default.aspx.

[46] H-GAC, 2022e. Residential Wastewater Assistance Program. https://www.h-gac.com/on-site-sewage-facilities

[47] Exploration Green, 2022. https://www.explorationgreen.org/

EG is expected to improve water quality within the Horsepen/Armand Bayou watershed. EG is establishing wetlands within retention areas (Figure 7); and volunteers have been encouraged to participate in planting events and maintain a nursery. EG partners have commissioned a study to monitor the benefits of the wetland plants.

EG, a 200-acre former golf course, is anticipated to have a storage capacity of 1,680 acre-feet or ½-billion gallons of water[48]. EG is expected to contain 38 acres of water surface area, 39 acres of wetlands, 4 habitat islands, 101 acres of upland/island areas, permanent depth of 6 feet, additional 8 feet of water storage and over 5 miles of biking/walking trails.

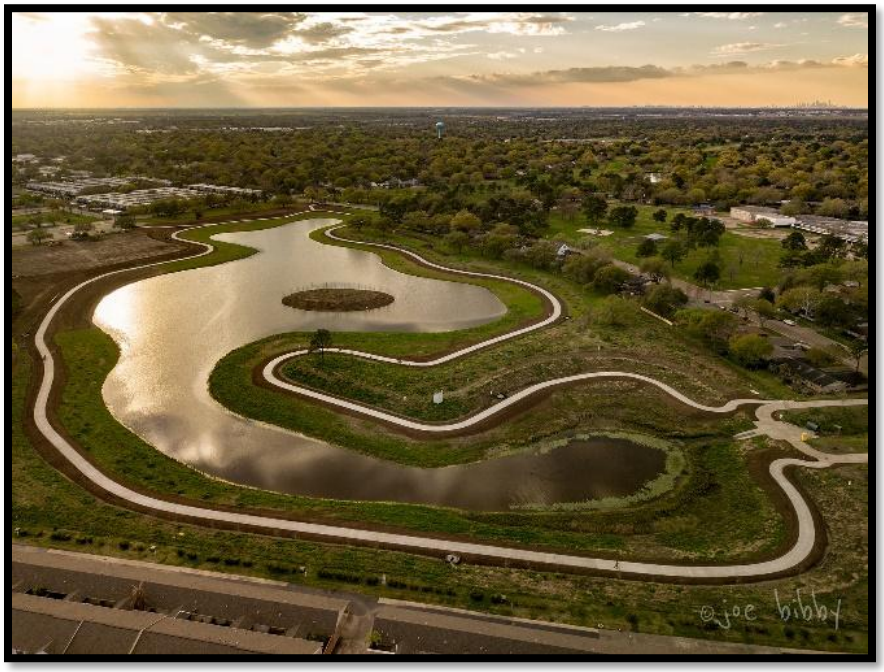

Figure 8. Aerial photo of one of the basins at EG, City of Houston, TX.

City of Houston Green Development Incentives (2021 Annual Report)

The City of Houston established the Green Development Incentives[49] program to promote the use of green infrastructure through municipal and private projects. The incentives were determined by a study funded through Houston Endowment.

[48] FEMA, 2019. Exploration Green prevents flooding, enhances Houston-area community. Press Release Oct. 19, 2019. https://www.fema.gov/press-release/20210318/exploration-green-prevents-flooding-enhances-houston-area-community

[49] City of Houston, 2021. Incentives For Green Development. https://cityofhouston.news/mayor-turner-announces-incentives-for-green-development-launch/

The city wants a robust green infrastructure program to encourage use in new development and redevelopment leading to economic, social, and environmental benefits.

The program seeks to incentivize by:

- Integrated green stormwater infrastructure development rules
- Property tax abatement
- Award and recognition program
- Increased permitting process certainty and speed.

Targeted Monitoring 2020-2021 (2022 Annual Report)

Targeted monitoring is an investigative approach to survey a waterbody to identify potential sources of bacteria (Figure 9). The BIG encourages organizations and jurisdictions to increase source monitoring, particularly in AUs where ambient monitoring has determined elevated levels of fecal bacteria. The BIG produces an annual list of the top twenty AUs with the highest levels of fecal bacteria; and has developed a model program for those interested, to follow – Top Five Least Five[50].

Figure 9. Bayou Preservation Association Interns Targeted Monitoring

[50] H-GAC, 2022c. Top Five Least Five Project: https://www.h-gac.com/bacteria-implementation-group/reports

Beginning in 2020, two targeted monitoring projects were initiated in the region. One was funded through the TCEQ's Clean Rivers Program[51] and the second, TCEQ's Galveston Bay Estuary Program.

Status of Implementation and Lessons Learned

Ultimate success for the BIG will be achieved when the waters assessed by the state are no longer considered impaired, meaning they meet the state contact recreation standard. Achieving that goal requires annually assessing progress to determine what is working and what is not working, looking critically at what each of the BIG partners is doing to further the goals set forth in the 2013 I-Plan and now the I-Plan Update, sharing information, and coordinating future implementation activities. The Annual Reports are one tool meant to be a mechanism for annual assessment, encouraging efforts that appear to be working and redirecting implementation that seems to be falling short. It is also an opportunity to look at the I-Plan to see if expectations are being met or if some activities need further refinement, leading to updates or revisions.

Overall, bacteria levels for waterways in the BIG project area have decreased or remained stable since the BIG began working to address the problem in 2008. Even during a period of continued population growth and area-wide development pressure.

Bacteria levels in waterways have decreased from above six times the state's contact recreation standard to four times the standard (Figure 2). Since 2013, bacteria conditions have improved in 6 assessment units (AU), remained stable in 120, while deteriorating in 18 of the 144 AUs reviewed within the BIG Project Area. In fact, two AUs, 1004_01 and 1004D_01 on the West Fork of the San Jacinto River and Crystal Creek, respectively, now meet the contact recreation standard and were delisted for the TCEQ's 2016 Texas Integrated Report[52].

The assessment of each implementation activity includes determining progress made toward achieving the activity's interim goal: Not Started, Initiated, In Progress, or Completed. Additionally, each activity is assessed based on the BIG partner's efforts to advance the activity: Behind Schedule, On Schedule, Ahead of Schedule, or Completed and in Tracking.

[51] H-GAC, 2021. Targeted Monitoring 2020-2021. https://www.h-gac.com/getmedia/3a9a542a-9336-4318-848b-4ce24eb1521b/Targeted-Monitoring-Project-FY2020-2021

[52] TCEQ, 2019. 2016 Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d) De-listings. https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/16txir/2016_delist.pdf

Completed and in Tracking signifies that the activity has been completed and the BIG will continue to track.

Overall, six activities have been completed and 32 are In Progress, as of 2022. The six completed activities and five of the In Progress activities have been placed into Tracking to evaluate changes over time. Three activities were considered Ahead of Schedule and 24 On Schedule (Figure 10). This I-Plan Update incorporates the BIG's review of the 2013 I-Plan implementation, focused on those activities that were behind schedule or completed for opportunities to revise and enhance future implementation efforts. The bacteria reduction strategy sections that follow have been revised to reflect this review. The point being to again see bacteria reductions within the project watersheds, those seen in the first years of the 2013 I-Plan, over the anticipated next ten years of implementation.

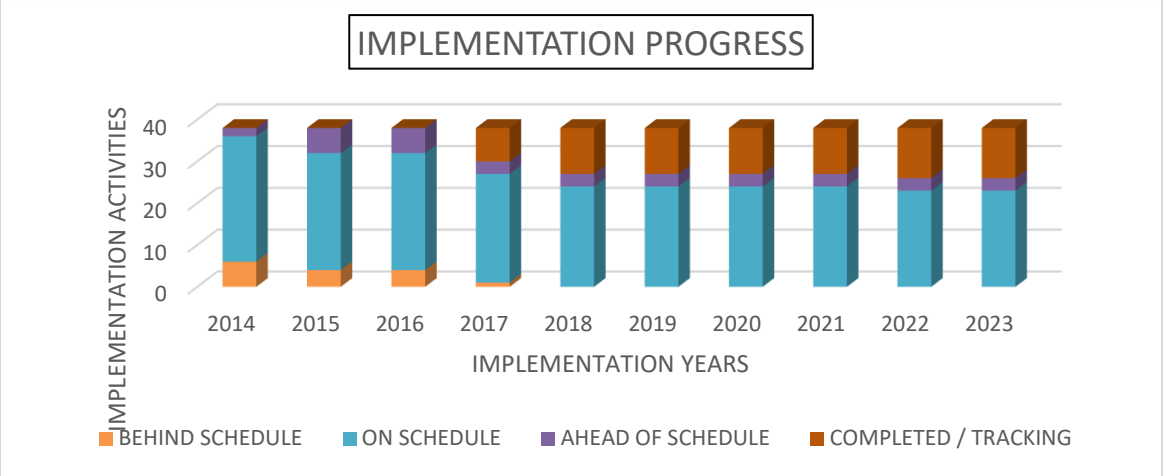

Figure 10. Implementation tracking for all 38 2013 I-Plan activities as reported in the 2022 Annual Report.

First Ten Year Summary of Implementation

The 2013 I-Plan contains 11 strategies with 38 activities. The 11 strategies were retained and each is individually described in the sections that follow. Much of what has been learned over the past ten years is expressed within each strategy section. However, some of the highlights are summarized below.

Implementation Strategy 1.0 Wastewater Treatment Facilities

This strategy focused on improving the function of wastewater treatment facilities. Seven activities that range from permitting targets to enhanced function, from regionalization efforts to enforcement and compliance, and finally irrigation. Most of this strategy's success was in changes to the permits that required facilities to meet an *E. coli* limit of 63 colony forming units/100 mL, half the standard limit of 126 colony forming units/100 mL. Since 2013, self-reporting data from individual facilities was available for analysis. This analysis

along with compliance data from Harris County suggests, contrary to concerns expressed prior, that facilities are able to meet the stricter limit at rates greater than 90% of the time. In support of this strategy, the BIG focused on providing technical workshops to the region's wastewater professionals to encourage best practice usage.

Implementation Strategy 2.0 Sanitary Sewer Systems

Sanitary sewer overflows are a large contributor of untreated human effluent to the region. This strategy focused on prevention through six activities centered on operation and maintenance, outreach and education, and reporting. Since 2013, reporting overflows to the TCEQ improved and expanded. The BIG was able to analyze the data. The largest number of overflows can generally be attributed to blockages, including fats, oils, grease and wipes, while the greatest volume typically was found to be due to failing infrastructure. That said, the data has some limits as there is tremendous variability in how the data is reported to the TCEQ. Going forward, it is hoped that the EPA and TCEQ efforts to convert paper submissions to an electronic format in 2025, will lower the variability, making for better comparisons and analysis. The BIG focused on workshops and outreach to highlight the many resources available to the public to report overflows to authorities and prevention of fats, oils, grease and wipes (Table 4). The BIG also encouraged targeted monitoring efforts to identify dry weather sources of bacteria and reporting to authorities.

Implementation Strategy 3.0 Onsite Sewage Facilities

Strategy 3.0 implementation through three strategies, focused on identifying and mapping permitted and unpermitted systems within the region. Harris County and H-GAC provide targeted outreach to water quality professionals, real estate professionals, and residents concerning new rules and regulations and the operation and maintenance features of these systems. Harris County, working with local partners, sought to address areas with high concentrations of failing facilities within the county. H-GAC was approved by the TCEQ to receive Supplemental Environmental Project funds distributed from by entities partially in lieu of fines given over to Texas General Revenue for permit violations. These funds are used to pump out, repair or replace failing systems where the homeowner meets income.

Table 4. Implementation resources

IMPLEMENTATION RESOURCES			
RESOURCE	**NAME**	**USE**	**WEBSITE**
FUNDING and TECHNICAL ASSISTANCE	319 Nonpoint Source Grant	Non permitted Nonpoint Source Reduction Measures	https://www.tceq.texas.gov/waterquality/nonpoint-source/grants
	319 Nonpoint Source Grant	Agriculture and Silviculture Nonpoint Source Measures	https://www.tsswcb.texas.gov/programs/texas-nonpoint-source-management-program
	320 Estuary Program	Water Quality Improvement, Conservation, Restoration, Public Outreach and Education, and Research	https://gbep.texas.gov/
	Clean Water State Revolving Fund	Low-cost financial assistance for wastewater, reuse, and stormwater infrastructure	http://www.twdb.texas.gov/financial/programs/CWSRF/
	EPA Water Infrastructure and Resiliency	Resource to explore innovative finance solutions	https://www.epa.gov/waterfinancecenter
	Low Impact Development / Green Infrastructure	Guidance on use and maintenance (H-GAC)	https://www.h-gac.com/low-impact-development
		City of Houston Incentives for Green Infrastructure	http://www.houstontx.gov/igd/
	Natural Resources Conservation Services Environmental Quality Incentives Program	Resource Conservation for Agriculture and Silviculture	https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives
	Onsite Sewage Facility	Homeowner, real estate, and inspector technical assistance and funding	https://www.h-gac.com/on-site-sewage-facilities
	Texas Parks and Wildlife Landowner Incentive Program	Enact conservation practices on private lands	https://tpwd.texas.gov/landwater/land/private/lip/#menu

IMPLEMENTATION RESOURCES			
RESOURCE	**NAME**	**USE**	**WEBSITE**
	Texas Water Infrastructure Coordination Committee	Identify and develop solutions to water and wastewater	https://twicc.org/resources/funding.html
	USDA Rural Development Grant	Rural Wastewater Infrastructure	https://www.rd.usda.gov/programs-services/water-waste-disposal-loan-grant-program
	USDA Waste and Environmental Program	Multiple assistance programs	https://www.rd.usda.gov/programs-services/all-programs/water-environmental-programs
	Water Quality Management Plan	Soil and Water Conservation for Agriculture and Silviculture	www.tsswcb.texas.gov/index.php/programs/water-quality-management-plan
Outreach and Education	Clean Waterways	Water quality outreach and education	www.cleanwaterways.org
	Clean Waters Initiative Workshops	Technical workshops covering a variety of water quality information	https://www.h-gac.com/clean-water-initiative-workshops
	Coastal Communities	Nonpoint source outreach and education information	https://www.h-gac.com/coastal-communities
	Fats, Oils, Grease, Wipes	Cease the Grease	http://ceasethegrease.net/
		Protect Our Pipes	https://www.houstonpublicworks.org/protect-our-pipes
		Patty Potty	www.pattypotty.com
	Lone Star Healthy Streams	Agriculture BMPs	http://lshs.tamu.edu/bmps/
	Municipal Public Education	Regional Public Education Services Program	https://www.hcfcd.org/Resources/Education-Materials/Regional-Public-Education-Services-Program
		Coastal Communities	https://www.h-gac.com/coastal-communities
	Onsite Sewage Facility	Public outreach and education	https://www.h-gac.com/on-site-sewage-facilities
	Pet Waste	Basic information on pet wastes	https://www.h-gac.com/pet-waste-pollutes
Reporting	City of Houston Bureau of Pollution Control and Prevention	Service helpline and pollution reporting	www.houstontx.gov/311 and 713.837.0311

IMPLEMENTATION RESOURCES			
RESOURCE	**NAME**	**USE**	**WEBSITE**
	Galveston Bay Action Network	Pollution reporting in five counties surrounding Galveston Bay	https://www.gbanmap.com/
	HCFCD Citizen's Service Hotline	Telephone reporting system	713.684.4197
	Illegal Dumping	Pollution reporting system for MS4s	www.cleanbayous.org
Data	Clear Rivers Program	Ambient monitoring data	https://www.h-gac.com/clean-rivers-program/data
	EPA Enforcement and Compliance History Online	Permit tracking and compliance database	https://echo.epa.gov/
	HCFCD BMP Database	Best Management Practices Monitoring	www.bmpbase.org
	LID Tracking	Low Impact Development Resource	https://www.h-gac.com/low-impact-development/designing-for-impact
	Onsite Sewage Facility	Mapping tool	https://datalab.h-gac.com/ossf/
	Wastewater and Stormwater	Permit look up	www.tceq.texas.gov/agency/data/lookup-data/status-stormwater-wastewater.html

qualifications. Additionally, H-GAC has been receiving similar funds from cases before the Harris County District Attorney.

Implementation Strategy 4.0 Stormwater and Land Development

This strategy looks at managing bacteria within stormwater, through six activities, particularly with those local governments and jurisdictions that maintain stormwater permits with the TCEQ. Municipal separate storm sewer system (MS4) permit program encourages the use of best practices to manage stormwater. The program has seen enhance requirements with each renewal. One requirement is in addressing effluent that reaches impaired waters. MS4 permit holders are encouraged to implement practices that will reduce bacteria and to work with watershed programs like the BIG. To help enhance the regions stormwater programs, the BIG has supported technical workshops on minimum control measures and the use of low impact development/green infrastructure (GI) practices. Harris County prior to the approval of the 2013 I-Plan wrote GI practices into their stormwater regulations[5354], providing an option for detention offset for their use. The City of Houston recently initiated a program to encourage GI through recognition, tax abatement and faster permit approval[55]. Harris County Flood Control District has been applying water quality features to their wet bottom detention basins[56].

Implementation Strategy 5.0 Construction

Through one activity, strategy 5 focused attention on compliance with stormwater rules and regulations. The BIG focused on hosting technical workshops covering the construction general permit and MS4 minimum control measures. Successful best practices control soil

---

[53] Harris County, 2020. Regulations of Harris County, Texas For the Approval and Acceptance of Infrastructure. https://www.eng.hctx.net/Portals/23/Publications/Infras-Regs-09-2020.pdf.

[54] Harris County, 2011. Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management. https://www.hcfcd.org/Portals/62/Technical_Document_Library/Harris%20County%20Low%20Impact%20Development%20Design%20Criteria%20Manual/2011-FINAL-LID-GIDC.pdf?ver=lqZ1iPKSieC-zpHI32Jjvw%3d%3d&timestamp=1668637659423. Last modified November 2, 2020.

[55] City of Houston, 2022. Incentives For Green Development. http://www.houstontx.gov/igd/

[56] Harris County Flood Control District, 2014. Wet Bottom Detention Basins with Water Quality Features. https://www.hcfcd.org/Portals/62/Technical_Document_Library/Design%20Guidelines%20for%20HCFCD%20Wet%20Bottom%20Detention%20Basins%20with%20Water%20Quality%20Features/Design-Guidelines-WetBottom-Basins-FINAL.pdf?ver=s9hGneR0kmw12DSvFlzKgA%3d%3d&timestamp=1668637913446. Last modified October 5, 2020.

erosion and construction debris, which has been demonstrated to host bacteria and are key requirements of a construction general permit.

Implementation Strategy 6.0 Illicit Discharges and Dumping

Strategy 6.0 contains three activities which look at detection and elimination of illicit discharges, regulations and enforcement, and monitoring waste hauler actions. Since 2013, the BIG's attention was on detecting and eliminating illicit discharges. This was done through workshops that highlighted requirements of MS4 permit holders to map sanitary and storm conveyance structures, and on new technology to assist in monitoring systems. The BIG encouraged surveying and monitoring of dry weather events to identify and correct illicit discharges. For the I-Plan Update, a new activity was added to address recreational boater wastes. Including Jarbo Bayou and a portion of Lake Houston in the BIG Project Area added a potential new bacteria source.

Strategy 7.0 Agriculture and Animal Source

Utilizing two activities, the BIG encouraged coordination with resource agencies to draw attention to agriculture and feral hog sources of bacteria. This is a heavy outreach strategy requiring meetings and workshops with interested land owners (Table 4). Agencies like the Texas State Soil and Water Conservation Board and Texas AgriLIfe held workshops with landowners to help address sources and identify opportunities to remove feral hogs. The strategy was expanded in the I-Plan Update to include silviculture practices. The expansion of the project area included large areas of managed timber in the East Fork of the San Jacinto River.

Strategy 8.0 Residential

Strategy 8.0 through two activities is tied to education and outreach addressing residential sources of bacteria, e.g., pet wastes; fats oils, grease, and wipes, and links to other strategies, i.e., onsite sewage facilities and sanitary sewer systems. The BIG focused on hosting workshops and coordinating with outreach and education events. Gathering and sharing resources (Table 4) and initiating stormwater programs with communities.

Strategy 9.0 Monitoring and I-Plan Revision

There are four activities in Strategy 9.0 that focus on tracking bacteria concentrations within the BIG Project Area, ambient and non-ambient water quality data, maintaining an implementation activity database, and accessing and informing I-Plan implementation. The BIG has continued to analyze bacteria trends throughout the region. BIG partners have increased targeted monitoring efforts (non-ambient) to determine best practice efficacy and to track potential sources of bacteria. The BIG has produced an annual report covering implementation since 2013. Through these efforts the BIG has sought to determine what

strategies and actions have worked toward lowering bacteria and how that information was used to direct future implementation and for this update.

Strategy 10.0 Research

Strategy 10.0 seeks, through four activities, to better understand how specific practices reduce bacteria, identify potential alternative indicators to better refine contact recreation impairments and to track other research that can improve reduction strategies.

Strategy 11.0 Geographic Priority Framework

The framework's goal is to better target implementation to project areas to see localized improvement. The one activity's original intent was to use the magnitude of bacteria within a waterbody as a means to narrow the focus of implementation. Producing the ranked order of waterbodies from highest concentration of bacteria to the lowest, the BIG hoped that implementors would target the highest ones and those closest to the contact recreation standard for implementation, i.e., waterbodies where a discernable improvement could be made or delisting could be possible. Moving forward with the I-Plan Update, the geographic priority framework will look to incorporate areas of underserved population and environmental justice.

References

City of Houston, 2022. Incentives For Green Development. http://www.houstontx.gov/igd/

EPA, 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. https://www.epa.gov/sites/default/files/2015-09/documents/2008_04_18_nps_watershed_handbook_handbook-2.pdf

EPA, 2022. Impaired Waters and Total Maximum Daily Loads. https://www.epa.gov/tmdl. Last modified September 15, 2022.

Exploration Green, 2022. https://www.explorationgreen.org/

FEMA, 2019. Exploration Green prevents flooding, enhances Houston-area community. Press Release Oct. 19, 2019. https://www.fema.gov/press-release/20210318/exploration-green-prevents-flooding-enhances-houston-area-community

Galveston Bay Foundation, 2022a. Cease the Grease Campaign. http://ceasethegrease.net/

Galveston Bay Foundation, 2022b. Galveston Bay Action Network. https://galvbay.org/gban-reporting-tool/

Harris County, 2011. Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management. https://www.hcfcd.org/Portals/62/Technical_Document_Library/Harris%20County%20Low%20Impact%20Development%20Design%20Criteria%20Manual/2011-FINAL-LID-GIDC.pdf?ver=lqZ1iPKSieC-zpHI32Jjvw%3d%3d&timestamp=1668637659423. Last modified November 2, 2020.

Harris County Flood Control District, 2014. Wet Bottom Detention Basins with Water Quality Features. https://www.hcfcd.org/Portals/62/Technical_Document_Library/Design%20Guidelines%20for%20HCFCD%20Wet%20Bottom%20Detention%20Basins%20with%20Water%20Quality%20Features/Design-Guidelines-WetBottom-Basins-FINAL.pdf?ver=s9hGneR0kmw12DSvFlzKgA%3d%3d&timestamp=1668637913446. Last modified October 5, 2020.

Harris County, 2020. Regulations of Harris County, Texas For the Approval and Acceptance of Infrastructure. https://www.eng.hctx.net/Portals/23/Publications/Infras-Regs-09-2020.pdf.

H-GAC, 2013. Implementation Plan for Seventy-Two Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region. https://www.h-gac.com/bacteria-implementation-group/reports. Accessed October 1, 2022.

H-GAC, 2015. Implementation Plan Addendum 2. https://www.h-gac.com/getmedia/09bb4674-0400-4078-b748-630e144adc15/2Addendum82015.pdf

H-GAC, 2016. Implementation Plan Addendum 3. https://www.h-gac.com/getmedia/aba91b96-8c6f-4df2-8307-8521cc833364/3Addendum52016.pdf

H-GAC, 2018. Implementation Plan Addendum 4. https://www.h-gac.com/getmedia/1645ceb1-8c6a-4a29-b2f6-2794dba062f6/4Addendum62018.pdf

H-GAC, 2021. Targeted Monitoring 2020-2021. https://www.h-gac.com/getmedia/3a9a542a-9336-4318-848b-4ce24eb1521b/Targeted-Monitoring-Project-FY2020-2021

H-GAC, 2022a. Bacteria Implementation Group (BIG). https://www.h-gac.com/bacteria-implementation-group. Accessed October 1, 2022.

H-GAC, 2022b. Bacteria Implementation Group Reports. https://www.h-gac.com/bacteria-implementation-group/reports. Accessed November 1, 2022.

H-GAC, 2022c. Top Five Least Five Project: https://www.h-gac.com/bacteria-implementation-group/reports

H-GAC, 2022d. Designing For Impact. https://www.h-gac.com/low-impact-development

H-GAC, 2022e. Residential Wastewater Assistance Program. https://www.h-gac.com/on-site-sewage-facilities

Reed, Stowe & Yanke, LLC. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas. Texas On-site Wastewater Treatment Council.TCEQ, 2008. Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/68-clear-creek-tmdl-adopted.pdf

TCEQ, 2009. Eighteen Total Maximum Daily Loads for Bacteria in Buffalo and Whiteoak Bayous and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/22-buffalo-whiteoak-bayous-tmdl-adopted.pdf

TCEQ, 2010a. Five Total Maximum Daily Loads for Indicator Bacteria in Brays Bayou Above Tidal and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-brays-bayou-tmdl-adopted.pdf. Adopted September 15, 2010. Approved by the EPA September 27, 2010.

TCEQ, 2010b. Thirteen Total Maximum Daily Loads for Indicator Bacteria in Eastern Houston Watersheds. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-east-houston-tmdl-adopted.pdf

TCEQ, 2010c. Eight Total Maximum Daily Loads for Indicator Bacteria in Greens Bayou Above Tidal and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-greens-bayou-tmdl-adopted.pdf

TCEQ, 2010d. Four Total Maximum Daily Loads for Indicator Bacteria in Halls Bayou and Tributaries. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-halls-bayou-tmdl-adopted.pdf

TCEQ, 2010e. Four Total Maximum Daily Loads for Indicator Bacteria in the Sims Bayou Above Tidal Watershed. Four Total Maximum Daily Loads for Indicator Bacteria in Sims Bayou Above Tidal and Tributary (texas.gov).

TCEQ, 2013a. One TMDL added by Addendum April 2013. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-eastern-houston-tmdl-addendum-one.pdf

TCEQ, 2013b. One TMDL added by Addendum April 2013. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-sims-bayou-tmdl-addendum-one.pdf

TCEQ, 2015. Six Total Maximum Daily Loads for Indicator Bacteria in the Armand Bayou Watershed. Six Total Maximum Daily Loads for Bacteria in Armand Bayou; Segments 1113, 1113A, 1113B, 1113C, 1113D, and 1113E (texas.gov). Adopted August 5, 2015. Approved by the EPA October 2, 2015.

TCEQ, 2016. Seven Total Maximum Daily Loads for Indicator Bacteria in the East and West Forks of the San Jacinto River, Lake Houston, and Crystal Creek Watersheds. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/82b-ewfsjr-tmdl-adopted.pdf

TCEQ. 2018a. Texas Surface Water Quality Standards, 2018, 30 TAC 307. texreg.sos.state.tx.us/public/readtac%24ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y.

TCEQ, 2018b. One TMDL added by Addendum October 2018. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/89c-armand-bacteria-addendum-one.pdf

TCEQ, 2018c. Two TMDLs added by Addendum October 2018. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/68b-clear-creek-bacteria-tmdl-addendum-two.pdf

TCEQ, 2018d. One Total Maximum Daily Load for Indicator Bacteria in Jarbo Bayou. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/106-jarbo-bayou-bacteria-tmdl-adopted.pdf

TCEQ, 2018e. One TMDL added by Addendum October 2018. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/82c-ewfsj-bacteria-tmdl-addendum-one.pdf

TCEQ, 2019. 2016 Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d) De-listings. https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/16txir/2016_delist.pdf

TCEQ, 2021. One TMDL for Harris County Flood Control Ditch D 138 Added by Addendum II, January 2021. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/72-brays-bayou-tmdl-addendum-two.pdf.

TCEQ, 2021b. One TMDL for Horsepen Creek Added by Addendum III, January 2021. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/22-buffalo-whiteoak-bayous-tmdl-addendum-three.pdf

TCEQ, 2022a. Houston-Galveston Region: I-Plan and TMDLs. https://www.tceq.texas.gov/waterquality/tmdl/nav/42-houstonbacteria/42-houstonbig-tmdlplan. Last modified September 9, 2022.

TCEQ, 2022b. Texas Water Quality Standards. https://www.tceq.texas.gov/waterquality/standards/eq_swqs.html. Last modified August 24, 2022.

TCEQ, 2022c. Total Maximum Daily Load Program: Communities Working Together to Improve Water Quality. https://www.tceq.texas.gov/waterquality/tmdl. Last modified June 17, 2022.

TCEQ, 2022d. Texas Integrated Report of Surface Water Quality for Clean Water Act Section 305(b) and 303 (d) https://www.tceq.texas.gov/waterquality/assessment. Last modified August 24, 2022.

TCEQ, 2022e. Water Quality Management Plan. https://www.tceq.texas.gov/permitting/wqmp/WQmanagement_comment.html. Last modified November 14, 2022.

TCEQ, 2022f. One Total Maximum Daily Load for Indicator Bacteria in Walnut Creek added by Addendum III, October 2020. https://www.tceq.texas.gov/downloads/water-quality/tmdl/houston-galveston-recreational-42/82f-lakehouston-tmdl-addendum04-2022april.pdf

TCWP, 2022. Ghirardi Family WaterSmart Park. https://tcwp.tamu.edu/ghirardi-watersmart-park/

U.S. Code, 2020. Clean Water Act § 303(d), 33 U.S.C. § 1313. https://www.govinfo.gov/app/collection/uscode/2020/title33/chapter26/subchapterIII. Accessed October 1, 2022.

Implementation Strategy 1.0: Wastewater Treatment Facilities

Although bacteria are found in fecal waste of all warm-blooded animals, it is the intent of the BIG to focus resources on bacteria from human sources. When not dominated by stormwater, a large portion of the flow in many of the region's waterways can come from wastewater effluent. Possible sources of bacteria from wastewater treatment facilities (WWTFs) include insufficiently treated effluent and unauthorized/accidental discharge, including sludge. Centralized wastewater service covers an area of approximately 289,331.9 acres or 64 percent of the BIG project area (Figure 1)[57].

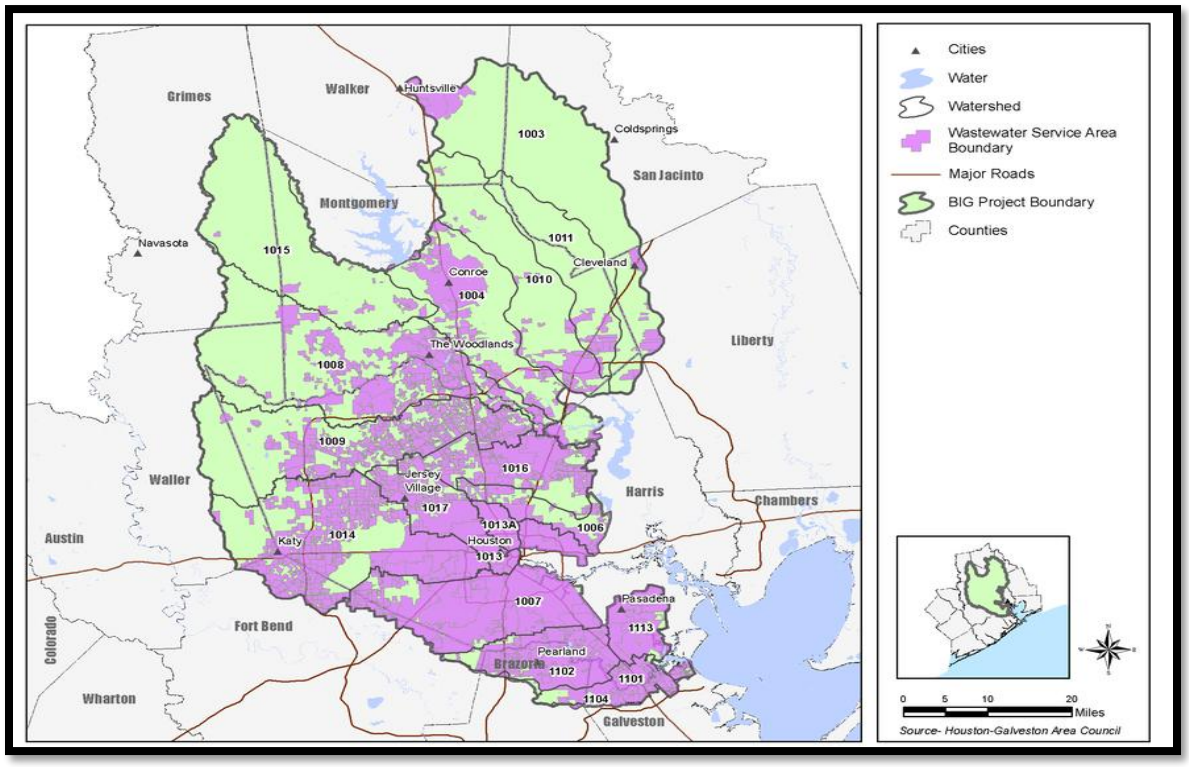

Figure 11. Wastewater service area within the BIG project area

[57] 2019, H-GAC. Based on service area boundaries submitted by districts to the TCEQ.

In Texas, the permit requirement to monitor fecal bacteria at WWTFs has increased our understanding of bacteria loading from WWTFs. WWTFs self-report bacteria monitoring to the state through their Discharge Monitoring Report (DMR). Results from monitoring of bacteria in the BIG region suggests that the levels of indicator bacteria in effluent from individual WWTFs is typically low. Based on the self-reported Grab/Max limit, only 3.2 percent of the facilities in 2020 were found to be exceeding the single-sample criterion for *E. coli* (Table 1). The results also suggest WWTFs have improved over time.[58]

As of January 1, 2019, the BIG region has 630 permitted WWTFs[59]. Of those 630 permits, 540 submit DMRs to the state[60]. Based on the DMRs, there are 507 domestic WWTFs and 33 industrial WWTFs with 506 domestic and 17 industrial WWTFs submitting bacteria data. The distribution of domestic WWTFs based on permitted flow has changed since 2013. Previously the majority (43%) of domestic WWTFs in the BIG project area were those permitted for flow less than 0.1 million gallons per day, or MGD. At present this has changed with the majority of domestic WWTFs found evenly distributed across four permitted flow categories between those plants less than 0.5 MGD and those less than 5 MGD (See

Table and

.)

Table 5. DMR Exceedance Table

Year	Total Geomean Results Reported from Permittees with Limits in Permits	Samples Exceeding Geomean Limit	Percent Samples Exceeding Geomean Limit	Geomean Percent Compliance	Total Grab/Max Results Reported from Permittees with Limits in Permits	Samples Exceeding Grab/ Max Limit	Percent Samples Exceeding Grab/Max Limit	Grab/Max Percent Compliance
2012	2,686	33	1.2	98.8	2,670	166	6.2	93.8
2013	3,905	39	1.0	99.0	3,998	200	5.0	95.0
2014	4,433	38	0.9	99.1	4,594	131	2.9	97.1

[58] Discharge Monitoring Reports from WWTFs within the BIG Project Area supplied to the USEPA. (EPA Registry, February 2020).

[59] (EPA Registry, February 2020)

[60] (TCEQ Central Registry, February 2020)

Year	Total Geomean Results Reported from Permittees with Limits in Permits	Samples Exceeding Geomean Limit	Percent Samples Exceeding Geomean Limit	Geomean Percent Compliance	Total Grab/Max Results Reported from Permittees with Limits in Permits	Samples Exceeding Grab/ Max Limit	Percent Samples Exceeding Grab/Max Limit	Grab/Max Percent Compliance
2015	4,558	21	0.5	99.5	4,728	182	3.8	96.2
2016	4,636	23	0.5	99.5	4,810	127	2.6	97.4
2017	4,720	31	0.7	99.3	4,904	153	3.1	96.9
2018	4,793	15	0.3	99.7	5,016	115	2.3	97.7
2019	5,060	33	0.7	99.3	5,160	164	3.2	96.8

Table 2: Domestic and Industrial WWTFs[61]

Permitted Flow (MGD)	Number of Domestic WWTF	Percentage of Domestic WWTF	Number of Industrial WWTF	Percentage of Industrial WWTF
0 to less than 0.1	125	24.70%	10	58.82%
0.1 to less than 0.5	136	26.88%	5	29.41%
0.5 to less than 1	113	22.33%	1	5.88%
1 to less than 5	100	19.76%	1	5.88%
5 to less than 10	19	3.75%	0	0
10 or greater	13	2.57%	0	0
Total	**506**	**100.00%**	**17**	**100.00%**

[61] These numbers were extracted from a database, maintained by H-GAC, of permitted WWTF in the thirteen-county region.

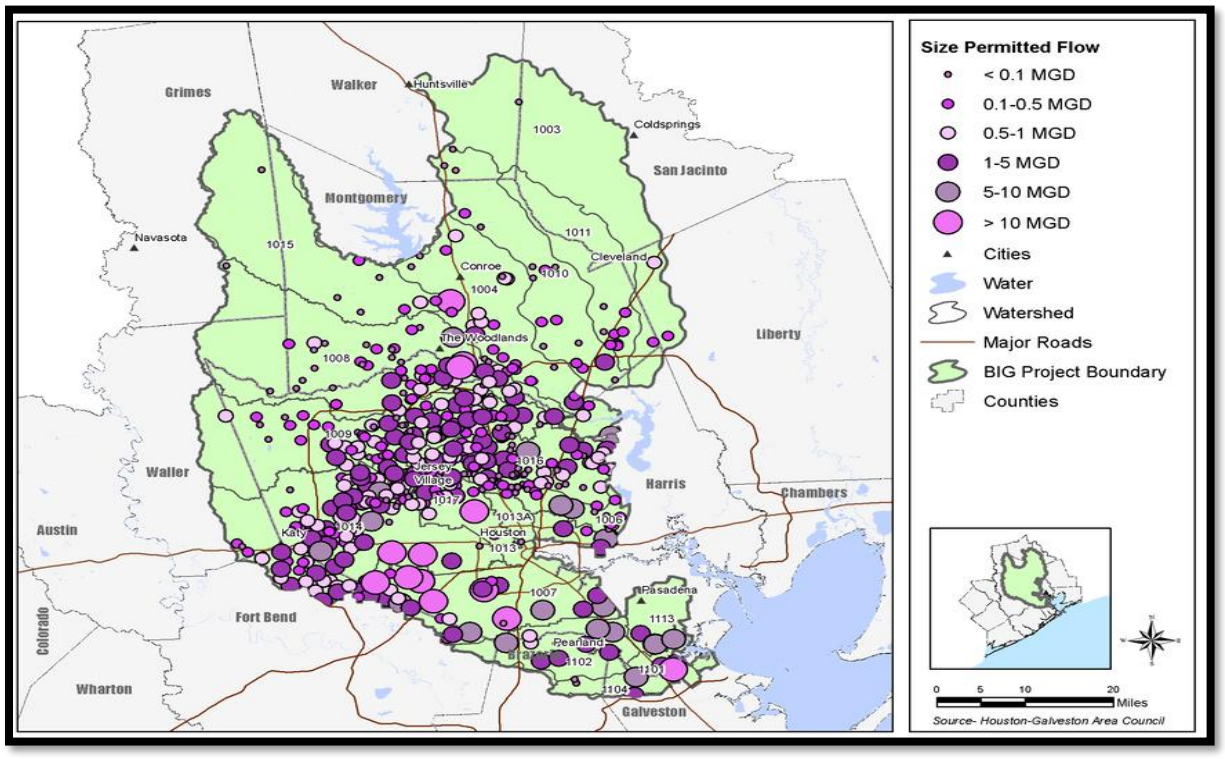

Figure 12. WWTF Permitted Flow within the BIG project area

The TCEQ has developed criteria for actual classified stream segment testing using *E. coli* as the indicator bacteria for freshwater and *Enterococci* for saltwater per Appendix A of 30 Tex. Admin. Code § 307.10 (1).[62] Domestic WWTFs and industrial WWTFs permitted for fecal bacteria were required since 2009 as their permits were renewed, to include fecal bacteria limits. Since 2009, 506 domestic and 17 industrial WWTFs include fecal bacteria effluent monitoring with their DMRs.

Implementation Activity 1.1: Encourage More Rigorous Bacteria Monitoring

Action

WWTFs in Texas are required through their permit to monitor for fecal indicator bacteria. Monitoring is carried out at a specified frequency and generally determined by facility discharge volume (See

[62] See Appendix A of 30 Tex. Admin. Code § 307.10 (1) (2011) (Site-specific Uses and Criteria for Classified Segments)

Table 6).[63] The BIG encourages as part of Activity 1.1, WWTFs collect additional bacteria samples to determine sufficient sanitation treatment. Samples collected, while ideally at the compliance weir, would likely be collected elsewhere to prevent use for compliance purposes. The BIG is also willing to pilot a study with a WWTF operator(s) to evaluate monitoring frequency and determine the optimal frequency. On an annual basis, H-GAC and its partners will provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

The BIG recommended with the 2013 I-Plan (Table 2), that the frequency of monitoring be increased over what was currently required by the TCEQ (Table 3). In addition to what is currently required, according to bacteria monitoring regulations, in 30 Tex. Admin. Code § 319.9(b)[64], a permittee that has at least twelve months of uninterrupted compliance with its bacteria limit may notify the commission of its compliance and request a less frequent measurement schedule.

It was believed at the time of the 2013 I-Plan that the increased frequency would expand the available data to evaluate WWTF performance and determine potential areas for improvement. Over time, the increased data was expected to help operators understand the effects of variables such as rainfall and infiltration. In addition, the data could help improve load reduction because operators will have more information to use to adjust and control facilities to reduce bacteria levels. The additional data may also protect compliant WWTFs from more stringent regulations that could be imposed if receiving stream quality fails to improve. Frequencies shown in ***Error! Reference source not found.***2 could be increased, depending on WWTF performance, other site sampling frequencies, and the impairment of the receiving stream.

Following the I-Plan's approval, WWTF permits were not revised with the recommended increase in monitoring frequency. The BIG sought clarification from TCEQ on this action. TCEQ reported that the frequencies for WWTFs would remain as current regulations found in in 30 Tex. Admin. Code § 319.9(b). TCEQ did suggest that they would be open to facilities that wished to make a requested change[65]. TCEQ

[63] See 34 Tex. Reg. 3495 (2009), *adopted* 34 Tex. Reg. 8332 (2009) (codified as an amendment to 30 Tex. Admin. Code § 319.9(b))

[64] See 30 Tex. Admin. Code § 319.9(b)

[65] Communication with TCEQ, (2018)

also stated that the BIG could work with WWTFs to increase frequencies voluntarily.

Table 6: *Proposed* monitoring frequencies for domestic WWTFs in the BIG Project Area

Permitted Flow (MGD)	Chlorine systems	Ultraviolet systems	Natural systems
0 to less than 0.1	**1/week***	5/week	**3/week***
0.1 to less than 0.5	**1/week***	5/week	**3/week***
0.5 to less than 1	**3/week***	Daily	**3/week***
1 to less than 5	**3/week***	Daily	3/week
5 to less than 10	**5/week***	Daily	5/week
10 or greater	5/week	Daily	Daily

*These *proposed* values differ from existing values.

Table 7: Current monitoring frequency for domestic WWTFs[66] in the BIG Project Area

Permitted Flow (MGD)	Chlorine systems	Ultraviolet systems	Natural systems
0 to less than 0.1	1/quarter	5/week	1/month
0.1 to less than 0.5	1/month	5/week	2/month
0.5 to less than 1	2/month	Daily	1/week
1 to less than 5	1/week	Daily	3/week
5 to less than 10	3/week	Daily	5/week
10 or greater	5/week	Daily	Daily

[66] See 30 Tex. Admin. Code § 319.9 (2011) (Table (b): Frequency of Bacteria Measurement)

Metric

Track frequencies based on DMRs and observe continued performance to determine if further steps to understand operations are needed. Work with TCEQ, TEEX and others to provide outreach and operational technical transfer.

Milestone

Offer at minimum one WWTF technical workshop per year.

Monitoring

Programmatic: Report metric and # workshops provided

Environmental: CRP Data; Change in AU impairments

Implementation Activity 1.2: Continue to Track the Use of More Strict Bacteria Limits Within the BIG Project Area

Action

Over 80 percent of WWTFs' permits require meeting the bacteria limit of 63 cfu/100 mL. The BIG recommends with Activity 1.2, that H-GAC will annually track the number of WWTFs required to meet the more stringent limit and compliance with this limit. DMR and independent data will be used to evaluate compliance and determine if additional steps are needed to ensure WWTFs can meet these limits. On an annual basis, H-GAC and/or its partners will provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

The TCEQ adopted a rule on November 4, 2009, requiring all TPDES domestic wastewater permits be updated to include bacteria limits for all WWTFs.[67] The regulations stated that "by adopting bacteria limits, there will be a more direct and possibly more accurate measure of the level of disinfection achieved in domestic effluent discharged to both fresh and salt water."[68] Current regulations have set

[67] See 34 Tex. Reg. 3495 (2009), *adopted* 34 Tex. Reg. 8332 (2009) (codified as an amendment to 30 Tex. Admin. Code § 319.9(b)), since amended See 30 Tex. Admin. Code § 309.3 (i) (January 9, 2020)

[68] See 30 Tex. Admin. Code § 309.3 (i) (January 9, 2020)

the monthly geometric mean bacteria effluent limit and the daily maximum bacteria effluent limit at the most stringent contact recreation category level.[69]

However, in certain situations, if waterways are to meet contact recreation standards, effluent limits could be made more stringent for WWTFs discharging into bacteria-impaired watersheds. In fact, the approved Buffalo and Whiteoak bayous TMDL[70] stated, "if WWTFs were to discharge at the water quality criterion (126 cfu/100 mL), there would be no capacity to accommodate other loads and existing downstream discharges"[71]. Therefore, for domestic facilities releasing effluent into freshwater, the BIG resolved and recommended to the TCEQ that bacteria limits in domestic WWTF permits throughout the BIG project area be set at 63 cfu/100 mL for the geometric mean of the monthly samples[72] of *E. coli* effluent, using any method approved under 40 C.F.R. § 136, and 200 cfu/100 mL for the daily maximum *E. coli* effluent limit. The authority to set these stricter limits was given explicitly in the rule itself,[73] where it states "the commission may impose more stringent requirements in permits than those specified…on a case-by-case basis, where appropriate to maintain desired water quality levels or protect human health."[74]

As allowed for in the Buffalo and Whiteoak bayous TMDL, the BIG resolved that the bacteria limit be set at a geometric mean of 126 cfu/100 mL for the monthly samples at a WWTF's next permit renewal or major amendment and that the new limit be phased in, such that three years after the permit's effective date the effluent limit shall be a geometric mean of 63 cfu/100 mL for the monthly samples.[75]This

[69] See 30 Tex. Admin. Code § 309.3(h)(2) (January 9, 2020) (Application of Effluent Sets)

[70] See 30 Tex. Admin. Code § 309.3 (i) (January 9, 2020)

[71] The Buffalo and Whiteoak Bayous TMDL and other TMDLs proposed and anticipated in the BIG region specify that *E. coli* limits for WWTF effluent be one half of the water quality criterion, currently 63 MPN/100 mL, in calculations of the WWTF Waste Load Allocation. More stringent limits for Enterococci were not specified by the TMDLs. The Clear Creek TMDL did not recommend the more stringent limits.

[72] After identifying and rejecting outliers, consistent with ASTM E 178-80, "Standard Practice for Dealing With Outlying Observations" (Section 14.02, General Methods and Instrumentation - General Test Methods; Forensic Sciences: Terminology; Conformity Assessment: Statistical Methods).

[73] See 30 Tex. Admin. Code § 309.3 (January 9, 2020) (Application of Effluent Sets)

[74] See 30 Tex. Admin. Code § 309.3 (i) (January 9, 2020)

[75] After identifying and rejecting outliers, consistent with ASTM E 178-80, "Standard Practice for Dealing With Outlying Observations" (Section 14.02, General Methods and Instrumentation - General Test Methods; Forensic Sciences: Terminology; Conformity Assessment: Statistical Methods)

phased in approach allowed the WWTFs to implement *E. coli* monitoring while each plant plans and implements processes to address *E. coli* discharges.

For domestic facilities where the TCEQ determines that *Enterococcus*, rather than *E. coli*, is the appropriate indicator bacteria, the BIG recommended that the Enterococcus effluent limit be set at 23 cfu/100 mL for the geometric mean of the monthly samples[76] and 57 cfu/100 mL for the daily maximum, using any method approved under 40 C.F.R. Part 136.

Metric

#WWTF using 63 cfu/100 mL for the *E. coli* limit or 23 cfu/100 mL for the Enterococci limit.

Milestones

Annual Completed Assessments

Monitoring

Programmatic Goal: Report metric.

Environmental Goal: CRP analysis, change in AU impairment status

Implementation Activity 1.3: Enhance WWTF Compliance

Action

The BIG recommends H-GAC track compliance and enforcement through DMR reporting and Harris County Pollution Control. The BIG will work with H-GAC, WEAT, TRWA, TWUA and AWBD to identify a list of WWTFs that are consistently underperforming their peers to encourage participation in technical workshops and other training opportunities. For example, the BIG can encourage those facilities with greater than 10% exceedances to participate (Figure 3). The BIG also supports, should additional resources become available, for TCEQ to expand the number of inspections over and above what TCEQ reported to the BIG as noted below. On an annual basis, H-GAC and/or its partners will provide at minimum annually, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

Stakeholders were concerned during development of the I-Plan first edition, that the number of investigations, reviews, and enforcement being performed by TCEQ were insufficient. The BIG

[76] After identifying and rejecting outliers, consistent with ASTM E 178-80, "Standard Practice for Dealing With Outlying Observations" (Section 14.02, General Methods and Instrumentation - General Test Methods; Forensic Sciences: Terminology; Conformity Assessment: Statistical Methods)

recommended at that time, TCEQ conduct unannounced and focused inspections with a goal to have all facilities inspected every two years. It was suggested that there were multiple methods to address the low numbers of investigations and reviews performed. One method would be to increase the number of staff performing investigations, either through hiring additional TCEQ staff or through a contract with local programs. Another method would be to change TCEQ operating procedures.

TCEQ reported to the BIG in 2018 that it does not plan to increase compliance monitoring. Rather TCEQ has a compliance monitoring strategy agreement with the EPA that requires all major facilities (permitted to discharge more than 1.0 MGD) to be investigated every two years and minor facilities once every five years, however, TCEQ effectively conducts more investigations on WWTFs than the EPA currently requires. All complaints regarding WWTFs received by the TCEQ are investigated, therefore, more frequent investigations will occur for facilities for which complaints are received. TCEQ also conducts investigations for enforcement follow-up. Additionally, focused investigations are used frequently to streamline the investigation process to focus on known problem areas.

Unannounced investigations do occur, when appropriate. Unannounced investigations are conducted in response to complaints, or during emergency events, for regulated entities with unsatisfactory compliance history status, for enforcement follow-up investigations, or upon discretion of local management for any other justifiable reason.

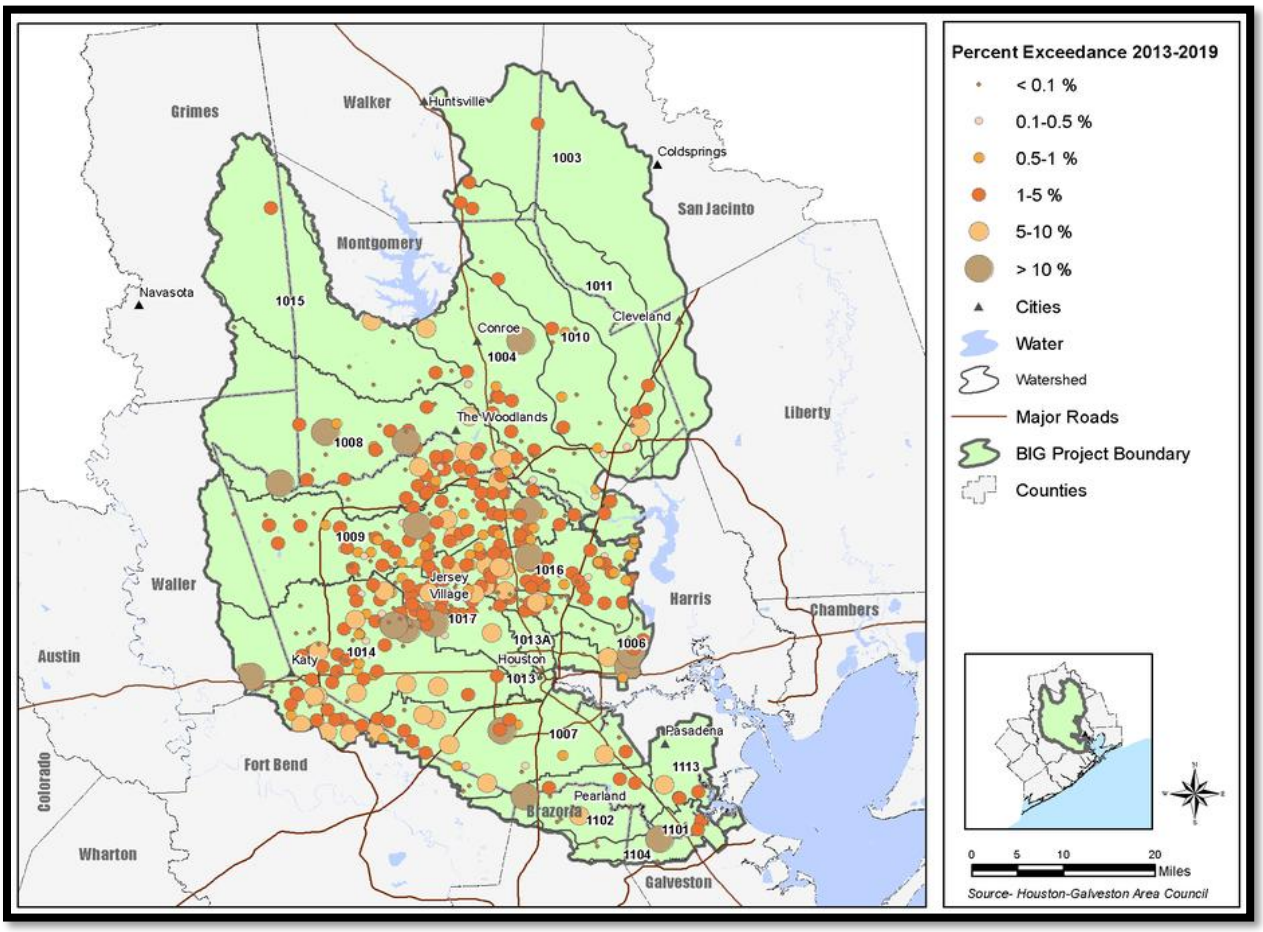

Figure 13. WWTF Percent Exceedances within the BIG Project Area

Metric

DMR and Harris County Pollution Control compliance data.

Milestone

Work with WEAT, TRWA, TWUA, and AWBD to identify and work with WWTFs underperforming their peers though targeted education.

Offer at minimum one WWTF technical workshop per year.

Monitoring

Programmatic Goal: Report metric, # of targeted outreach opportunities and # workshops provided

Environmental Goal: CRP Analysis, Change in AU impairment status

Implementation Activity 1.4: Track Changes to Improve Design and Operation Criteria for New Plants

Action

The BIG recommends tracking developments to improved design and operation criteria through rule and research. The BIG will provide a forum to share changes with local and regional operators and municipal governments. The forum can be through BIG meetings, wastewater association meetings and/or technical workshops. On an annual basis, H-GAC and/or its partners will provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

Much of the existing design and operation criteria for WWTFs was improved in 2008 when 30 Tex. Admin. Code § 217 was adopted and then amended in 2015[77]. As a greater understanding of how plant design impacts bacteria outputs is understood the BIG recommends local governments reopen discussion of design criteria in the future and consider whether adopting stricter requirements within their jurisdiction would be appropriate.

Metric

Harris County Design Criteria reviews and TCEQ Central Registry (Engineer Applications for upgrades by county); Host Annual WWTF workshop

Milestones

Offer at minimum one WWTF technical workshop per year.

Monitoring

Programmatic Goal: Report metric and # workshops provided.

Environmental Goal: CRP Analysis, Change to AU impairment status

Implementation Activity 1.5: Upgrade Facilities

Action

The BIG encourages WWTFs considering redesign, whether to meet permit requirements or for expansion, upgrade their facilities using the latest design criteria. On an annual basis, H-GAC and/or its

[77] 30 Tex. Admin. Code § 217(2011) (Design Criteria for Domestic Wastewater Systems) (formerly § 317),Texas Administrative Code (state.tx.us)

partners will provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

Bacteria monitoring may reveal WWTFs that are not meeting effluent limits. Upgrades or repairs, as appropriate, will be the responsibility of each individual facility in order to comply with individual permits. Some types of facilities may have more trouble than others in meeting bacteria standards. These facilities may need to undertake an intensive redesign. Grants, although generally not great in size, may be available. Possible sources of funding include:

- EPA via the Texas Water Development Board, Clean Water State Revolving Fund Program
- U.S. Department of Commerce, Economic Development Grants for Public Works and Development Facilities
- U.S. Department of Agriculture, Rural Utilities Service Water and Waste Disposal Program
- U.S. Department of Housing and Urban Development, State Community Development Block Grant Program

Metric

Harris County Design Criteria reviews and TCEQ Central Registry (Engineer Applications for upgrades by county);); Host Annual WWTF workshop

Milestones

Offer at minimum one WWTF technical workshop per year.

Monitoring

Programmatic Goal: Report metric and # Workshops provided.

Environmental Goal: CRP Analysis, Change to AU impairment status

Implementation Activity 1.6: Consider Regionalization of WWTFs

Action

The BIG supports TCEQ and local authorities use of regionalization to address chronically failing WWTFs and planning and permitting of future WWTF installations within the project area. Harris County and the City of Houston report on plants being considered for regionalization each year. Additionally, the BIG supports TCEQ's requirement that all new WWTF permit applicants consider regionalization when and where possible as prescribed in 30 Tex. Admin. Code § 217. On an annual basis, H-GAC and/or its partners will provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

Notwithstanding TCEQ and local enforcement authority, WWTFs that are chronically or severely out of compliance with the bacteria limits set in their TPDES permit shall be encouraged to address the problems through operational improvements and/or capital improvements. If the facility continues violating bacteria limits set in their TPDES permit, the BIG encourages the TCEQ or any local government with jurisdictional authority to require the WWTF to evaluate facility regionalization and implement as appropriate. If regionalization is not a viable alternative, the facility should be required to be modified to meet higher design and monitoring standards.

Metric

Reported number of plants considering or completing regionalization – Harris County, City of Houston; Host Annual WWTF workshop

Milestones

Offer at minimum one WWTF technical workshop per year.

Monitoring

Programmatic Goal: Report metric and # of workshops provided

Environmental Goal: CRP Analysis, Changes to AU impairment status

Implementation Activity 1.7: Use Treated Effluent for Facility Irrigation

Action

The BIG encourages the use of treated effluent for facility irrigation following applicable standards as set forth in 30 Tex. Admin. Code § 210 (Quality, Texas Administrative Code Chapter 210, 1997). On an annual basis, H-GAC and/or its partners will provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

Background

Many domestic WWTFs currently do not use their effluent for purposes of irrigation of facility grounds. Using effluent for facility irrigation will allow the water to trickle through the grass and soil, filtering out additional pollutants. Each domestic WWTF is required to consider the use of treated effluent for facility irrigation purposes and is encouraged to incorporate its use as appropriate prior to the next renewal of its permit.

Metric

of applications for reuse each year TCEQ Central Registry – Engineering Plans and Specifications / Monitoring Effluent Reports (MERs) noting reuse amounts; Host Annual WWTF workshop

Milestones

Offer at minimum one WWTF technical workshop per year.

Monitoring

Programmatic Goal: Report metric and # workshops provided.

Environmental Goal: CRP Analysis, Changes in AU impairment status.

Implementation Strategy 2.0: Sanitary Sewer Systems

This implementation strategy focuses on the underground infrastructure (pipes), ancillary support processes (lift stations), and the management of the network of infrastructure that is connected to the wastewater treatment facility itself. Activities to be implemented in the wastewater treatment facilities are discussed in the previous section.

Sanitary sewers can fail to function properly due to blockages, line breaks, defects that allow stormwater and groundwater to overload the system, lapses in operation, inadequate design and construction, power failures, and vandalism. The EPA has concluded that sanitary sewer overflows (SSOs) contribute to bacteria loading in almost all impaired streams but may or may not be a primary source of loading. EPA acknowledges that SSO data is difficult to assess.[78]

In a Report to Congress, the EPA addressed the extent and possible solutions to human health and environmental impacts caused by SSOs.[79] In the Houston region, sanitary sewer systems are separate and not intentionally combined with stormwater sewer systems. SSOs are untreated or partially treated discharges from sanitary sewers. "SSOs can range in volume from one gallon to millions of gallons. The microbial pathogens and other pollutants present in SSOs can cause or contribute to water quality impairments, beach closures, shellfish bed closures, contamination of drinking water supplies, and other environmental and human health problems."[80]Based on sanitary sewer system operator reports to the TCEQ Region 12 office a yearly average of 1,065 overflows were reported representing a yearly average of over 4.6 million gallons. Overflows are found in generally all watersheds with greater occurrences reported within the City of Houston (Figure 4).

In general, implementation actions consist of encouraging improvements to sanitary sewers; reducing the amount of fats, oils, and grease entering the systems; addressing lift station inadequacies; improving reporting of violations; strengthening controls on subscriber systems;[81] maintaining an accurate map of sanitary sewer coverage; and evaluating the penalty structure for SSOs and other sanitary sewer violations.

[78] (U.S. Environmental Protection Agency 2004)

[79] (U.S. Environmental Protection Agency 2004)

[80] (U.S. Environmental Protection Agency 2004)

[81] A subscriber system is a sewer system that conveys flow to a wastewater treatment facility that is owned by a separate entity. The term is not intended to indicate individual private laterals, such as a homeowner's connection to a sewer system.

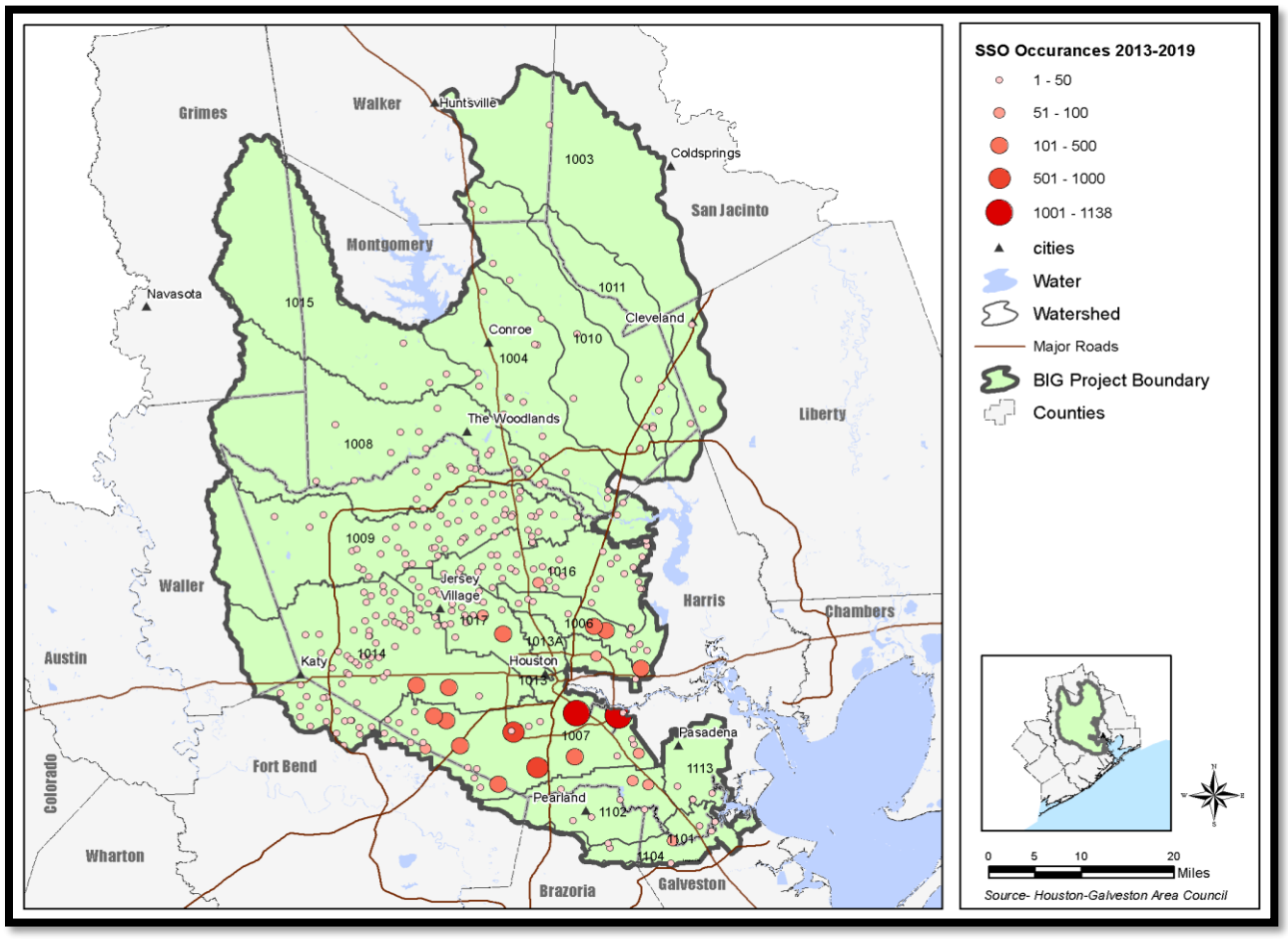

Figure 14. SSO occurrences within the BIG Project Area

Implementation Activity 2.1: Develop Utility Asset Management Programs for Sanitary Sewer Systems

Action

The BIG recommends all WWTFs discharging to a stream within the BIG project area adopt a utility asset management program (UAMP)-type plan that own and operate a collection system. The BIG encourages the TCEQ to consider requiring UAMPs for all permit renewals for WWTFs discharging to a stream within the BIG project area. As allowable by law, the UAMP plan should apply to any subscriber systems that contribute to the WWTF.[82]

[82] See sample language in "Model NPDES Permit Language for Sanitary Sewer Overflows (draft)" (U.S. Environmental Protection Agency 2007)

To support this action, H-GAC and/or its partners will on an annual basis, provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions. Meeting topics may include a description of the problems presented by sanitary sewer systems, a definition of CMOM, an outline of EPA guidelines, case studies, and a description of benefits such as cost savings, cost avoidances, and pollution reduction. In an effort to make the information accessible to an expanded audience, the meetings will be recorded and made available in a webcast format during the meeting and as an online archive. Potential development partners include the Water Environment Association of Texas, the TCEQ, the Water Environment Research Foundation, the EPA, the Texas Water Utility Association, the Texas Rural Water Association, and the Association of Water Board Directors – Texas. Continuing education credits should be given to operators for participation in training related to UAMP.

Background

A UAMP is a common-sense, proactive approach to managing, maintaining, and operating a sanitary sewer system. The EPA's Capacity, Management, Operation, and Maintenance (CMOM) is probably the most well-known UAMP. This section uses CMOM as a guide for this implementation activity, but these programs are intended to function independently of the EPA unless the system's owner or operator requests its technical or other assistance.

UAMPs provide a framework for self-evaluation and planning for the function, condition, and performance of a sanitary sewer system. Currently, UAMPs are voluntary in Texas, although the TCEQ or EPA can require them through a consent decree or administrative order. To facilitate the development and implementation of many elements of UAMPs, the TCEQ offers the Sanitary Sewer Overflow Initiative (SSOI), a voluntary program to improve a system's operation. Some operators have voluntarily implemented a program to improve performance and reduce costs. UAMP elements will vary with requirements and circumstances of individual entities. For example, a small, well-run system with fewer than a dozen connections would have a simple program, possibly described in less than two pages. A large or problematic system would have a substantial UAMP, proportional to its size or problems.

The intent of the BIG was that all permits for WWTFs with authority over the collection system discharging to a stream within the BIG project area include requirements for UAMP plans. The BIG recognized that valid constraints may prevent the TCEQ from including such requirements in all plans and that, in such situations, TCEQ may encourage those facilities to voluntarily develop such plans.

H-GAC or other appropriate entities were to, as resources became available, track the inclusion of UAMP plan requirements in WWTF permits and the voluntary development of UAMP plans by permitted facilities not subject to permit requirements for UAMP plans. The BIG was to evaluate the adoption of UAMP plans and whether additional actions should be recommended.

These recommendations were intended to reduce bacteria loading by reducing the possibility of malfunctions such as blockages, line breaks, inflow and infiltration of stormwater and groundwater, lapses in operation, inadequate design and construction, power failures, and vandalism. By reducing the possibility of malfunction, the BIG intended that wide adoption of UAMP plans would reduce the possibility of discharges of untreated or partially treated sewage from a sanitary sewer system, at the same time they improve the services provided to customers.

Operators of existing systems were encouraged to develop a UAMP plan prior to the inclusion requirements in a permit. In general, components of the UAMP plan would include clearly stated goals, a description of the organization, the permittee's legal authority, an overflow emergency response plan, measures and activities, design and performance standards, a capacity assurance plan, provisions for self-audits, and a communication plan. Activities specified in the plan might include lift station maintenance, provision of alternative power sources such as generators for lift stations, periodic manhole surveys that include cover levels and wall condition, periodic line cleaning, and condition surveys. More details and resources for plan development are provided in **Error! Reference source not found.**.

Operators of sanitary sewer systems were encouraged to seek technical assistance from either the TCEQ or the EPA as appropriate, although the oversight of neither agency is a requirement of the program. Owners and operators were encouraged to consider participating in the TCEQ's voluntary SSOI program to improve system performance and to facilitate development of an appropriate UAMP plan. The TCEQ's Small Business and Local Government Assistance program is also a source of technical assistance.[83] Minimum elements of the UAMP plan would include the provision of updated coverage maps, confirmation of subscriber system registration (see Implementation Activity 2.5), and improved reporting requirements (see Implementation Activity 2.4). As resources are available, H-GAC shall collect and make available copies of UAMP, CMOM, and SSOI plans for reference.

The TCEQ was encouraged to make facilities that do not have a UAMP plan, and facilities that are not implementing their UAMP plan, higher priorities for inspections and enforcement.

Metric

WWTFs in SSOI or reporting use of life cycle management if available, WWTF technical workshop

[83] See also "Guide for Evaluating Capacity, Management, Operation, and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems" (U.S. Evironmental Protection Agency 2005)

Milestone

Offer at minimum one WWTF technical workshop per year that includes WWTF/SSS Lifecycle management.

Monitoring

Programmatic: Report metric and # Workshops provided

Environmental: CRP Analysis, Changes in AU impairment status

Implementation Activity 2.2: Address Fats, Oils, Grease, and Wipes

Action

H-GAC and its partners will track programs including, MS4s, utility districts, and non-profits, offering Fats, Oils, Grease and Wipes. H-GAC and its partners will coordinate with voluntary programs to review SSO data. The programs will be evaluated to determine if there is an observable reduction in the number of SSOs attributed to Fats, Oils, Grease or Wipes.

Background

Fats, oils, and grease are the leading cause of blockages in sanitary sewers, and the EPA estimates that blockages account for nearly 50 percent of all SSOs.[84] This implementation activity encourages local governmental entities to require owners of sanitary sewer systems to determine the proper size for grease traps, to inspect them, and to require grease traps be properly cleaned and otherwise maintained. H-GAC, in consultation with stakeholders and as resources allow, shall develop model language to facilitate the adoption of appropriate legal mechanisms.

The TCEQ developed a model ordinance in response to the Texas 78th State Legislature's amendment of the Texas Water Code, and created standards for managing grease stoppages in utilities' sanitary sewer lines.[85] The City of Houston incorporated elements of the model language into its Code of Ordinances in 2007.[86]

[84] (U.S. Environmental Protection Agency 2004)

[85] See Tex. Water Code Ann. § 26.0491 (2010) (Model Standards to Prevent Discharge of Untreated Wastewater from Sanitary Sewers). (State of Texas 2004)

[86] See Houston, Tex., Code of Ordinances, Chapter 47, Article 7 (2008). (City of Houston 2008)

Possible topics for public education include efforts targeted at reducing fats, oils, and grease from residences and multi-family dwellings. Available resources include the *Can Your Fats*[87] brochure developed by Harris County and the City of Houston, the City of Houston's ~~*Corral the Grease* program~~ Protect Our Pipes[88], Take Care of Texas' Clean Pipes are Green Pipes[89] and the TCEQ's *Let's Tackle the Grease in This Kitchen*[91] poster and video.

Metric

Assessment of # of Fats, Oils and Grease Programs via MS4; Reported SSOs; WWTF technical workshop

Milestones

Residents Reached, #MS4s reporting outreach programs; #SSOs; Offer at minimum one WWTF technical workshop per year

Monitoring

Programmatic: Report metric, # workshops provided

Environmental: CRP Analysis.

Implementation Activity 2.3: Encourage Appropriate Mechanisms to Maintain Function at Lift Stations

Action

The TCEQ update emergency requirements for lift stations requiring alternative power sources, 30 Tex. Admin. Code § 217 (TCEQ 2015). The BIG recommends tracking the number of SSOs attributed to lift station failure to determine if additional action is needed. H-GAC and/or its partners will on an annual basis, provide at minimum, one WWTF technical workshop for the purpose of providing the latest research, technology, operational maintenance and rulemaking to operators and local jurisdictions.

[87] (Harris County & City of Houston 2009)

[88] https://www.publicworks.houstontx.gov/protect-our-pipes

[89] https://takecareoftexas.org/

[91] https://www.tceq.texas.gov/downloads/publications/gi/grease-poster-gi-290.pdf (TCEQ 2007)

Background

Occasionally, lift stations may cease to function and may discharge sewage into waterways, as demonstrated during the extensive power outages following Hurricane Ike in 2008. Lift stations may also fail to function during circumstances other than power outages, such as mechanical failure or repair.

Lift station operators are encouraged to undertake appropriate actions to maintain function of lift stations during power outages and other situations. Operators shall develop a comprehensive plan, possibly part of the UAMP plan, to address such situations. Appropriate mechanisms for inclusion in the plan might include installing underground power lines to lift stations, negotiating with power providers to reclassify lift stations as a higher priority for service restoration, installing solar-powered generators, developing partnerships with transportation partners to allow hybrid vehicles to serve as mobile generators, installing quick-connects if the use of mobile generators is necessary, using by-pass pumps, or using a wireless remote system. Conventional generators, whether fueled by natural gas or diesel fuel, might also be appropriate. Owners and operators are strongly encouraged to install quick-connects at lift stations. Quick-connects allow the quick connection of lift stations to alternative power sources such as mobile generators without the need for time-consuming and expensive facility modifications during a post-storm or other failure.

Metric

Reported SSOs at Lift Stations due to malfunction; Annual WWTF workshop

Milestones

Offer at minimum one WWTF technical workshop per year; Minimum of one WWTF technical workshop per year

Monitoring

Programmatic: Report metric and # workshops provided

Environmental: CRP analysis, Change in AU impairment status.

Implementation Activity 2.4: Improve Reporting Requirements for Sanitary Sewer Overflows

Action

The BIG should track the effort to establish Phase II MS4 permittee electronic reporting, including SSOs. If the state's reporting database does not include SSO reporting, the BIG should work with the TCEQ to pilot an SSO electronic report program, like the program currently in place at the City of Houston. The

BIG should track the efforts to expand broadband access to all communities to ensure that electronic submissions do not pose a burden on smaller permittees.

Background

Current EPA regulations specify reporting requirements for noncompliance, including SSOs, in 40 C.F.R.[92]. The first action the BIG recommended was to implement statewide database to record reported SSOs, allowing operators of sanitary sewer systems to enter information directly into State of Texas Environmental Electronic Reporting System. The electronic reporting by Phase II municipal separate storm sewer system (MS4) permittees has been extended to December 21, 2023. It is anticipated that this will facilitate electronic reporting of SSOs. Currently, the BIG receives SSO reports annually from the TCEQ that includes permit number, permittee name, SSO incident, volume, location, and description.

The second activity the BIG recommended was to develop ability for communities to use statewide database to record reported SSOs. This will likely be included with the electronic reporting rule. H-GAC and the BIG should assist with the rollout of the electronic reporting rule. Included with this second activity was to assist the region in expanding broadband internet access that would assist smaller permittees access to electronic reporting.

The existing TCEQ database security features require a broadband Internet connection for access. Until all sanitary sewer operators have access to a broadband internet connection, database reporting should not be required.

In 2009, using American Recovery and Reinvestment Act funds, the Texas Department of Agriculture began mapping the coverage of broadband internet access in Texas.[93] Once areas without coverage have been identified, funds may be available to develop coverage in rural areas, including all of the non-urban areas of the BIG region. H-GAC has been working to determine areas of need and working with providers to provide access.

Once a statewide database is available and all communities in the BIG project area have the ability to report electronically, operators' permits shall require them to utilize the database to report SSOs.

The third and final activity was to require reporting of SSOs to local programs. EPA regulations allow WWTF permits to include requirements that SSOs be reported to local programs, such as those of cities and counties. The statewide database described in the preceding section should be developed to include

[92] 40 C.F.R. §§ 122.41(1) (6) and (7) (2011)

[93] See Connected Texas website(Connected Texas 2010)

reporting capabilities that would allow the program to automatically alert local governments about SSOs.

Metric

Reported SSOs, Establishment of electronic reporting of SSOs; WWTF technical workshop

Milestones

Electronic reporting of SSOs in five years, Offer at minimum one WWTF technical workshop per year

Monitoring

Programmatic: Report metric and # workshops provided

Environmental: CRP Analysis, Changes in AU impairment status

Implementation Activity 2.5: Strengthen Controls on Subscriber Systems

Action

The BIG will encourage local sanitary system permittees to reevaluate and strengthen contract language with subscriber systems where necessary to clearly state subscriber system responsibility to report SSOs and to include remedies for failing to maintain system integrity. H-GAC will maintain example subscriber system contracts. The BIG will review as resources allow, example contracts and determine how to strengthen the language to encourage greater subscriber system compliance.

Background

Subscriber systems are those systems that do not operate their own WWTFs or have their own permits, but instead enter into contracts with permitted WWTFs. (The term subscriber system is not intended to include private laterals such as those connecting a private residence to a sanitary sewer system.) While the exact linear footage of subscriber sanitary sewers in the project area is unknown, it is also unknown whether the contracts that WWTFs have with subscriber systems provide adequate controls and responsibility for operation, management, and maintenance of the subscriber system. Contracts could be developed to require appropriate controls.

The BIG recognized two approaches to take to identify subscriber systems. First, H-GAC was to contact WWTF permittees and ask them to provide information regarding subscriber systems. Second, the BIG was to petition the TCEQ for rulemaking to require registration of subscriber systems. As resources are available, H-GAC or another appropriate agency was to distribute information about subscriber systems. If stakeholder concerns regarding subscriber systems remain after five years, the BIG was to consider consulting with the TCEQ to address subscriber systems or petitioning the TCEQ to require that subscriber systems have their own wastewater discharge permits. TCEQ noted since the I-Plan was

drafted that the agency was not planning on tracking subscriber systems, but rather that was in the purvey of the permit holder.

A second action was to have H-GAC work with attorneys for WWTFs, municipal utility districts (MUDs), and other stakeholders to develop model contract documents. Contracts might address operation or maintenance requirements, rights to inspect or repair, flow reduction incentives, flow metering, and the ability to pass on fines or other financial burdens resulting from violations of permit requirements and for unauthorized discharges. H-GAC hosts example contracts via its website.

A third and final action was for H-GAC to provide a circuit rider program to review and evaluate subscription contracts and implement terms identified in this section. This program was to proceed on a voluntary basis by watershed, using the geographic prioritization framework recommended by the BIG and described under activity 11 on the I-Plan. As part of the program, education on UAMP, metering, and UAMP development assistance were to be provided. Appropriate WWTFs, MUDs, and their attorneys and accountants would be expected to participate. It was determined that SSOs location could not be accurately and precisely located to sufficiently determined a geographic focus. Should improvements to activity 2.4 take place, targeted SSO outreach, including a focus on subscriber systems could potentially be carried out.

Metric

Reported SSOs, Conduct survey of WWTF operators, WWTF technical workshop

Milestones

Survey completed in 2023, Offer at minimum one WWTF technical workshop per year

Monitoring

Programmatic: Report metric and # workshops provided

Environmental: CRP Analysis, Changes in AU impairment status

Implementation Strategy 3.0: On-site Sewage Facilities

An on-site sewage facility (OSSF, commonly referred to as a septic system) does not send waste through a system of pipes to be treated elsewhere. Instead, it uses a combination of physical and chemical methods to treat the waste at the owner's location. Thirty-six percent of the watershed is assumed to be using OSSFs after removing areas served by centralized wastewater. There are 49,856 permitted OSSFs in the project area (Table 1 and Figure 1). An additional 104,270 non-registered OSSFs are estimated within the project area (Table 1). It is notable that H-GAC lacks OSSF data for San Jacinto County (Figure 1).

Table 8. OSSFs by watershed

Watershed	# Permitted OSSF	# Estimated Non-Registered OSSFs	Estimated Total
GREENS BAYOU	3,942	20,976	24,918
WHITE OAK BAYOU	1,401	2,732	4,133
BUFFALO BAYOU	143	18	161
SIMS BAYOU	211	279	490
CYPRESS CREEK	4,398	6,367	10,765
LITTLE CYPRESS CREEK	1,730	1,429	3,159
WILLOW CREEK	1,824	1,421	3,245
BARKER RESERVOIR	1,001	787	1,788
BRAYS BAYOU	201	11,117	11,318
SPRING CREEK	14,116	12,498	26,614
CANEY CREEK	4,591	9,863	14,454
PEACH CREEK	1,594	5,268	6,862
EAST FORK SAN JACINTO RIVER	1,830	4,532	6,362
LAKE HOUSTON	152	5,969	6,121
ADDICKS RESERVOIR	707	1,134	1,841
CLEAR CREEK	2,667	4,481	7,148
HUNTING BAYOU	33	3	36
LAKE CREEK	3,786	4,238	8,024
WEST FORK SAN JACINTO RIVER	5,487	10,972	16,459
ARMAND BAYOU	42	186	228
Total	49,856	104,270	154,126

A study sponsored by the Texas On-Site Wastewater Treatment Research Council indicates that as many as 19 percent are failing in eastern Texas.[94] Applying 19 percent to the total estimated number of OSSF

[94] (Reed, Stowe, and Yanke, LLC 2001)

in the project area, 154,126, yields a potential for 29,284 failing systems. Enforcement is not uniform throughout the region. Furthermore, enforcement efforts often cease if owners of failing OSSFs do not have the resources to repair or replace their systems or to pay fines associated with violations.

Because properly functioning and maintained OSSFs contribute little to no bacteria to waterways, this I-Plan primarily focuses on OSSFs that are unpermitted, failing, or poorly maintained. The following implementation activities are intended to address these systems.

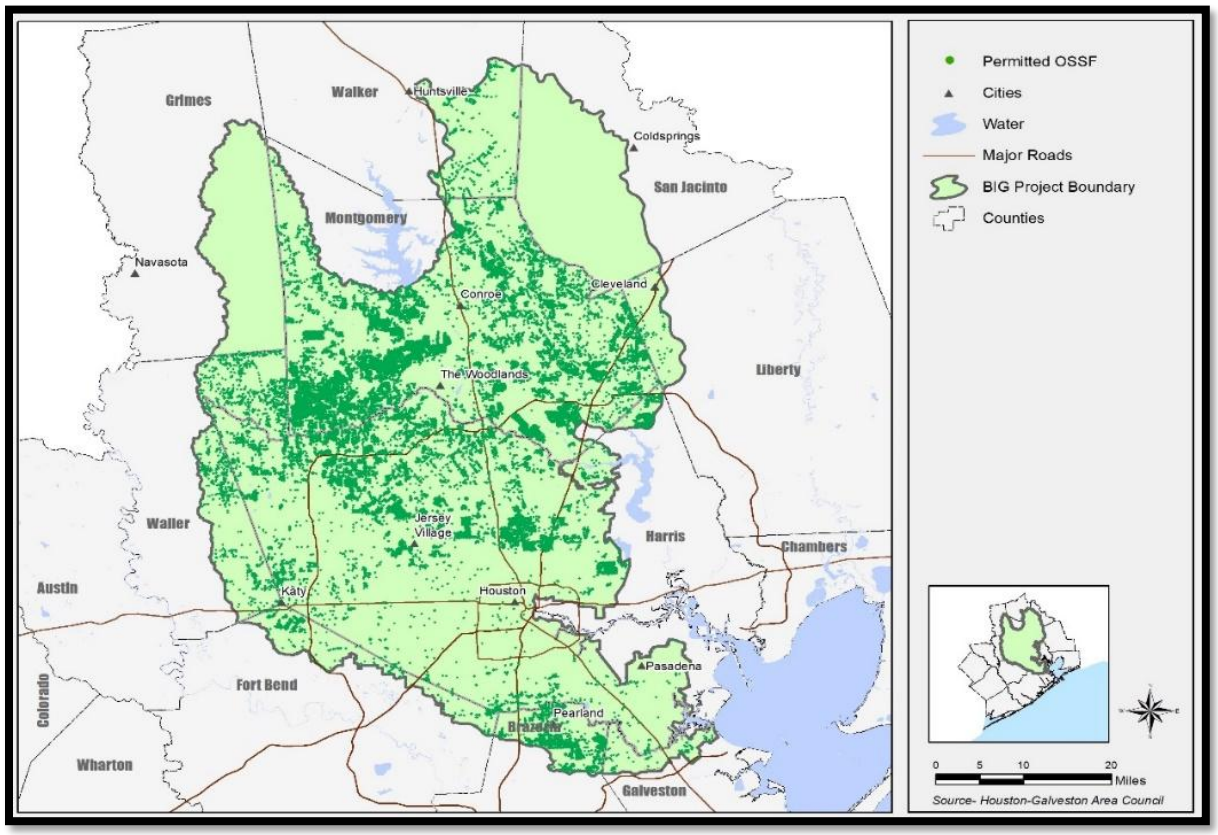

Figure 15. Permitted OSSFs within the BIG Project Area

Implementation Activity 3.1: Identify and Address Failing Systems

Action

The BIG and H-GAC will continue to work with the authorized agents,[95] [96]and other interested parties and will prepare a plan that will prioritize portions of the BIG project area to address known or suspected failing systems. H-GAC, Harris County and other BIG partners maintain programs to address failing systems through repairing or replacing failing OSSFs and when appropriate abandon the systems for centralized treatment.

[95] An authorized agent is defined in the Tex. Health & Safety Code Ann. § 366.002(1) (Definitions) as "a local governmental entity authorized by the commission to implement and enforce rules [related to OSSF regulations in Chapter 366 of the Health and Safety Code]" (TCEQ 2009b)

[96] On-Site Sewage Facilities | Houston-Galveston Area Council (H-GAC)

Background

The I-Plan first edition recommended four actions to implement this activity:

3.1.1: Annually Update Map of permitted and unpermitted OSSFs in the H-GAC and BIG Regions

H-GAC was to collect, and map permitted and non-registered OSSF information as resources were available. Authorized agents were encouraged to submit OSSF locations to H-GAC as frequently as reporting requirements are specified in 30 Tex. Admin. Code § 285.11(e)(2)[97]. Reporting requirements are monthly. H-GAC was to include Grimes and San Jacinto County data.

3.1.2: Identify target areas, timelines, and costs

H-GAC, working with stakeholders, was to analyze the initial mapping data and prepare a report of recommended target areas, timelines, and budgets. H-GAC was to solicit input from authorized agents and other interested parties. When possible, target areas were to be identified using the geographical prioritization framework described in **Error! Reference source not found.**. Additional criteria to select target areas were to include proximity to an impaired waterway, density of failing systems, and social and economic considerations. The report was to be used to facilitate grant applications and identify appropriate resources.

3.1.3: Address target areas and pursue funding

The BIG, H-GAC, local governments or other agencies were to seek to address failing systems in target areas with appropriate actions which may include enforcement, owner education, repair, replacement, connection to municipal treatment works (when appropriate), and public education. Local governments and H-GAC were to seek to secure funding to address failing OSSFs, particularly in target areas. In addition to local funding, a variety of funding sources may be available.

3.1.4: Reevaluate plan

Every five years, as resources allow H-GAC or other appropriate entity was to convene representatives of the TCEQ, authorized agents, and other stakeholders to review progress, priority areas, funding opportunities, and other elements of the regional plan.

[97] 30 Tex. Admin. Code § 285.11(e)(2).

H-GAC began mapping OSSFs in the region in 2009 and worked with the TCEQ and the region's authorized agents to inventory and map permitted OSSFs and reported OSSF violations. As part of the study, H-GAC identified non-registered OSSFs by analyzing data from appraisal districts, wastewater treatment plant service areas, census data, and other sources of information. Since 2021, H-GAC has been using 911 address location to assist with identification of non-registered systems.

H-GAC developed a Supplemental Environmental Program with the TCEQ to allow for environmental penalty fines to be directed to the repair and replacement of OSSFs[98]. Harris County, the East Aldine Management District, and the Airline Improvement District have identified areas with failing systems. Working with the districts, Harris County has been working to abandon many of the systems and hook them up to centralized wastewater through grant funds.

Metric

Completed Map; #OSSFs by Segment and AU; Regional Plan

Milestones

Annual OSSFs map update; Annual # of OSSFs pumped out, repaired, replaced, or abandoned; Grimes and San Jacinto County data year 2; Regional Plan – year 3; Re-evaluate Regional Plan - year 10

Monitoring

Programmatic Measure: Map revised, #OSSFs pumped out, repaired, replaced, or abandoned

Environmental Measure: CRP analysis, Change in AU impairment status.

Implementation Activity 3.2: Address Inadequate Maintenance of OSSFs

Action

The BIG and its partners will offer OSSF workshops and events that target homeowners, wastewater professionals, real estate agents, and home inspectors. H-GAC will maintain an online website that to provide homeowner education.

Background

Authorized agents and other stakeholders were concerned that homeowners do not know enough about maintaining an OSSF to identify problems and solutions in order to prevent failures. H-GAC

[98] H-GAC SEP Flier_EN-SP_0818.pdf

maintains an online website to provide homeowner education.[99][100][101] H-GAC website includes factsheets on OSSF homeowner maintenance. H-GAC provides homeowner education workshops to assist homeowners maintain their systems. Several counties have requirements for pump-out and maintenance logs for homeowners and/or maintenance providers. H-GAC carries a real estate and home inspector OSSF education program.

The I-Plan first edition identified four actions:

3.2.1: Homeowner education

As resources are available, H-GAC was to maintain a website to provide homeowner education. H-GAC was to host, create, or adapt educational material, such as flyers, advertisements, mailers, and other marketing pieces for distribution at schools, in newspapers and publications, and to real estate agents and property inspectors. H-GAC was to offer at minimum one homeowner OSSF maintenance course annually, within the BIG project area.

An interactive function of this website was to encourage OSSF owners to sign up for automatic reminders of required maintenance activities. This interaction not only benefits the homeowner, but it also serves as an information gathering tool for H-GAC regarding ownership, permitting and maintenance of OSSFs. Other possible elements of the website were to include an online pumpout and maintenance log for homeowners and a list of licensed maintenance providers. Municipalities, counties, communities, homeowner associations and other interested parties can post a link to the website from their websites, creating a familiar portal for residents.

3.2.2: Encourage repair and pumpout logs be kept by homeowners and/or maintenance providers

Authorized agents were encouraged to persuade homeowners and/or maintenance providers to maintain repair and pumpout logs, which may consist of proof of a valid maintenance contract, for their facilities. The logs were expected to describe repair and pumpout data for the previous five years. Authorized agents could choose to require such logs by way of updates to their permit regulations. Homeowners and/or maintenance providers were encouraged to allow potential homebuyers to review the logs upon request. Homeowners and/or maintenance providers were encouraged to provide the logs or a copy of the logs to new homeowners upon transfer of property. Homebuyers will be given

[99] On-Site Sewage Facilities | Houston-Galveston Area Council (H-GAC)

[100] Get Tools - Coastal Communities - TX (coastalcommunitiestx.com)

[101] Homeowner Maintenance of Aerobic Treatment Units (tamu.edu)

flyers or information sheets, possibly by real estate agents or property inspectors, that provide information about what a homebuyer or new owner should look for in the logs.

3.2.3: Coordinate with real estate industry

H-GAC was to provide a real estate workshop at minimum, biennially. H-GAC, authorized agents, and other entities were to, as resources are available, provide education opportunities to real estate agents, property inspectors, and consumers about identification and consequences of inadequate maintenance and the failure of OSSFs. The Texas Real Estate Commission requires property inspections at the time of sale, specifies education and certification requirements for licensed real estate salespersons and inspectors, and develops forms for use during sales and inspections. Each of these items can be modified to provide additional resources for homeowners related to their septic systems.

3.2.4: Additional actions

The TCEQ, authorized agents, and other parties were encouraged to develop actions to increase maintenance of OSSFs, including more inspections, incentives for proper maintenance, and requirements that systems must be maintained by a maintenance company or a trained homeowner. The TCEQ was encouraged to suspend or revoke licenses and registrations of poorly performing installers and maintenance providers.[102] As resources were available, H-GAC and other stakeholders were to develop continuing education opportunities regarding OSSF regulations and enforcement for district attorneys and justices of the peace to increase prosecution of OSSF violations.

Metric

Updated website; Real Estate/Inspector Workshop; Homeowner Workshop

Milestones

Update website annually, Real Estate/Inspector Workshop biennially; Homeowner Workshop annually

Monitoring

Programmatic: Update website, # homeowners reached, #workshop attendees

Environmental: CRP analysis, Change in AU impairment status.

[102] See 30 Tex. Admin. Code § 285.65 (2011) (Suspension or Revocation of License or Registration)

Implementation Activity 3.3: Legislation and Other Regulatory Actions

Action

The BIG and its partners will track changes in legislation and other regulatory actions to determine how those changes affect authorized agents, homeowners, and service providers. The BIG will offer workshops that provide opportunities to share this information with target audiences.

Background

The BIG recommended consideration of the following changes to Texas legislation, rules, and agency policy. The I-Plan first edition recommended two actions:

3.3.1: Model Order, Ordinance, or Resolution

The TCEQ was to provide a model order, ordinance, and resolution that can be used by authorized agents to meet the minimum requirements of OSSF laws and rules.[103] The TCEQ was to maintain a list of more stringent local rules that have been adopted. Authorized agents were encouraged to adopt more stringent local rules as appropriate.

3.3.2: Biennial Review

The TCEQ was to consider providing a biennial forum to consider changes to legislation, rules, policies, and guidance relating to management of OSSFs. As part of this forum, the TCEQ was to discuss and consider appropriate mechanisms for funding OSSF programs.

Note: ____ provides information about more stringent regulations enacted by authorized agents in the Houston-Galveston region.

Metric

Identification and evaluation of legislative rule changes and other regulatory actions.

Milestones

Annual Report, workshop, website update

Monitoring

Programmatic: Update website, # homeowners reached, #workshop attendees

Environmental: CRP analysis, Change in AU impairment status.

[103] See 30 Tex. Admin. Code § 285.10

Implementation Strategy 4.0: Stormwater and Land Development

The BIG project area has experienced sustained population growth resulting in increased land development, which in turn may impact bacteria levels in the waterways. Bacteria sources, such as waste from pets, wildlife, and humans, can be washed into storm drains and then discharged into local waterways. Because stormwater systems are designed to remove stormwater quickly and efficiently from developments, stormwater often bypasses the natural vegetative barriers that filter sheet flow over the land. Thus, bacteria loading may be more concentrated. Infrastructure, such as pipes, inlets, culverts, interceptors, basins, reservoirs, outfalls, and channelized waterways, can convey direct bacterial loading. The TMDLs for Buffalo and White Oak bayous indicate that stormwater from permitted municipal separate storm sewer systems (MS4s) is a significant source of bacteria loading.[104]

Based on the 2010 Census, the urbanized area used to determine the area of Phase II MS4 permits is 884,656 acres or 42.21% of the project area (Figure 1). Existing requirements of MS4 Phase II permits require permittees to address impaired waters within their jurisdiction. The permits also recommend Phase II MS4s work with TMDL watershed stakeholder groups. This I-Plan provides elements that address bacteria loading in stormwater and offers an adaptive rather than prescriptive approach to bacteria reduction. Phase II MS4s can claim coordination as part of their required annual report.

Furthermore, many smaller cities and some unincorporated county areas do not currently have stormwater permits but may become designated as an MS4-permitted community in the future, possibly because of the 2020 Census. Some smaller cities and unincorporated areas should be encouraged to voluntarily adopt the six elements of MS4 Phase II permits.[105] Examples of current programs are provided in _____, along with a list of stormwater permits in the region provided in **Error! Reference source not found.**.

[104] (TCEQ 2009a, p. 44)

[105] (U.S. Environmental Protection Agency 2000)

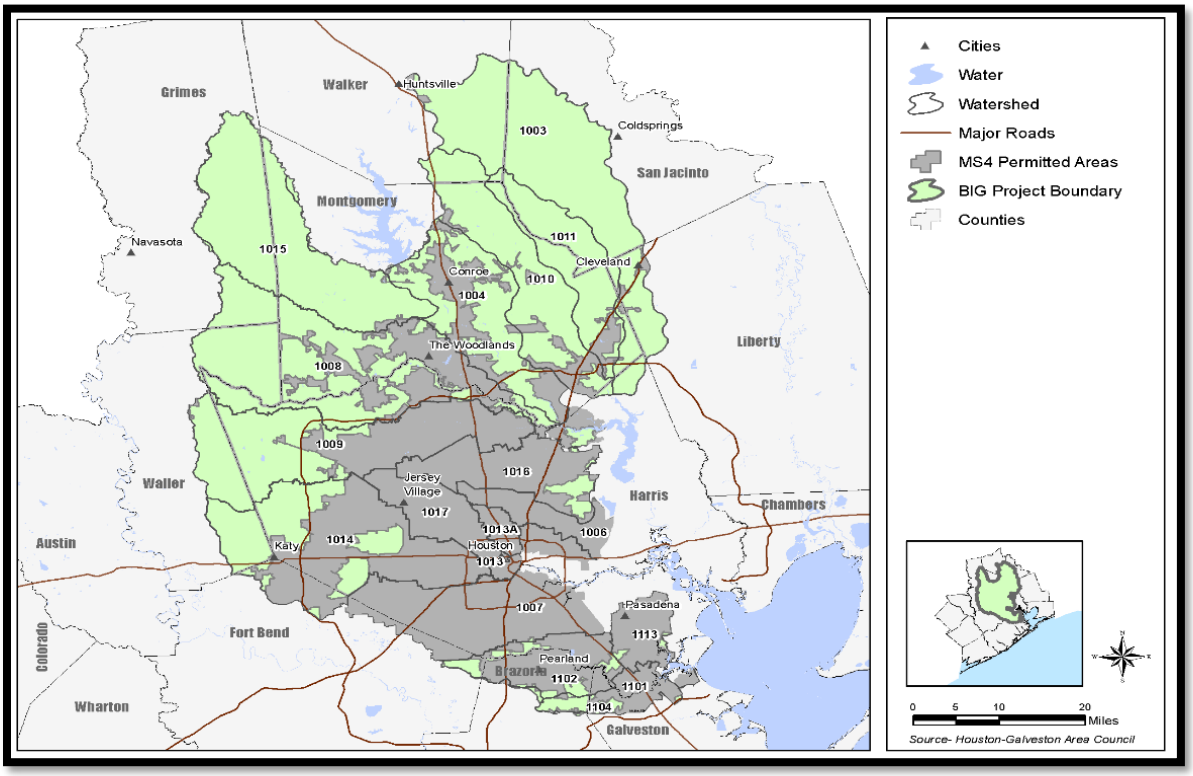

Figure 16. 2020 Census designated urbanized areas

Structural BMPs, such as modifications to stormwater outfalls that may reduce bacteria through aeration, treatment by sunlight, or physical removal of contaminants, have the potential to reduce bacteria loading into waterways. The BIG has documented 90 projects that are implementing water quality improvement practices[106] (Figure 2). Many of these projects include performance data. However, the data has not been made readily available to assess how well such BMPs might reduce bacteria loading. The BIG has identified the evaluation of the effectiveness of stormwater implementation activities as one of the top research priorities (See Research Priority 10.1.) Any research, particularly research relevant to the BIG area, should be reported and shared with BIG stakeholders, through Implementation Activities 4.2, 9.2, and 9.4.2, so that stakeholders can devise appropriate strategies for integrating structural stormwater BMPs into their activities.

[106] https://www.h-gac.com/low-impact-development/designing-for-impact

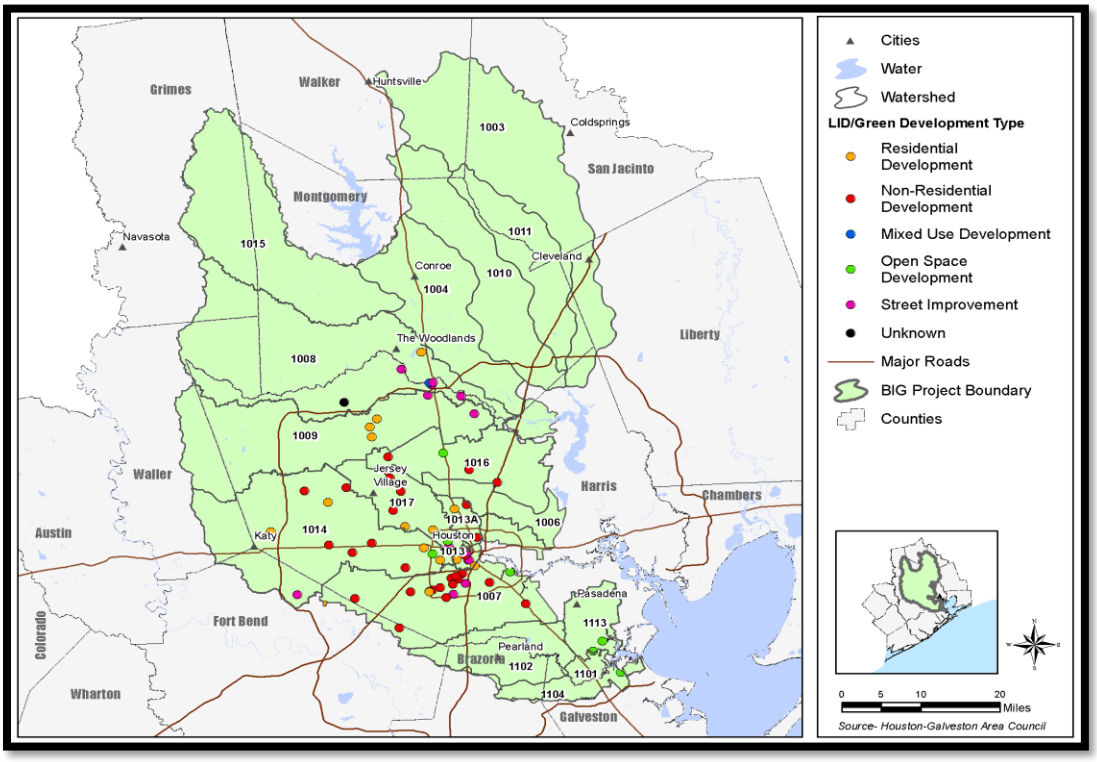

Figure 17. Low impact development practices implemented within the BIG project area

Implementation Activity 4.1: Continue Existing Programs

Action

The BIG and its partners will continue to track the progress of local stormwater programs. The 2020 US Census will be completed at the time of this revision and presents the potential for additional programs. Additionally, each permit renewal offers changes to existing programs. The last renewal added provision that included requirements to address impaired waters and emphasized coordination with TMDL watershed programs like the BIG.

Background

Local governments, especially those with MS4 permits, already employ extensive and innovative stormwater and land development programs, some of which address other bacteria sources identified in this I-Plan. These programs shall be continued as deemed appropriate by the entities that manage them.

For both the library of best practices and the networking meetings, particular attention should be paid to identifying best practices that involve the following:

- How to implement structural BMPs and stormwater controls that address bacteria reduction,
- Opportunities for watershed-based policies and activities,
- Codes, design criteria, and other specifications that address stormwater bacteria loading,

- How to encourage the use of green infrastructure in street design, sidewalk design, and stormwater management programs,
- How to incorporate bacteria reduction elements into flood control features where practicable, and
- How impervious cover affects water quality and bacteria loading, and best practices to address potential negative influences of impervious cover.

Metric

Report on current MS4 Phase II Programs; Stormwater Workshop

Milestones

Annual Report – once per year; Minimum one workshop per year

Monitoring

Programmatic: # MS4s within the Project Area; Reportable best practices; # MS4s participating in the BIG

Environmental: CRP Data; Change in AU impairments

Implementation Activity 4.2: Model Best Practices

Action

The BIG and its partners should continue to track and expand BMP resources. This includes the capture of installed BMP location and associated data on the H-GAC LID tracker. The Annual Report should highlight each year, recent BMPs and continue to support the Water Innovation Strategies of Excellence Awards (WISE).[107] A stormwater workshop should be convened each year to highlight the efforts of MS4s and other programs to address stormwater quality.

Background

The I-Plan first edition proposed existing programs to serve as models for other local governments and land developers in the project area. As resources became available, H-GAC was to provide forums for sharing information about existing programs and for coordinating collaboration.

Two actions were devised to:

[107] Water Innovation Strategies of Excellence Awards | Houston-Galveston Area Council (H-GAC)

4.2.1: Create and maintain an online library of best practices

H-GAC or another appropriate entity will create and maintain an online library of stormwater and land development best management practices (BMPs) and stormwater controls specific to bacteria load reduction that have been implemented regionally. Local governments will provide information about their BMPs and stormwater controls, which may include ordinances, policies, and structural BMPs and stormwater controls.

4.2.2: Coordinate networking meetings

As resources allow, H-GAC or another appropriate entity will facilitate a series of meetings relating to stormwater and land development BMPs and stormwater controls. Each meeting will highlight BMPs and stormwater controls implemented by MS4 permittees and focus on either a required element of an MS4 permit or BMPs and stormwater controls that fall outside the scope of the permit. These meetings should lead to discussion of model BMPs, stormwater controls, and other practices, including the identification of practical opportunities for collaboration at a watershed level. These meetings shall also serve as a forum for collaborative development and maintenance of regionally accepted codes, design criteria, structural BMP information, effectiveness monitoring and information, and guidelines.

Metric

Update to the LID tracker; WISE Awards; Stormwater Workshop, HCFCD BMP Database Updates

Milestones

Annual Report – once per year; LID tracker – once per year; Annual WISE Awards; Stormwater Workshop – minimum of once per year

Monitoring

Programmatic: #Attendance at workshops; # WISE Awards applicants; LID tracker update, HCFCD BMP Database

Environmental: CRP Data; Change in AU impairments

Implementation Activity 4.3: Encourage Expansion of Stormwater Management Programs

Action

The BIG and its partners encourage MS4 stormwater programs address impaired waters, specifically reducing bacteria, as part of the permit program through implementable BMPs. Non MS4s municipalities and local jurisdiction are encouraged to voluntarily incorporate BMPs within their jurisdictions.

Background

With the first edition, the BIG recommended existing stormwater management programs to be improved voluntarily, and the geographic application of stormwater programs to be expanded voluntarily, unless EPA chose to expand the definition of the area encompassed by an MS4.

The BIG proceeded to recommend three actions:

4.3.1: Encourage permitted MS4 communities to voluntarily expand and refine elements of their stormwater programs that address bacteria

Local governments should focus their existing programs on activities that are specific to bacteria reduction. The latest permit renewal requires Phase II MS4s to target impaired waters and to reduce pollutants in their permitted systems. Additionally, those requirements encourage Phase II entities to coordinate their efforts with watershed programs.

4.3.2: Encourage local governments without MS4 permits to voluntarily develop and implement a stormwater management program to address bacteria loading

Stormwater programs similar in structure and content to, or in conjunction with, MS4-permitted programs should be considered. A local government which does not require a stormwater permit should prepare, adopt, implement, and enforce as appropriate a stormwater management plan that meets the general requirements of the TCEQ's small MS4 general permit (TXR040000),[108] as suitable for their community. Elements of such a plan might include activities related to the six minimum control measures identified in a small MS4 general permit.[109]

4.3.3: If voluntary measures are not implemented or bacteria reduction is not being achieved, petition the TCEQ to mandate stormwater program development

The BIG can petition the TCEQ to require activities that are bacteria-specific in MS4 permits or to designate communities that do not already have an MS4 permit. Starting in year four after the adoption of this I-Plan, H-GAC shall, provided sufficient resources are available, evaluate communities to determine whether they have developed or improved a stormwater program to reduce bacteria loading in waterways. Criteria that will be evaluated are formal adoption of the stormwater plan by elected officials of the local government, funding levels for the program, self-reports of stormwater activities, and bacteria levels in local water bodies.

[108] General Permit TXR040000 for Phase II (Small) MS4s (TCEQ 2007)

[109] For more information, see the EPA's Fact Sheet 2.0: Small MS4 Stormwater Program Overview (U.S. Environmental Protection Agency 2005)

The H-GAC will provide a report to the BIG for evaluation. If local governments have not modified or created a stormwater program the BIG can recommend TCEQ consider additional permit requirements for those communities.

Metric

Workshops, meetings, or events that target Phase II MS4s; Track programs via Electronic Reporting Database (when established by TCEQ)

Milestones

Workshop – at minimum once per year, WISE Awards – once per year

Monitoring

Programmatic: #Attendance at workshops; # WISE Awards applicants

Environmental: CRP Data; Change in AU impairments

Implementation Activity 4.4: Promote Recognition Programs for Developments that Voluntarily Incorporate Bacteria Reduction Measures

Action

The BIG and its partners will support recognition programs by promoting events and encouraging participation. As an example, the City of Houston's Incentives For Green Development includes a new recognition program.[110] H-GAC's Water Innovation Strategies of Excellence (WISE) Awards also seek to recognize projects that support water quality improvement.

Background

Several recognition programs already exist or are being developed that address land development and infrastructure. Many of these programs are high-profile, comprehensive programs that could have a positive effect on bacteria loading from these sources. However, the programs are not specific to either bacteria or the BIG region. For this reason, the BIG proposed two complementary elements of action; participating in existing recognition programs and developing a recognition program specific to stormwater for the region. The WISE Awards are H-GAC's effort to develop an award program.

[110] Incentives for Green Development (houstontx.gov)

4.4.1: Encourage voluntary participation in existing recognition programs

Several voluntary programs that address land development and stormwater have been developed or are being developed, including:

- *Leadership in Energy & Environmental Design (LEED) 2009 for Neighborhood Development Rating System*[111]
- *International Green Construction Code*[112]
- *National Green Building Standard*[113]
- City of Houston Green Development Program

Although these programs focus specifically on neither bacteria reduction nor this region, they do contain elements that may help reduce bacteria loading. The BIG encourages local governments, land developers, and stakeholders to promote these programs and similar programs as appropriate. Local governments shall analyze their local regulations and programs in an effort to eliminate hurdles to the attainment of the requirements in these programs.

4.4.2: Continue a recognition program specific to stormwater and land development in the BIG area

H-GAC will continue a recognition program that will promote stormwater and land development practices that are intended to reduce bacteria loading from stormwater and land development. The program may apply to developments, builders, developers, local governments, drainage districts, and others. The Award Committee will consider, among other things:

- Criteria for development and redevelopment,
- Criteria for stormwater infrastructure,
- Integration with existing programs,
- Funding, and
- Scope of the program.

Metric

WISE Awards; Track other Award Programs

Milestones

WISE Awards – once per year

[111] (Congress for the New Urbanism, Natural Resources Defense Council, and the U.S. Green Building Council 2009)

[112] (International Code Council 2010)

[113] (National Association of Home Builders and the International Code Council n.d.)

Monitoring

Programmatic: # WISE Awards applicants

Environmental: CRP Data; Change in AU impairments

Implementation Activity 4.5: Provide Programmatic Outreach

Action

The BIG and its partners will provide outreach through one-on-one meetings, workshops, and/or events to encourage the continued growth, acceptance and use of BMPs to target the reduction of bacteria. H-GAC and its partners will continue to seek grants and other resources to address knowledge gaps, develop demonstration projects and identify and reduce barriers. Activity 4.5 will be used to share the latest BMP results, newest technology, and funding opportunities.

Background

The I-Plan first edition recommended, that as resources were available, H-GAC shall manage a circuit-rider program to provide evaluation and technical assistance to communities implementing stormwater programs. In particular, the circuit rider can provide assistance in identifying and adapting model program elements for specific communities, identifying partnership opportunities, identifying funding mechanisms, and evaluating local regulations that might present obstacles to pursuing recognition programs outlined in this section. The circuit rider program shall also work toward the collaborative development and maintenance of regionally-accepted codes, design criteria, structural BMP information, effectiveness monitoring and information, and guidelines, which may improve consistency in land development and redevelopment practices.

Metric

Workshops, meetings, or events that target Phase II MS4s; #Incentive Programs

Milestones

Workshop – at minimum once per year, WISE Awards – once per year

Monitoring

Programmatic: #Attendance at workshops; # WISE Awards applicants; #Incentive Programs

Environmental: CRP Data; Change in AU impairments

Implementation Activity 4.6: Establish Incentives for Bacteria Reduction Measures

Action

The BIG and its partners encourage local jurisdictions to establish incentive programs that will expand the use of BMPs to address stormwater quality. New developments and redevelopments should be encouraged to go above and beyond minimum standards. The BIG and its partners support incentives that reward the use of water quality improvement practices, such as the recent City of Houston Program or Harris County's offset detention requirements. The BIG will also conduct outreach to highlight this potential return on investment benefit for developers to include water quality improvement practices within their developments, including TCEQ's bond program.

Background

The I-Plan first edition recommended the BIG petition the TCEQ to facilitate the reimbursement of bacteria reduction measures. Specifically, the BIG was to work with TCEQ staff to interpret existing policies to facilitate MUD reimbursement to developers for stormwater quality features (which may otherwise be considered part of a developer's amenity package and not subject to MUD reimbursement) in their plans for development. As part of this discussion, the parties, including the engineering and development communities, were to work to develop criteria which can be used to determine the eligibility of a water-quality feature for reimbursement. If necessary, the BIG was to write a letter to the TCEQ encouraging the adoption of policies.

The TCEQ currently allows developer reimbursement using utility bond funds for costs associated with eligible stormwater quality structures (i.e. Low Impact Development and Green Infrastructure projects). Eligible projects need to provide evidence of a clear water quality attribute. Each project is reviewed on a case-by-case basis and should be identified in the bond application materials. Applicants are encouraged to schedule pre-application meetings with District staff to discuss the projects and their eligibility for reimbursement.

Metric

Workshops, meetings, or events that target Phase II MS4s; #Incentive Programs

Milestones

Workshop – at minimum once per year, WISE Awards – once per year

Monitoring

Programmatic: #Attendance at workshops; # WISE Awards applicants; #Incentive Programs

Environmental: CRP Data; Change in AU impairments

Implementation Strategy 5.0: Construction

The rapid population growth in the BIG project area has created a demand for new structures and expanded infrastructure (Figure 3). Construction sites for residential, commercial, and linear projects are common throughout the region. Although construction sites are not generally viewed as significant sources of bacteria;[114] they can contribute sediment and nutrients through runoff and erosion. Bacteria may be found at a construction site in products used for fertilization and landscaping and from improper disposal of on-site sanitary wastes.[115] Bacteria may also attach to sediment. Runoff from construction sites may also contain constituents, such as nutrients, solids, fine particles, and other solid material, that could potentially influence instream bacteria levels.

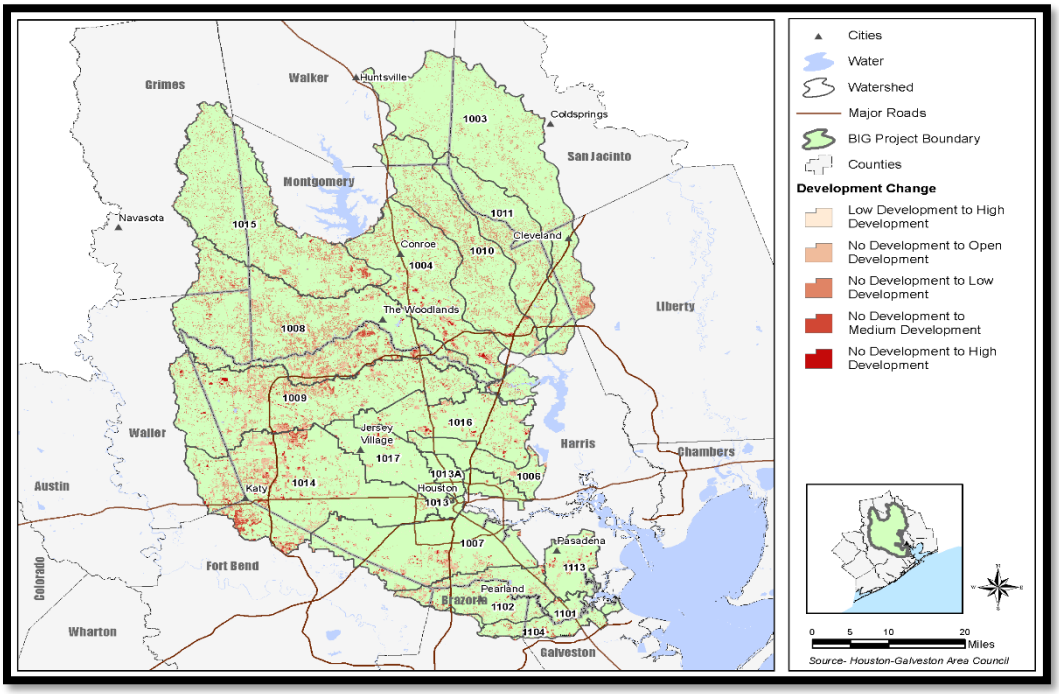

Figure 18. Development pressure in the BIG Project Area

Implementation Activity 5.1: Encourage Increased Compliance with and Enforcement of Stormwater Management Permits

Action

The BIG and its partners encourage greater compliance with and enforcement of stormwater management programs. The BIG encourages local jurisdictions to expand inspection programs when

[114] (U.S. Environmental Protection Agency 2005)

[115] (U.S. Environmental Protection Agency 2009a)

feasible, including novel ways, i.e. technology or citizen reporting[116]. The BIG will support enhancements by providing workshops and events to highlight emerging technology, including surveillance and BMPs. The BIG and its partners will increase public awareness of proper and improper use of BMPs at construction sites and ways to report.

Background

If a construction site complies with the TCEQ Construction General Permit (CGP), TXR150000,[117] as well as local stormwater management permits, sediment and bacteria in runoff can be minimized. Problems arise when construction sites do not have adequate erosion and sediment controls. A study conducted by researchers at the University of North Carolina found that greater enforcement of existing regulations, rather than more stringent regulations, is needed to better protect water quality downstream of construction sites.[118] As of February 1, 2010, EPA proposed to add turbidity limits to construction general permits at the time of permit renewals.[119] However, EPA's action is stayed as of this publication. The current CGP expires in 2013.

The I-Plan first edition determined that construction site regulations were adequate, requiring that sediment be retained on-site to the extent practicable.[120] The plan focused on the small number of state or local enforcement staff, faced with an overwhelming number of construction sites at any given time, which accounts for the inadequate enforcement of and, subsequently, limited compliance with the CGP in some areas as the challenge to managing construction sites.

The I-Plan recommended three actions:

5.1.1: Increase enforcement at construction sites by increasing the percentage of sites inspected

Local governments or other MS4 operators shall evaluate the need for staffing an appropriate construction inspection program. Additional inspectors shall be obtained if needed and as resources are available.

Current TCEQ staffing levels available to conduct stormwater inspections are insufficient. The BIG recommends that the TCEQ consider an increase of staff or resources to increase its inspection capacity

[116] City of Houston's 311 or the Galveston Bay Foundation's GBAN

[117] (TCEQ 2008d)(TCEQ 2008d)(TCEQ 2008d)(TCEQ 2008d)(TCEQ 2008d)

[118] (U.S. Environmental Protection Agency 2005)

[119] (U.S. Environmental Protection Agency 2009c)

[120] (TCEQ 2008d)

primarily where local governments do not have a staff. Additionally, the BIG recommends that the TCEQ consider expanding the regulated areas as described in Implementation Activity 4.3.

5.1.2: Develop and distribute educational material to inform contractors, construction site owners, developers, MS4 operators, and citizens of proper construction site practices

As resources are available, H-GAC will develop and distribute educational material to encourage conformance with requirements by regulated entities. Educational materials will also be used to foster active participation by citizens in improving water quality by reporting construction sites with poor housekeeping and sediment control practices. This public education effort will be combined with the efforts described later in
Implementation Activity 8.1, to expand homeowner education efforts throughout the BIG region to take advantage of economies of scale. Educational materials will need to have specific components to address contractors, construction site owners, MS4 operators, and the public.

The material will discuss why it is important to prevent sediment from leaving construction sites, outline general regulations to which a construction site must adhere, and provide contact information for reporting suspected violations. Increasing citizen knowledge can increase the likelihood of stormwater violations being reported and subsequently may increase the number of construction sites being brought into compliance. Educational materials will be distributed widely and in a variety of ways. including, but not limited to, by trade associations, by local governments (during building permit applications and the plan review process), through mailings and on the internet. Examples of publications that might be used as models are *Storm Water Management Handbook for Construction Activities*[121] developed by the City of Houston, Harris County, and Harris County Flood Control District, and *Don't Get Cited for a Dirty Site*[122] developed by Harris County.

5.1.3: Conduct training workshops for contractors, construction site owners, developers, and MS4 operators regarding stormwater management best management practices and encourage them to in turn require training of their crews

Contractors, construction site owners, developers, and MS4 operators are responsible for ensuring compliance. Therefore, it is in their best interest to ensure that construction workers under their supervision are properly trained in the installation and maintenance of erosion and sediment controls. As resources are available, H-GAC will develop training workshops about existing and emerging construction site BMPs and requirements. The workshops will be designed to help operators communicate requirements to employees. A good reference during training is the *Stormwater*

[121] (City of Houston 2006)

[122] (Russo 2008)

Management Handbook for Construction Activities[123] which includes easy-to-understand descriptions and diagrams of erosion controls and describes proper installation and maintenance.

Private construction operations should not be the only target of this activity. Local government departments, municipal districts, and other government entities involved in construction, and their contractors, and subcontractors, also must properly install and maintain erosion and sediment controls and educate their personnel. Training local government inspectors is also essential in the effort to improve compliance.

Metric

Workshops, meetings, or events that target Phase II MS4s; Host one workshop

Milestones

Workshop – at minimum once per year, WISE Awards – once per year

Monitoring

Programmatic: #Attendance at workshops; # WISE Awards applicants

Environmental: CRP Data; Change in AU impairments

[123] (City of Houston 2006)

Implementation Strategy 6.0: Illicit Discharges and Dumping

Illicit discharges and dumping illegally introduce contaminants into waterways. Illicit discharges are those improper discharges from the contained sanitary sewer system that are connected accidentally or on purpose to the stormwater system. Sources in addition to illicit discharges include direct discharges and dumping to the water body itself. While a wide variety of sources may introduce contaminants to a water body, the following implementation activities specifically address bacterial contamination, both mobile and stationary.

Many of the TMDLs in the BIG region indicate that illicit discharges and dumping account for significant dry-weather bacteria loadings. Outfalls in Buffalo and Whiteoak bayous TMDL have bacterial *E. coli* loads ranging from 7.43 X 10^5 to 2.21 X 10^{11} MPN/day.[124] In Whiteoak Bayou, these discharges represented the largest source of indicator bacteria loading.[125] Similarly, in Clear Creek, estimates indicate that between a quarter and a third of all outfalls have illicit dry-weather discharges, and that more than 20 percent of these had *E. coli* concentrations of over 1000 cfu/mL, more than eight times the in-stream standard.[126]

Stakeholders have expressed concern that mobile waste haulers may contribute bacteria directly to area bayous. Waste from septic systems, grease traps, and grit traps is hauled from its originating point. While regulations dictate this waste be properly transported and recorded on a manifest, anecdotal evidence raises suspicion that this waste may not always be properly disposed in a treatment facility.

The 2017 BIG Project Area expanded with the inclusion of a portion of Lake Houston watershed and Jarbo Bayou watershed. Clear Lake is the receiving water for Jarbo Bayou and active marinas can be found at that point. Clear Lake is an active area for boaters, including boats used for full time living and boats of sufficient size to host holding tanks. Like OSSFs, the tanks need to be pumped out and the waste treated properly. Clear Lake is considered a No Discharge Zone and any release of waste is considered an illicit discharge. Due to tidal exchange within Jarbo Bayou, illicit discharges from boaters could impact contact recreation within the bayou. Likewise, boats traveling in the upper reaches of Lake Houston can potentially pose a source of bacteria if not treated properly.

Given the transitory nature of these discharges, there are no flow-adjusted estimates for their contributions. They have been a widely cited potential source among the project stakeholders. Sampling data, such as unexplained spikes in bacteria levels with no corresponding permitted outfalls or sources nearby, may help identify illicit discharge sources.

---

[124] (TCEQ 2009a)

[125] (TCEQ 2009a)

[126] (TCEQ 2008b)

Programs to detect and eliminate these illegal discharges are an integral part of TPDES Phase I and II stormwater permits. As such, the activities discussed in this section may also be considered as part of Implementation Strategy 4.0. While all communities and jurisdictions will participate in implementation efforts, the extent to which these activities are applied may vary by individual need and ability.

Implementation Activity 6.1: Encourage Local Jurisdictions to Detect and Eliminate Illicit Discharges

Action

A majority of the BIG project area is under either a Phase I or Phase II permit and should therefore be establishing active programs. The BIG and its partners, including H-GAC and the Bayou Preservation Association have modeled illicit discharge detection and elimination programs since 2013. This presents an opportunity to share project results.

H-GAC and its partners should encourage local jurisdictions to enhance their programs by presenting project results through one-on-one meetings, seminars, and workshops. A majority of the BIG project area is under either a Phase I or Phase II permit and should therefore be establishing active programs.

Local jurisdictions are encouraged, as part of their MS4 Phase II permits, to share their efforts with the BIG, to reduce illicit discharges.

Background

Jurisdictions shall devise and implement a program, as they deem practicable, to detect and eliminate illicit discharges that assist them in identifying sources for further enforcement action. This implementation activity is similar to the programs required under stormwater permits, but with a specific focus on direct, bacteria-laden discharges. Existing illicit discharge programs can be modified to focus on bacteria.

Elements of the detection portion of the program may consist of:

- Conducting field surveys of waterways and associated drainage channels,
- Reviewing existing spatial data (geographic information system, engineering drawings, etc.) with on-site visual inspections of water body channels,
- Producing or revising a storm sewer map of all outfalls and the names and locations of all waters of the state that receive discharges from the outfalls,
- Producing or revising, to the level of detail that meets the specific need of the government entity, an initial record of located discharges for comparison against permitted discharges (stormwater outfalls, permitted industrial outfalls, etc.), and
- Reviewing, verifying, and updating the program and data on a regular basis.

Sampling data, where available, may help predict where unidentified illicit point sources may be located (such as unexplained spikes in bacteria levels with no corresponding permitted outfalls or sources nearby). Publicity and outreach efforts regarding these actions, indicating enforcement is imminent, will help promote self-enforcement by current or potential point source dischargers.

Next, the program will seek to eliminate illicit discharges to the extent allowable under state and local law and as resources allow. Entities will pursue elimination through their established methods. If the existing abilities to eliminate these discharges are deemed insufficient, the local entity shall expand their program as detailed in Implementation Activity 6.2, as appropriate. Several illicit discharge detection programs already exist and may be used as guides by stakeholders for developing or altering their approach.[127]

At least annually, local governments shall provide reports of how many illicit discharges have been found and how many have been eliminated. Provision of this information in a copy of an existing report is sufficient.

Metric

Local Reports; Meetings and Workshops

Milestones

Local Reports – annually; Meetings – minimum 5 per year; Workshops – minimum annually

Monitoring

Programmatic: #MS4 reporting; #meetings and workshops held

Environmental: CRP analysis, change in AU impairment status.

Implementation Activity 6.2: Improve Regulation and Enforcement of Illicit Discharges

Action

Aa part of its solid waste program, H-GAC will host city and county environmental enforcement officers and staff to discuss illegal dumping and other environmental concerns. H-GAC will coordinate illicit discharge programming with this annual workshop to enhance effort to use ordinance and regulatory rule making to enhance the removal of illicit discharges and illegal dumping.

[127] An example, *A Guidance Manual for Identifying and Eliminating Illicit Connections Municipal Separate Storm Sewer Systems (MS4)*, is available online. (Galveston County Health District 2002)

Background

To the extent allowable under state and local laws, an ordinance or other regulatory mechanism was to be utilized to prohibit and eliminate illicit discharges. Each jurisdiction was to also establish guidelines for enforcement for removing the source of an illicit discharge.

Stakeholders are concerned current regulations and penalties often fail to act as deterrents, especially given a perceived low level of standardization and enforcement. Jurisdictions were to review and enforce existing regulations, or, as appropriate, develop or improve regulations relating to illicit discharges.

As resources are available, H-GAC was to compile local regulations and make the information available for other communities to emulate as appropriate. H-GAC will also facilitate coordination of standardization, as resources are available, possibly as part of the circuit rider program described in Implementation Strategy 4.0.

Metric

Environmental Enforcement Workshop

Milestones

Workshop - annually

Monitoring

Programmatic: Environmental Enforcement Roundtable; #Programs established to track and enforce illegal discharges. # of illegal discharges/dumping identified and addressed

Environmental: CRP analysis, change in AU impairment status.

Implementation Activity 6.3: Monitor and Control Waste Hauler Activities

Action

Track MS4 programs that monitor and control waste hauler activities through their MS4 annual reports. H-GAC will identify model programs to highlight within the BIG Annual Report and on its website.

Background

Waste haulers routinely transport bacteria-laden materials, including septic, grease trap, and grit trap wastes. When this highly concentrated, untreated waste is discharged into waterways instead of being properly disposed of or treated, it may represent a significant local increase in bacterial loading. Under this implementation activity, bacteria control will occur through the development of monitoring and control programs by individual communities and by a pilot program to monitor waste hauler fleets.

The I-Plan first edition recommended two actions:

6.3.1: Develop regulations pertaining to waste hauler activities

While many jurisdictions have some degree of regulation regarding waste hauler activities, some programs have had greater success than others. Jurisdictions were to, according to their needs and as practicable, create or update a program designed to monitor and control waste hauler activities. This program would integrate inspection and enforcement capacities in order to ensure the ability to provide a strong disincentive for non-compliance. State law[128] allows counties and municipalities to permit and regulate the activities of septic, grease trap, and grit trap waste haulers, up to and including criminal penalties for non-compliance. As resources are available, H-GAC was to compile and make available information about the most effective waste hauler programs.

The City of Pasadena's program, for example, requires all waste haulers have a license or permit, know the nature of their cargo, and maintain a manifest. The program sets forth penalties for violations of these and other requirements, including revocation of permits and monetary fines for each day of non-compliance.[129] Stakeholders may choose to pursue a regional approach to better track haulers who may operate in numerous jurisdictions. A previous regional project, the Environmental Enforcement Database Application (maintained from 2003-2008 as a pilot project by the H-GAC) shared secure information for local enforcement agencies regarding waste hauler violations. A similar project may help individual entities identify and curtail violators.

6.3.2: Waste Hauler Fleet Tracking Pilot Program

To promote accountability and compliance among waste haulers, the BIG was to consider pursuing a grant to develop a pilot program to install global positioning transponders and/or other apparatus or technology on the vehicles of waste haulers who have violated regulations relating to waste transport and disposal. H-GAC, the TCEQ, local jurisdictions, and waste companies were to have access to the transponder feed to determine whether individual haulers are making unscheduled stops that may correlate to illicit discharges. Potential funding sources include EPA Section 319(h) nonpoint source program funding (via the TCEQ or the Texas State Soil and Water Conservation Board), State Revolving Fund monies through the Texas Water Development Board, and private foundations.

[128] See Tex. Health & Safety Code Ann. § 368 (2011) (Subchapter A - Transporters of Grease Trap, Sand Trap, and Septic Waste)

[129] See City of Pasadena, Tex., Code of Ordinances, ch. 37 (Water, Sewers and Sewage Disposal, Article VIII - Liquid Waste Generators and Transporters)

Metric

Track MS4 programs

Milestones

Annually report on MS4 waste hauler programs

Monitoring

Programmatic: #MS4 reporting; #meetings and workshops held

Environmental: CRP analysis, change in AU impairment status.

Implementation Activity 6.4. Boater Wastes

Action

The BIG recommends tracking and supporting boater waste programs carried out by the Galveston Bay Foundation and its partners. H-GAC and its partners will coordinate with the Galveston Bay Foundation to share the latest information on boater waste measures. H-GAC and its partners will encourage stakeholder participation in Galveston Bay Boater Waste programs through active promotion of events and provide planning assistance. Additionally, the BIG through other activities implemented in the Jarbo Bayou watershed contained in this I-Plan will support the implementation of *The Implementation Plan for Bacteria in Waters of the Upper Texas Gulf Coast* (UTGC)[130].

Background

The UTGC I-Plan was developed to address bacteria sources impeding the safe recreational consumption of oysters found in Galveston Bay. The UTGC I-Plan specifically targets boater wastes, including those in Clear Lake, as one of the bacteria source contributions for remediation. The Galveston Bay Foundation (GBF) is the lead implementer of this UTGC I-Plan as its mission is to protect Galveston Bay's resources for future generations. The BIG recognizes this work and through this action seeks to support the GBF's efforts to address boater wastes. The UTGC I-Plan identifies five boater waste management measures for implementation:

- Increase Access to Pump-Out Facilities,
- Enforce Existing Regulations,
- Enhance Outreach and Marketing, and
- Conduct Water Quality Monitoring in Marinas.

[130] https://www.tceq.texas.gov/waterquality/tmdl/74-uppercoastoyster.html

Metric

Outreach Events, # Pump Stations

Milestones

Annually report on efforts to address boater wastes

Monitoring

Programmatic: #program/actions undertaken, #pumpout facilities available, #boaters/marinas engaged

Environmental: CRP analysis, change in AU impairment status.

Implementation Strategy 7.0: Agriculture, Animal, and Silviculture Sources

Bacteria loads can come from agricultural and forestland practices, feral hogs, and wildlife. Feral hogs are identified in the TMDLs, particularly as nonpoint sources of concern. Additional areas of concern include the bacteria to attach to sediment in runoff, the potential effect that nutrients have on bacteria growth rates in water bodies, and livestock's direct deposition of fecal waste in waterways. Existing management programs are traditionally voluntary, unless large populations of animals are involved. The voluntary expansion of existing soil, livestock, and silviculture management programs could assist lowering bacteria levels in waterways, particularly in subwatersheds where substantial areas of land are devoted to forest, crop, pasture, and range practices. (See **Error! Reference source not found.**1 and Table 1.)

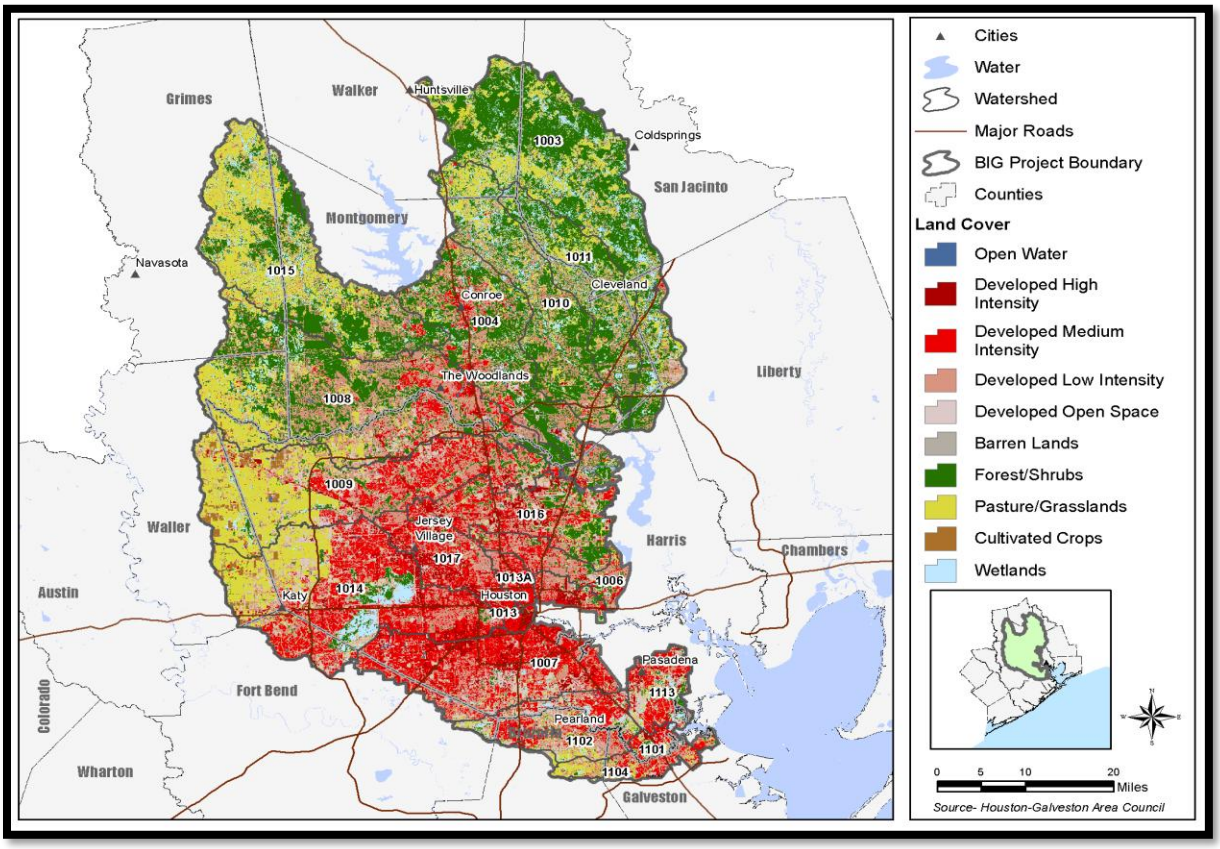

Figure 19. Land cover types within the BIG Project Area

Table 1. Total land cover types within the BIG Project Area

According to the technical documents for each of the TMDLs, there are no Concentrated Animal Feeding Operations (CAFOs) in the areas covered by this I-Plan. However, livestock populations have been estimated for the watersheds within the BIG project area. Cattle and poultry are most abundant livestock in the region. Estimated populations are described in Table2.

Table 2. Estimated Livestock Populations by TMDL watershed

Other animals of concern throughout the region include horses, swine, sheep, and goats, with their densities varying by watershed. For example, horse populations are prevalent in the Cypress Creek and Spring Creek watersheds.

Healthy trees and forests are critically important to protecting water resources and sustaining them in the future. Approximately 50 percent of the freshwater resources in Texas originate on forestlands, which provide a continuous and abundant supply of clean water. In fact, many state and national forests were established to protect the country's water sources. Forestry Best Management Practices (BMPs) are the principal means of protecting water resources during forestry activities. Forestry BMPs are conservation practices that protect soil and water resources, two key elements necessary for growing a healthy, sustainable, and productive forest. BMPs can include methods such as leaving a buffer zone of trees next to a stream, installing a culvert to cross a waterway, or establishing grass on forest roads to prevent erosion.

A prominent concern raised by stakeholders pertains to feral hogs. In addition to being a nuisance to landowners because of their rooting and wallowing and occasional predation of small livestock, feral hogs discharge large amounts of bacteria and nutrients into the environment through fecal waste. It has been estimated that there are 36,284 feral hogs in the BIG Project Area (Table 3). Hogs are known to reproduce quickly, have no natural predators, and spend most of their time either in or around water.[131] Hogs are likely a significant source of bacteria for some of the impaired waterways encompassed by this I-Plan.

Table 3. Feral hog populations by watershed within the BIG project area

Watershed	***High Quality***	***Low Quality***	***Total***
Clear Creek	*32,007.07*	*47,170.61*	*1,476*
Armand Bayou	*9,232.50*	*14,327.57*	*436*
Sims Bayou	*5,667.51*	*29,574.07*	*556*

[131] (Taylor n.d.)

Brays Bayou	*1,675.75*	*23,677.49*	*372*
Buffalo Bayou	*1,754.92*	*20,993.41*	*337*
Barker Reservoir	*34,964.47*	*26,594.64*	*1,266*
Hunting Bayou	*1,775.82*	*7,019.89*	*143*
White Oak Bayou	*1,788.50*	*27,859.85*	*433*
Addicks Reservoir	*32,506.34*	*31,385.25*	*1,269*
Greens Bayou	*31,090.35*	*57,914.29*	*1,602*
Lake Houston	*7,208.26*	*6,598.90*	*276*
Cypress Creek	*80,536.51*	*55,927.41*	*2,841*
Little Cypress	*15,874.54*	*13,868.54*	*600*
Willow Creek	*10,399.18*	*19,700.85*	*540*
Spring Creek	*151,309.89*	*79,778.37*	*4,987*
Lake Creek	*174,210.33*	*27,478.66*	*4,846*
West Fork	*77,743.68*	*46,617.96*	*2,640*
Caney Creek	*105,717.84*	*33,463.08*	*3,174*
Peach Creek	*79,057.81*	*16,509.26*	*2,255*
East Fork	*230,049.90*	*24,198.78*	*6,232*
Total	*1,084,571.17*	*610,658.88*	*36,284*

The five governmental agencies in the following list will be responsible for implementing management measures aimed at reducing nonpoint source loadings from agricultural and forest land operations. Their duties and activities related to this I-Plan are described in greater detail in **Error! Reference source not found.**.

- **Texas State Soil and Water Conservation Board (TSSWCB**) – The TSSWCB is the lead agency in Texas responsible for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural (forestry) nonpoint source pollution.[132]
- **Natural Resources Conservation Service (NRCS)** – The NRCS provides conservation planning and technical assistance to landowners, groups, and units of government to develop and implement conservation plans that protect, conserve, and enhance their natural resources.
- **Soil and Water Conservation Districts (SWCDs)** – Through decades-old agreements, SWCDs offer agricultural landowners and operators technical assistance through partnerships with the NRCS and the TSSWCB.
- **Texas AgriLife Extension Service** – AgriLife Extension, an agency of the Texas A&M University System, provides quality, relevant outreach and continuing education programs and services to Texans.
- **Texas A&M Forest Service** – The Forest Service seeks to inform and educate landowners on sustainable land management practices.

Additional agencies may be able to facilitate voluntary actions pertaining to wildlife and property management activities. Agencies include Texas Parks and Wildlife Department, the U.S. Fish and Wildlife Service, wildlife management associations and co-ops, and other entities.[133]

Implementation Activity 7.1: Promote Increased Participation in Existing Programs for Erosion Control, Nutrient Reduction, and Livestock Management

Action

The BIG recommends tracking and supporting programs carried out by agricultural resource agencies. Actions can include securing venues and assisting with the publication, agenda setting, registration, and other support tasks for workshops and events. Encourage agencies sharing activities and promote benefits of best practices through the annual report and watershed meetings.

Background

A variety of programs provide farmers and ranchers with the technical and financial assistance necessary to combine agricultural and forest land production with environmental control actions. These actions may address water quality, reduction of soil erosion and sedimentation, livestock waste management, and other issues that are likely to reduce bacteria in regional waterways.

[132] See Tex. Agric. Code § 201.026

[133] The Private Landowner Network maintains a comprehensive list of resources available to private landowners at http://www.privatelandownernetwork.org/grantprograms/.

Funding mechanisms identified by stakeholders include:

- Environmental Quality Incentives Program (EQIP), administered by the NRCS;
- Water Quality Management Plan Program (WQMP), a part of the Texas Non-Point Source Management Program administered by the TSSWCB through the SWCDs;
- Texas Climate Smart Initiative administered by the TSSWCB and Texas AgriLife[134];
- Conservation Innovation Grants, administered by the NRCS;
- Conservation Stewardship Program (CSP), administered by the NRCS;
- Agricultural Land Easement Program, administered by the NRCS;
- Wetlands Reserve Easement Program, administered by the NRCS

The funding mechanisms in the preceding list should not be considered an exhaustive list. Additional programs may be added as this I-Plan is updated.

These voluntary programs provide technical and financial assistance. Program participation levels should be increased by increasing familiarity with the program through marketing. Primary methods for disseminating information and increasing participation include:

- Texas AgriLife Extension Service agents' contact with the public;
- Public outreach from local SWCDs;
- Information distribution through local 4-H clubs, rodeos, the Texas Farm Bureau, the Texas and Southwestern Cattle Raisers Association, the Independent Cattleman's Association of Texas, Future Farmers of America, and at Agricultural Field Days; and
- Word of mouth.

Implementation of erosion control, nutrient reduction, and livestock management programs likely will not result in immediate cost savings to the landowner. However, implementation does have other benefits that should be promoted, including increased plant health, increased infiltration, reduced erosion, and increased filtration and trapping of nutrients. Additionally, participation should help landowners avoid violating water quality regulations and the associated fines. If a participating landowner violates water quality regulations while following an approved plan, the regulating agency may give the landowner an opportunity to implement BMPs to come into compliance. Also, when new mandatory implementation practices come into effect, participating landowners are often not forced to update their operations, as they are already in compliance with water quality regulations. Success stories should be highlighted.

The Montgomery County and Harris County SWCDs have informational materials for small landowners regarding environmental best practices for agriculture. These could be updated and made available to

[134] Texas Climate-Smart Initiative | Texas State Soil and Water Conservation Board

landowners in all watersheds. Providing landowners with clear and practical information may increase the likelihood of them implementing agricultural management measures, whether independently or through an existing program.

Texas A&M Forest Service, in cooperation with the forest sector and numerous other partners, develops and periodically updates non-regulatory BMP guidelines, provides education, outreach, and training on their application; and monitors their implementation on randomly selected forest operations. Over the years, the use of BMPs has become common throughout the forest sector.

Targeted program promotion will increase through word-of-mouth campaigns and Extension Agent involvement. Additional promotion methods include emails; notices in newsletters and local newspapers; participation in local festivals, rodeos, and fairs; and development of school programs. Promotion efforts will be conducted by TSSWCB, local SWCDs, NRCS, AgriLife Extension, H-GAC, and other agencies as appropriate with a goal of increasing participation in the programs each year. The BIG will provide this I-Plan to the implementing agencies along with a formal request for their assistance in encouraging program participation in accordance with this Implementation Activity.

Metric

Program Outreach, BMP projects, Area under a program (WQMP, CAP, EQIP, eta.).

Milestones

Annual workshop

Monitoring

Programmatic: Number of Outreach/Individuals contacted via workshops, events, or one-on-one, Implemented BMPs or Area under a program (WQMP, CAP, EQIP, eta.).

Environmental: CRP Analysis, Change in AU impairment status.

Implementation Activity 7.2: Promote the Management of Feral Hog Populations

Action

The BIG recommends tracking and supporting feral hog programs carried out by the Texas AgriLife Extension Service through Texas A&M University and their local county extension agents. H-GAC and its partners will encourage stakeholder participation in Texas AgriLife programs through active promotion of event and providing planning assistance. H-GAC and its partners will coordinate with Texas AgriLife to share the latest research and information on trapping techniques and other control measures.

Background

Feral hogs are not considered wildlife by the TPWD. As such, feral hogs can be hunted and captured without a license throughout the year. To effectively manage feral hog populations, Texas AgriLife has found that removal rates as high as 50-75% are needed, just to maintain a population size.

The Texas Wildlife Damage Management Service, a division of the Texas AgriLife Extension Service, is a valuable resource for training, technical assistance, and direct control in wildlife damage management including feral hog populations.[135] Control methods include snaring, live trapping, shooting, hunting with dogs, aerial hunting, exclusion, and habitat management.[136] Live trapping requires transporting feral hogs to approved holding facilities to prevent transmission of disease.[137]

The BIG region will take advantage of the services provided by the Texas Wildlife Damage Management Service by arranging two feral hog management workshops for landowners, local governments, and other interested individuals. H-GAC will request that workshops be held in strategic locations throughout the BIG region. Workshops will be heavily promoted in the Extension Service newsletter, local newspapers, and radio stations. Management activities, as described, can also be implemented by local governments as appropriate.

Metric

Program Outreach, Removal projects, changes to control measures

Milestones

Annual workshop

Monitoring

Programmatic: Number of Outreach/Individuals contacted via workshops, events, or one-on-one, Implemented reduction efforts.

Environmental: CRP Analysis, Change in AU impairment status.

[135] (Coping with Feral Hogs 2010)

[136] (Muir and McEwen 2007)

[137] https://www.tahc.texas.gov/animal_health/swine/FeralSwineFacilities.pdf

Implementation Strategy 8.0: Residential

Individual residents in the BIG area make only small contributions to waterway pollution. However, the cumulative effect can be significantly detrimental. Similarly, the combined effort of millions of residents participating in activities that reduce bacteria pollution can have a significant positive effect. The BIG Project Area had an estimated population of 5,365,724 in 2019. The area is expected to grow by 47% to 7,900,200 by 2050. As the population in the region grows (see Figure Figure 20XX), the collective actions of individuals will have a greater impact.

Residential contributions to bacteria loading in waterways include bacteria discharging from a residential site either during runoff events or directly, and fats, oils, and grease clogging sanitary sewer lines and resulting in overflows. Decorative ponds, OSSFs, and pet waste can contribute bacteria during runoff events or through direct discharge. Fertilizers, grass clippings, runoff from overwatering, and general lawn care practices may enhance the ability of bacteria to grow and regrow in the environment. Pouring fats, oils, and grease down sink drains can clog sanitary sewer lines, potentially leading to SSOs and direct discharges of bacteria to the bayous.

This implementation strategy is aimed at changing public behaviors through education efforts that empower residents to participate in actions that improve water quality. While enforcement, or the threat of enforcement, may be effective against stakeholders regulated by permits, this strategy instead focuses on positive activities that promote public education.

Public education efforts should inform the public about:

- Why waterways are important to the region,
- Why bacteria is an issue, and
- What they can do to reduce bacteria in area waterways.

Many of the activities are easy and inexpensive. Residents can properly dispose of cooking grease, use appropriate lawn care practices, and pick up and properly dispose of pet waste. The simple task of picking up after pets can improve water quality. If individuals can change their behavior, they can help improve water quality.

Figure 20: Map of Projected Changes in Population Density

Implementation Activity 8.1: Expand Homeowner Education Efforts Throughout the BIG Project Area

Action

The BIG recommends supporting existing outreach programs of H-GAC, GBF, Texas AgriLife, JTF, local MS4s, and others. Support includes providing a venue to discuss what is working, promotion of successful programs, and encouraging coordination and dissemination.

Background

As resources become available, communities, cities, counties, and other entities shall provide public education that individual residents can use to reduce bacterial loading to area waterways. Topics that should be addressed in a homeowner education program include pet waste disposal, best management practices for yard care, OSSF tips, and proper disposal of fats, oils, and grease.

This implementation activity will take advantage of existing public education programs and materials. Some communities in the region already have educational programs that address bacterial loading and are willing to share materials, including the cities of Houston and Pasadena and Harris County. The *Clean Water, Clear Choice* program[138]is an example of a multi-jurisdictional effort.

Houston is currently developing a stormwater education program where a state-approved, Houston-specific, stormwater education curriculum is being created. Other regional, local governments may access, use, and promote the curriculum and other educational material at no charge.

The Harris County Regional Watershed Education Program[139] allows MS4-permitted communities to buy into their education program at a current rate of 53 cents per resident. Materials available through this program include brochures, presentations, advertisements, and direct mail pieces.

Another resource for communities developing education programs is the Public Participation and Education Subcommittee[140] of the Galveston Bay Estuary Program. This group provides opportunities for idea sharing, learning about resources, and coordinating education and outreach efforts throughout the region.

[138] (Stormwater Management Joint Task Force n.d.)

[139] (Harris County n.d.)

[140] (Galveston Bay Estuary Program n.d.)

In addition to local programs, resources are available from outside the region. The EPA's Nonpoint Source Outreach Toolbox[141] is an excellent resource that provides public education materials, for radio, television, or print, as well as case studies on a wide range of topics, including OSSFs, pet waste, gardens and lawns, as well as general stormwater and storm drain awareness. Some materials may require small changes for application in local communities, but many will not.

A community may create its own education program and materials if it prefers. Funding may be available for these projects from the Galveston Bay Estuary Program and Texas' Nonpoint Source Grant Program, among other sources.

8.1.1: Continue or begin a homeowner education program based on existing models

For areas currently under an MS4 permit, public education efforts shall continue to place a high priority on bacteria reduction activities. Communities that don't currently engage in homeowner education efforts will be strongly encouraged to implement a program with guidance from existing programs and materials. A consistent message throughout the area covered by this I-Plan is desirable and might be more effective. H-GAC or another appropriate agency shall convene an annual meeting to identify common messages appropriate for the region and specific to bacteria. This forum will also provide an opportunity to identify funding sources and highlight existing programs. When appropriate, this forum will be held in conjunction with a widely-attended, water-quality event. Messages may include bacteria reduction activities (such as a pet waste campaign), activities that promote responsibility and concern for the cleanliness of our waterways (such as water clean-up events like River, Lakes, Bays 'N Bayous Trash Bash[142]), storm drain awareness activities (such as inlet marking), wastewater education (such as reminding residents that sewer lines clogged with grease or other materials will overflow or backup into homes), and activities to reduce illegal dumping (such as the use of strategically placed signage throughout the region). These education efforts should coordinate with education requirements of stormwater management permits.

8.1.2: Conduct pilot studies to evaluate results of education efforts

To measure success of public education efforts, communities shall, as resources are available, conduct studies to determine whether improvements in water quality have resulted from homeowner education efforts. Ambient water quality monitoring regularly conducted throughout the region may not adequately document the effectiveness of a specific education program at reducing bacteria in a water body. Pilot studies, which include water quality monitoring specific to the education efforts in question, should be conducted instead. For example, an appropriate location for a small-scale study could be a neighborhood whose stormwater discharges through a limited number storm sewer outfalls.

[141] (U.S. Environmental Protection Agency n.d.)

[142] (Houston-Galveston Area Council n.d.)

Opportunities for collaboration between communities on studies may exist and should be explored. Studies should include pre-education monitoring, an education effort, and post-education monitoring. Studies may also document load reductions, public awareness of water quality issues, and behavior change as reported by individual residents. H-GAC water quality staff could provide technical assistance in developing a monitoring strategy for individual pilot studies as appropriate. Any pilot studies should be undertaken in the context of Research Priority 10.1.

Metric

Program Outreach and Event Tracking; Review MS4 Activities

Milestones

Annual workshop

Monitoring

Programmatic: Number of Outreach/Individuals contacted via workshops, events, or one-on-one, Implemented reduction efforts.

Environmental: CRP Analysis, Change in AU impairment status.

Implementation Strategy 9.0: Monitoring and I-Plan Revision

In order to assess progress toward reducing bacterial loading, BIG needed to evaluate, on a regular basis, the results of ongoing monitoring. This evaluation is used to determine current and future changes necessary to successfully execute this I-Plan.

The I-Plan addresses a period of 25 years. However, given the many unknowns pertaining to bacteria sources, the cost-effectiveness of management activities, and the availability of resources for implementation, this time frame is provisional. As such, it is important to continually track both actions taken and instream bacteria levels to gauge the rate of progress and adapt the strategy accordingly.

Monitoring and annual evaluations will determine if the I-Plan or any of its parts are complete, must address a longer time frame, or require revision. Every five years, as resources are available and with stakeholder participation, a more in-depth evaluation should be completed.

Assessments of environmental water quality and programmatic implementation data in support of this I-plan by the BIG and its partners, forms the basis for an annual report prepared by H-GAC. Routine ambient water quality monitoring is defined as collecting water quality constituents without regard to any influence of point or non-point source pollution and considered unbiased sampling without regard to season or ambient conditions. Non-ambient water quality data would feature assessment of direct point and/or non-point source pollution and can be biased with regard to season or ambient conditions. Programmatic implementation data refers to the actions and activities carried out by BIG and its partners that directly implement the strategies within this I-Plan.

Conclusions derived from post-implementation water quality monitoring data will be an important indicator of whether implementation activities supplied by BIG and its partners are resulting in the desired reduction of bacteria loading. The contents of the annual report will be reviewed by BIG to determine strategic changes that are necessary to the I-Plan in order to improve progress.

Implementation Activity 9.1: Continue to Utilize Ambient Water Quality Monitoring and Data Analysis

Action

Use the Clean Rivers Program to track the trends in ambient bacterial concentrations. Tracking includes producing Project Area, Segment and AU trend lines. When and where possible use Clean Rivers Program data to evaluate programmatic progress.

Background

The results of monitoring and evaluating ambient water quality can help determine whether waterways are meeting standards for bacteria. The results will also identify trends of improvement and degradation that need to be addressed. This activity includes three elements: continuing the existing ambient water quality monitoring program, encouraging the use of two indicator organisms in sampling, and developing molecular-based methods. Activity 9.1.2 was carried out (XX/XX/XXXX – XX/XX/XXXX) in freshwater assessment units. The results of this side-by-side analysis found XXXXX.

9.1.1: Continue to Utilize Clean Rivers Program

Ambient water quality monitoring within the BIG area is primarily the responsibility of the Clean Rivers Program, administered by H-GAC and the TCEQ in conjunction with local partner agencies. This program is ongoing and does not require additional funding for its current efforts. See **Error! Reference source not found.** for locations of monitoring stations in the BIG project area. More detailed information regarding monitoring data can be found on H-GAC's Water Resources Information Map, or WRIM[143][144].

[143] https://h-gac.maps.arcgis.com/apps/MapSeries/index.html?appid=30b802d67f5d4a2aa7915cc30bca9318, (May 2024)

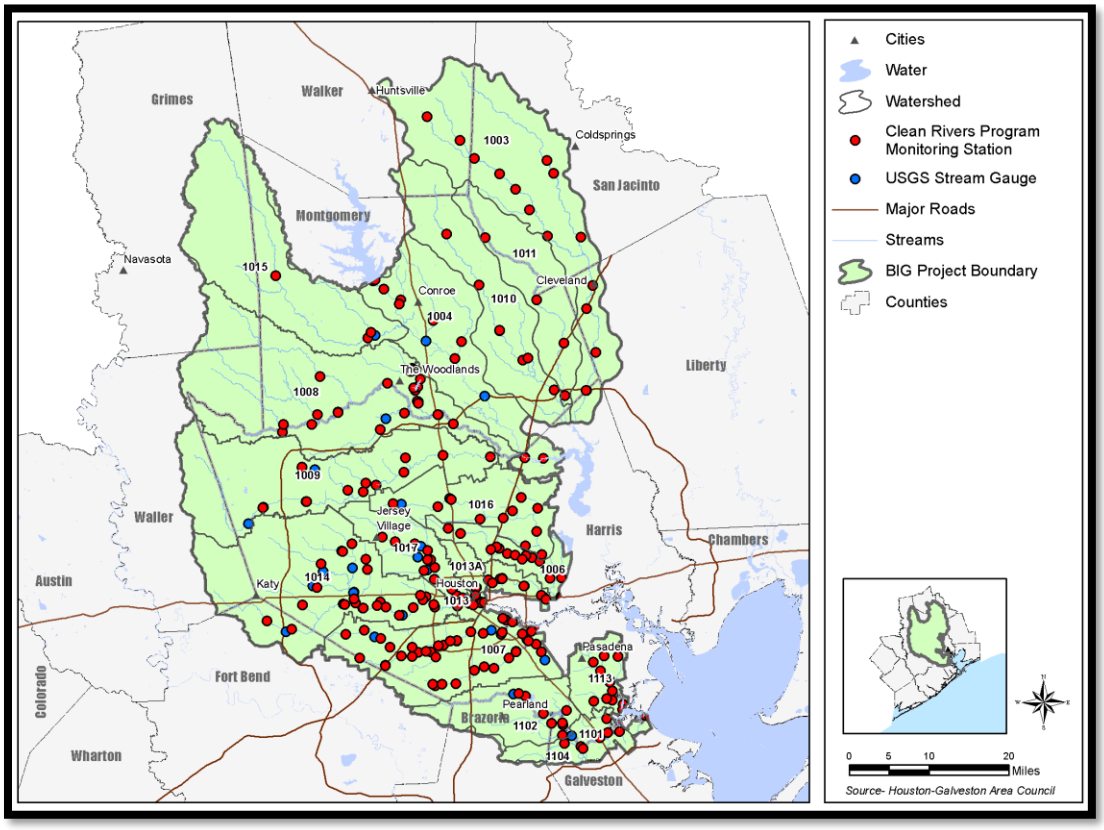

Figure 21: Map of Clean Rivers Program Monitoring Stations

The Clean Rivers Program is comprehensive, collecting samples region-wide, and should remain the primary source of data for ambient water quality.[145] This monitoring network includes over 300 sites and provides long-term data accredited by the TCEQ's National Environmental Laboratory Accreditation Program or NELAP[146] for the evaluation of ambient conditions in the region's waterways. Monitoring sites are strategically chosen to give the greatest degree of coverage while also attempting to isolate individual waterways or their smaller units to allow for the accumulation of data with direct relevance to local conditions. Monitoring is conducted under a regional Quality Assurance Project Plan (QAPP).[147] Any new

[145] Clean Rivers Program | Houston-Galveston Area Council (H-GAC), (May 2024)

[146] Environmental Laboratory (NELAP) Accreditation - Texas Commission on Environmental Quality - www.tceq.texas.gov, (May 2024).

[147] Multi-Basin Quality Assurance Project Plan (QAPP) | Houston-Galveston Area Council (H-GAC), (May 2024).

ambient monitoring by local partners shall be coordinated with the Clean Rivers Program and shall utilize the regional QAPP.

The Basin Summary Report,[148] produced every five years, evaluates at least seven years of data for each assessment unit and identifies statistically significant changes. Along with the general benefit of coordinated regional data, these trend indicators will help guide I-Plan- revisions and serve to verify the impact of implementation activities.

The local Clean Rivers Program steering committee meets regularly to discuss ways to improve the ambient water quality monitoring program. Local efforts are coordinated with those statewide to ensure consistency of data and to identify appropriate program improvements, which has already allowed for changes to facilitate this I-Plan. Specifically, monitoring reports now contain standardized information about any recreation that is observed at the sampling site.

9.1.2: Test for Additional Indicators

The presence of *E. coli* or Enterococcus species in water is a commonly employed indicator of the presence of enteric pathogens. Generally, TCEQ guidance and the location of the water sample determine which of the indicators is used. As resources are available, the abundance of both *E. coli* and Enterococcus species should be evaluated at freshwater sampling locations, to ensure a greater ability to correlate impacts of implementation activities on water quality. Additional parameters such as molecular-based methods should be monitored, as deemed necessary and feasible, to target specific activities or sources for which the general correlation between indicators is not precise enough to show impacts. Additional testing may require a new or amended QAPP and should take into account any existing or ongoing research on correlating current indicator bacteria with pathogens of concern. (See Research Priority 10.3.)

Metric

Data and graphical analysis, including AU level, assessing ambient data for use in decision making and within the Annual Report and/or Regional Implementation Database.

Milestones

Data analysis completed annually

Monitoring

Programmatic: Annual Report and/or Implementation database

Environmental: CRP data collection and analysis results

[148] Basin Highlights/Summary Reports | Houston-Galveston Area Council (H-GAC), (May 2024).

Implementation Activity 9.2: Conduct and Coordinate Non-Ambient Water Quality Monitoring

Action

Routinely implement targeted non-ambient monitoring and monitoring of implementation activities, including best management practices, as funding allows. BIG and its partners track non-ambient monitoring results and document any programmatic and environmental benefits.

Background

While the established ambient monitoring program will form the base of the data, some implementation activities, including monitoring plans for specific implementation activities, may require targeted sampling that may be site or contaminant specific. It should be noted that the non-ambient program should be separate from the existing ambient program, and individual Quality Assurance Project Plans depending on funding sources, may be required. The 2013 I-Plan recommended three activities. These activities are to follow this review. During implementation, it was determined that TCEQ would not approve a region-wide non-ambient monitoring QAPP (9.2.1). This activity was never completed.

Activity 9.2.2 is the creation and maintenance of a regional non-ambient monitoring database. A BMP database[149] was created by the Harris County Flood Control District (HCFCD) to host data collected by the district's staff. The database is modeled after the International Stormwater BMP Database.[150] HCFCD is open to accept BMP data and information from other organizations. To accept these other data as sources , the data must be in a format consistent with the database. HCFCD will work with submitting organizations to ensure the data is appropriately formatted. However, there are some BMP implementation projects that may not conform with these standards. The BIG recommends that H-GAC set up a database to house other non-ambient water quality data.

Activity 9.2.3. focuses on conducting targeted monitoring. H-GAC, Bayou Preservation Association, and their partners, for example, have routinely investigated waterways within the BIG Project Area to identify potential sources of bacteria. These projects highlight opportunities to correct problems while monitoring under an approved Quality Assurance Project Plans. A sample targeted monitoring program is provided through the H-GAC website to serve as a model program for the region's MS4 Phase II communities.[151] H-GAC and others have identified, gathered, and attempted to assess sources on non-ambient water quality data tied to best practice implementation. While sources and the amount of data remains relatively small, there is evidence for

[149] BMPbase-Regional BMP Database

[150] INT'L STORMWATER BMP DBASE (bmpdatabase.org)

[151] Bacteria Implementation Group Reports | Houston-Galveston Area Council (H-GAC), (May 2024)

the use of site-specific best practices for the management and reduction of bacteria. BIG continues to encourage expanded monitoring of best practices to catalogue benefits.

9.2.1: Create and use a regional non-ambient QAPP

BIG worked to establish a regional QAPP for non-ambient monitoring activities. Applicable sections of existing monitoring efforts, such as Harris County Flood Control District's wet weather monitoring for wet bottom detention basins, should be adopted and incorporated into a regional QAPP, as applicable and practicable. BIG was unsuccessful in establishing a regional QAPP.

9.2.2: Create and maintain a regional non-ambient monitoring database

Individual stakeholders are responsible for implementing activities in their jurisdictions. However, to serve the combined purpose and interests of this I-Plan, the monitoring of non-ambient water quality data, as funding allows, will be combined in a regional non-ambient monitoring database. This database could be compatible and coordinated with similar related databases, including the International Stormwater BMP Database and the regional BMP effectiveness database being developed by the Harris County Flood Control District. This database could serve as a clearinghouse for non-ambient or targeted water quality monitoring data from across the region, to ensure availability and coordination of all related efforts. The database will be created in consultation with stakeholders and maintained by H-GAC and will be made available online. The coordinated approach to data acquisition will allow stakeholders, even when working separately, to benefit from their shared experiences. Evaluation of implementation activity effectiveness for one stakeholder can help other stakeholders make more informed decisions concerning the suite of measures they implement to meet the strategies of this I-Plan. Additional data sources that could be incorporated into the database include wet/dry weather monitoring data from MS4 permit holder annual reports, outfall monitoring, and pertinent data (including current and incoming monitoring requirements) from WWTF Discharge Monitoring Reports. This database shall be integrated with the Regional Implementation Activity Database , described in Implementation Activity 9.3. An ad hoc committee will be invited to participate in the creation of the database. This activity is not intended to create an additional reporting or liability burden for stakeholders.

9.2.3: Implement targeted monitoring

Targeted monitoring should be implemented in those places where an entity needs to determine the direct impact of an implementation activity or BMP at a site where ambient monitoring will be unable to indicate changes to water quality as a result of the activity. Targeted monitoring may address sampling needs such as:

- Conditions during or differences in loading during dry and wet weather,
- Changes in instream bacteria levels throughout the day,
- Bacteria levels and loading during high-flow and low-flow regimes, and
- Locations specific to implementation activities, such as stormwater BMPs, or potential bacteria sources, such as the evaluation of bacteria levels in water coming from an outfall pipe.

Targeted monitoring of this type is already underway in the BIG area, such as conducted by MS4 Phase I entities as part of stormwater permit requirements. These efforts should continue as practicable. Additionally, other entities, regardless of MS4 status, should consider or continue targeted monitoring as needed to evaluate implemented measures. The data collections efforts they undertake should be coordinated as either part of a regional QAPP or follow quality assurance data standards and submit to H-GAC for inclusion into the regional monitoring database developed for non-ambient water quality in the region.

Metric

Annually assess Targeted Monitoring Programs, encourage uploading to HCFCD Stormwater Database, Create the H-GAC Targeted Monitoring Database

Milestones

and Type of Targeted Monitoring Programs/year; # of Uploads to databases

Monitoring

Programmatic: Assessment of the Targeted Monitoring Program; Stormwater database update

Environmental: CRP data collection and analysis results; Targeted monitoring data analysis

Implementation Activity 9.3: Create and Maintain a Regional Implementation Activity Database

Action

Continue to maintain and improve the Regional Implementation Activity Database. The database serves to track the actions and activities taken over time to implement the I-Plan. As such the database should track the actions of the BIG and its partners and serve as a reporting tool to MS4s Phase II and other stakeholders.

Background

Implementation tracking provides information that can be used to determine if progress is being made toward meeting the goals of the TMDL. Tracking also allows stakeholders to evaluate actions taken, identify those which may not be working, and make any changes that may be necessary to keep the I-Plan on track. The implementation activity database will contain information on implementation activities conducted by the stakeholders. Each stakeholder will be provided a list of the implementation activities designated under this I-Plan. Each year, the individual stakeholders will provide a report on the activities they implement during the year, and any related information regarding the activities. The BIG, through the H-GAC, will provide a reasonable reminder to each stakeholder prior to the due date, compile the individual reports in the database, and publish a summary as part of an annual I-Plan report. As an incentive to report in a timely

manner and in addition to a list of implementation activities undertaken, the report will identify communities that either did not report or did not undertake implementation activities.

While there will be additional paperwork requested of stakeholders, the intent is not to increase reporting requirements unduly. Thus, copies of or access to existing reports or records can be submitted as part of the annual report to the BIG.

Metric

Updates to the Regional Implementation Activity Database

Milestones

Annual update to the Regional Implementation Activity Database

Monitoring

Programmatic: Updated Regional Implementation Activity Database

Environmental: CRP data collection and analysis results

Implementation Activity 9.4: Assess Monitoring Results and Modify I-Plan

Action

BIG and its partners will assess programmatic and environmental data to annually track progress that includes reducing contact recreation risk as determined through a reduction in bacteria concentration levels all or in parts of the BIG Project Area. Progress will be reported by seeking to identify actions taken and either through direct targeted monitoring or via ambient monitoring any status or trend changes to bacteria loadings. The annual report and the Regional Implementation Activity Database (Implementation Activity 9.3) will be used to communicate results. A periodic progress review by the BIG and its partners will be used to determine if the current I-Plan is working or if changes are warranted.

Background

9.4.1: Assess Data

The information contained in the three databases (ambient, non-ambient, and implementation activity) shall be used to assess progress toward meeting the goals of this I-Plan. Annually, H-GAC shall assess information in the reports to identify whether progress is being made. In particular, H-GAC shall evaluate the following:

1. Does ambient water quality monitoring data indicate that bacteria levels are changing? If so, are the bacteria levels improving or degrading?
2. Do non-ambient water quality monitoring data indicate that implementation activities are reducing bacteria loading?

3. Are implementation activities and controls being undertaken as described in this I-Plan? Which activities have been implemented and which have not?

9.4.2: Communicate results

The information identified through the assessment process will form the basis for an annual report. H-GAC shall compile the annual report and shall present this information to stakeholders through various channels, including e-mail, web publication, presentations, and at an annual meeting.

9.4.3: Continue the BIG

The BIG shall continue to be the decision-making body for this I-Plan, as identified in its ground rules.

9.4.4: Update the I--Plan

The BIG shall review the annual report and, as appropriate, update the I-Plan. As it evaluates the I-Plan, the BIG shall consider reported activities and whether identified milestones are being met, changes in bacteria levels in waterways, changes to surface water quality standards or other regulations, and research. While progress shall be evaluated annually, a more rigorous evaluation should be conducted every five years. At the end of five years, the BIG shall identify costs for the implementation activities.

In its document titled, "Clarification Regarding Phased Total Maximum Daily Loads,"[152] the EPA describes adaptive implementation as "an iterative implementation process that makes progress toward achieving water quality goals while using any new data and information to reduce uncertainly and adjust implementation activities." It is under these auspices that the BIG shall approach updates to the I-Plan. H-GAC shall provide support for these efforts.

9.4.5: Expand the geographic scope of the I-Plan as appropriate

As other watersheds in the vicinity of the BIG project area have TMDLs adopted by the TCEQ, stakeholders from those watersheds may petition the BIG to consider incorporating those watersheds into the I-Plan. These requests shall be considered by BIG as part of its annual review of the I-Plan. Communities and stakeholders within the region are encouraged to participate in I-Plan activities, either informally and voluntarily, or formally upon incorporation by the BIG into the I-Plan. Voluntary action is particularly encouraged in those watersheds with streams that are impaired for bacteria but which do not yet have adopted TMDLs.

Metric

Reportable Actions; Annual Report; Review I-Plan for Updates

[152] Clarification Regarding "Phased" Total Maximum Daily Loads (U.S. Environmental Protection Agency)

Milestones

of actions reported and assess/year; Annual Report

Monitoring

Programmatic: # of actions reported; Annual Report printed

Environmental: CRP data collection and analysis results

Implementation Strategy 10.0: Research

Bacterial contamination of waterways is a concern for the BIG project area, as reflected in the TMDL studies that this I-Plan addresses. The studies provide a general overview of the extent and character of the presence of bacteria, but they are not sufficient to determine the most cost-effective courses of action to achieve contact recreation standards. A dynamic process is required where affected entities continually expand their knowledge of bacteria sources and effects and where various management approaches are tested and refined. This section identifies potential research topics that will be critical to this undertaking.

Recognizing that many of these topics would be area-specific, the BIG was asked to prioritize those which would have the greatest impact on management actions across the area. Three topics emerged. These topics are pertinent to the entire BIG area, are intended to be implemented as resources are available, and may be superseded as necessary for research needs that are specific to individual stakeholders. Research would be conducted using appropriate methodology and quality assurance that have been developed in consultation with the TCEQ and the EPA. In the following text, although the research priorities are presented in a numerical order, this is not a rank order.

The I-Plan's stakeholders identified three priority research topics which address the following:

- Effectiveness of stormwater activities
- Bacteria persistence and regrowth
- Appropriate indicators

Additional topics were identified and, although important, were not identified as top priorities. Many of these topics are related to the three research priorities. As funding is available, these additional research topics should be considered.

A variety of funding sources should be pursued, with a variety of partners. It is unlikely that any one local entity will find it appropriate to conduct this research. Given the large-scale character of the undertakings, entities should look to coordinate efforts with the various academic institutions of the greater Houston area, federal and state agencies like the EPA, Center for Disease Control and Prevention, and Department of State Health Services, water and environmental research groups like Water Environment Research Foundation and Water Environment Association of Texas, and similar potential partners. A shared project, the result of an inter-local agreement or similar instrument, may allow local entities to feasibly investigate these issues. However, the more practical avenue is likely to be the BIG group as a whole advocating for a national or state-level entity to address research priorities.

Research Priority 10.1: Evaluate the Effectiveness of Stormwater Implementation Activities

Action

As funding is available, the BIG and its partners will evaluate the effectiveness of stormwater implementation activities. The BIG will encourage its members, consultants, and the larger region's stakeholders to consider investment in the evaluation of best practices implemented. Actions taken should also be aligned with the Monitoring Activity 9.2 to encourage the collection on non-ambient monitoring and securing the data within stormwater databases for long term storage and future use.

Background

Additional monitoring of current and future stormwater projects in the planning area will help provide an area-specific set of data on the relative effectiveness of different management practices. This effort would draw from current and proposed activities undertaken by Phase I MS4 permitted entities. The effectiveness studies would include both structural measures and behavioral measures. Structural measures might be based on both traditional drainage engineering, such as specifications for stormwater outfalls, and sustainable infrastructure design methodologies, such as Green Infrastructure and Low Impact Development. Behavioral measures, such as public outreach, public reporting of illicit discharges, and efforts aimed at changing behaviors. The data collected and the results from the comparative evaluations should be made available to all stakeholders through the monitoring databases described in Implementation Strategy 9.0.

Metric

Completed Effectiveness Studies

Milestones

Effectiveness Studies – minimum of 1 every five years

Monitoring

Programmatic: # of Studies Implemented;

Environmental: CRP data collection and analysis results

Research Priority 10.2: Further Evaluate Bacteria Persistence and Regrowth

Action

The BIG considers this activity complete. Research published during implementation of the 2013 I-Plan suggests that indicator bacteria persist in the environment[153] potentially influencing the ambient monitoring concentration results. The BIG is interested in furthering research studying factors influencing contact recreation human health risks and identifying new cost-effective bacterial source identification methods, i.e., microbial DNA techniques, that can be applied more broadly (see 10.3). No specific metrics, milestones, or monitoring components are recommended for this activity.

Background

To better understand the extent of human contributions to bacterial loading in waterways, the underlying base layer of background or endemic bacteria should be studied in greater detail. Previous studies of water bodies in the region, including evaluations of Buffalo and White Oak bayous in Harris County,[154] indicated that naturally occurring bacteria are prevalent and persistent in our slow-moving waterways. While these naturally occurring bacteria are certainly supplemented with bacteria from human activities and other sources, the relationship and relative percentages of each should be studied in greater detail. Additionally, the character and cycle of bacteria in the waterway pertaining to regrowth potential requires further evaluation. More realistic and comprehensive simulations are required to more fully grasp the nature of bacterial behavior in the waterways. Implementing agencies that choose to conduct these studies for specific projects will make their data available for the rest of the stakeholders through the monitoring databases (or through H-GAC as a facilitator). The results could be used to provide more precise predictions of bacterial loading by following the impact of loading over time within the waterway.

Research Priority 10.3: Determine Appropriate Indicators

Action

The EPA and other organizations are reviewing alternative indicators. The BIG recommends further review as the current indicators present some concerns for accurately reflecting human health risk exposure during contact recreation. Research in the areas of rapid enumeration, use of viral indicators, and microbial source

[153] Brinkmeyeret. Al. 2015. Distribution and persistence of Escherichia coli and Enterococci in stream bed and bank sediments from two urban streams in Houston, TX. First published in Science of the Total Environment 502: 650-658). Available at Distribution and persistence of *Escherichia coli* and Enterococci in stream bed and bank sediments from two urban streams in Houston, TX - [PDF Document] (documents.page).

[154] (Brinkmeyer, Amon and Schwarz 2008), (Petersen et al. 2006), and (NSF International Engineering & Research Services 2007)

track[155] since 2013 could offer alternatives to the current indicators. The BIG will coordinate workshops that address this topic to elevate discussion and encourage further research.

Background

An indicator species is an organism whose presence is highly correlated to the presence of another organism (or group of organisms). *E. coli* or Enterococcus are used as indicator bacteria based on their pervasiveness and correlation between their presence and the presence of a wide range of potential microbial pathogens. However, that general correlation may not be precise enough to justify their exclusive use in monitoring for this I-Plan. While these indicators are generally accepted nationwide, they may not reflect the unique balance of microbial pathogens and water quality characteristics of the region's semi-tropical urban bayous and local water bodies. The initial nation-wide Recreational Water Quality Criteria, established in 1986, were based on studies done in New York and Oklahoma. These were subsequently replaced in 2012 and further revised in 2017 and 2023.[156] The potential need for alternate, supplemental, or multiple indicators should be determined to refine the I-Plan's monitoring approach and further assist stakeholders in identifying sources.

Updated indicators recommended by the EPA[157]should be incorporated into future revisions of this I-Plan. Additional consideration of the best indicator(s) for the area could help supplement their findings by providing a more specific understanding of local correlations between indicators and pathogens. Stakeholders are encouraged to participate in EPA's discussion of indicators and to encourage the EPA to consider environments similar to those in the Houston region.

Metric

Topic related workshop; review of indicator research

Milestones

Workshop – minimum of 2 every five years

Monitoring

Programmatic: # workshops held;

Environmental: CRP data collection and analysis results

[155] Research to Support and Implement Recreational Water Quality Criteria (RWQC) | US EPA, (May 2024)

[156] (U.S. Environmental Protection Agency 2023) Report on the 2nd Five-Year Review of EPA's Recreational Water Quality Criteria (June 2024)

[157] Research to Support and Implement Recreational Water Quality Criteria (RWQC) | US EPA, (May 2024)

Research Priority 10.4: Additional Research Topics

Action

The BIG will maintain a prioritized list of applied research topics. The BIG will collaborate with and encourage academia and its partners to pursue funding.

Background

A variety of additional research topics were identified by stakeholders during the development of the 2013 I-Plan. The following list gives a brief description of broad groups of research topics and some possible research questions that were developed. Research addressing these topics should be conducted as resources are available.

- *WWTFs:* Studies should examine the correlation between bacteria levels in effluent and in-stream bacteria levels. Have in-stream bacteria levels changed as a result of the TCEQ's new rules that limit bacteria levels in effluent? Research may also be conducted to identify how other constituents in wastewater effluent may influence in-stream bacteria levels. How are in-stream bacteria levels influenced by sludge discharges, nutrients, and stormwater discharges from WWTFs?
- *Health risks:* The studies should include cumulative review of epidemiological studies, collection of new epidemiological data, and/or microbial risk assessment efforts aimed at determining human health risks from recreational activities in, on, or near bayous in the BIG region. What is the relationship between the levels of pathogens and indicators in different watersheds?
- *Recreational use:* Generally, eight or more illnesses above the background level are considered problematic. Does the rate of illness from contact recreation in impaired waterways in the project area exceed this threshold? What is the level of recreation on the waterways?
- *Land use:* Research could analyze the correlations between land use, turbidity, and in-stream bacteria levels. Some land use types may lead to increased turbidity and may be associated with increased bacteria levels. Consideration should be given to evaluating the per-capita contribution of bacteria in relative compact mixed-use developments versus lower density developments. Historical land use prior to development may also influence in-stream bacteria levels. Is there a correlation between impervious surfaces and in-stream bacteria levels?
- *Modeling:* The document, "Bacteria Total Maximum Daily Load Task Force Final Report,"[158] contains summary information about the selection and application of various water quality models for use in Texas. However, many questions were raised by the authors regarding how well the models work, how they can be improved to be more accurate, and how well they function as predictive models. Research could be done to provide answers to the questions raised in the report. Subsequent

[158] (Jones, et al. 2007)

revisions to the nation-wide Recreational Water Quality Criteria (Research Priority 10.3) and results regarding the effectiveness of Texas TMDL projects on water quality reported in the 2022 study by Schramm et al. should be taken into consideration.[159] One particular input for which further information could be done is to improve the flow data available for classified stream sections.

- *Unimpaired waterways:* A minority of sampled waterways in the project area are *not* considered impaired for bacteria. Why do these assessment units have relatively low bacteria levels? How could this information be applied to lower bacteria levels in impaired waterways?
- *Nutrients and other constituents:* Waterways in the project area contain constituents such as nutrients, fine particles, sediment, soil, and other solid materials. Studies and research should examine how such constituents influence instream bacteria levels.

Metric

Topic related workshop; review of research; maintained prioritized list

Milestones

Workshop – minimum of 2 every five years; Annual research priority list

Monitoring

Programmatic: # of workshops held;

Environmental: CRP data collection and analysis results

[159] (Schramm et al. 2022)

Implementation Strategy 11.0: Geographic Priority Framework

Action

The BIG will annually produce a project area list of AUs prioritized based on fecal bacteria concentration ranked from highest to lowest. Future implementation of each strategy listed within the I-Plan Update will consider this list and associated geographic priorities, including: likelihood of demonstrating success (e.g. fecal bacteria reduction),recreation use level, size of the watershed, number of identified sources, social demographics, funding, land cover or land use, local stakeholder support or resources, accessibility, and other important factors.

Background

In order to achieve state standards for contact recreation in the BIG region's waterways, all stakeholders would need to be responsible for some aspects of implementation. Some Implementation Activities, such as those described in Implementation Activity 1.1, were to be implemented throughout the BIG Project Area. Others, such as Implementation Activity 3.1, were to be implemented in targeted areas. It is this second group of implementation activities, those that are geographically targeted, that needed a framework for prioritization. The framework described here provided guidance to communities in setting local implementation priorities.

Implementation Activity 11.1: Considered recommended criteria when selecting geographic locations for projects

As a community prioritized actions within its watersheds it was to consider five main categories of concern: bacteria level, accessibility, use level, implementation opportunities, and future land use changes. Table 8 listed criteria included in these categories. Communities weret to gather input from residents when setting priorities. This was to be accomplished through public meetings or surveys. However, an ordered approach was considered as well, such as targeting specific watersheds or suspected sources.

Table 8: Criteria to be considered when selecting geographic priorities

Category	Criteria to Consider
Bacteria Level	• Is the 7-year bacteria geometric mean for the waterway above the water quality criteria for bacteria? If yes, what is the magnitude of the exceedance? • Based on land use surrounding the waterway, is the source of bacteria more likely human or animal? • Is the flow in the waterway primarily effluent from wastewater treatment facilities? • How many impaired stream segments could be affected by the transport of bacteria downstream from the waterway?
Accessibility	• Is there a large population within 0.25 miles of the waterway? [Note: The meaning of the phrase "large population" can differ from community to community.] • Are there public access points (ramps, bridges, trails, developed parks) to the waterway?
Use Level	• Is contact recreation occurring in the waterway? • If the waterway is not currently used for recreation, would the waterway be used for recreation if the bacteria level were low? • Is the waterway part of a drinking water supply? • Are there signs that the waterway is being used for recreation (rope swings, fishing debris, beer cans, or graffiti)? • Is there an existing group that promotes protection and improvement of the waterway as a community asset? • Are the characteristics of the waterway such that individuals could use it for recreation (appropriate flow, depth, natural or man- made banks)?

Category	Criteria to Consider
Implementation Opportunities	• Are there existing groups to partner with for implementation? • Is there political will to lower a particular waterway's bacteria level? • What funds are available? • Can funding be leveraged with funding from upstream or downstream jurisdictions to expand spatial extent of an IA? • What are initial construction or installation costs? • What are estimated long-term maintenance costs? • Is there a waterway that could easily meet the standard? • Can a specific source of bacteria be singled out to better target IAs? • How much land is available to develop stormwater treatment facilities?
Future Land Use Changes	• What development is expected in the watershed? • Is the waterway threatened, but not yet listed as impaired? [Note: H-GAC Clean Rivers Program staff periodically analyzes water quality data to determine trends and can provide this information to interested communities. Additionally, raw data is available for download from the H-GAC website.]

Metric

Geometric mean list from highest to lowest

Milestones

Annual list; Annual report review of geographic targeted projects

Monitoring

Programmatic: Annual list;

Environmental: CRP data collection and analysis results