**TEXAS COMMISSION ON ENVIRONMENTAL QUALITY**

# AGENDA ITEM REQUEST

**Consideration of an Implementation Plan**
**For Public Comment**

**AGENDA REQUESTED:** August 21, 2013

**DATE OF REQUEST:** August 2, 2013

**NAME & NUMBER OF PERSON TO CONTACT REGARDING CHANGES TO THIS REQUEST, IF NEEDED:** Charlotte Horn, 239-0779

**CAPTION: Docket No. 2013-0853-TML**. Consideration for approval to publish and solicit public comment on a draft *Implementation Plan for Eight Total Maximum Daily Loads for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries.* (Ron Stein, Robert Brush) Project No. 2013-026-TML-NR

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# Texas Commission on Environmental Quality

INTEROFFICE MEMORANDUM

**To:** Commissioners **Date:** August 2, 2013

**Thru:** Bridget C. Bohac, Chief Clerk

Zak Covar, Executive Director

**From:** L'Oreal W. Stepney, P.E., Deputy Director
Office of Water

**Subject:** Docket No. 2013-0853-TML; Project No. 2013-026-TML-NR
Proposal of *Implementation Plan for Eight Total Maximum Daily Loads for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries* for Public Comment

**Background and Current Practice:** The document *Eight Total Maximum Daily Loads for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries* was adopted by the Texas Commission on Environmental Quality (TCEQ) on February 8, 2012, and approved by the United States Environmental Protection Agency (EPA) on June 6, 2012. The second part of the Total Maximum Daily Load (TMDL) process is approval of an Implementation Plan (I-Plan) which describes the strategy and activities the TCEQ and watershed partners will carry out to improve water quality in the affected watershed. The proposed *Implementation Plan for Eight Total maximum Daily Loads in Dickinson Bayou and Three Tidal Tributaries* was developed for this purpose and will proceed through the review process. The Water Quality Planning Division requests approval from the commission to propose the I-Plan for a formal public review and comment period. After the public comment period, staff will make appropriate changes to the draft I-Plan and respond to public comments. Following the public comment period, the TMDL Program will request that the commission consider approval of the final I-Plan. The I-Plan, combined with the TMDL, provides local, regional, and state organizations with a comprehensive strategy for restoring and maintaining water quality in an impaired watershed.

**Scope:** Consideration for approval to publish and solicit public comment on an I-Plan for eight TMDLs corresponding to eight assessment units (AUs) in five segments for indicator bacteria in the Dickinson Bayou watershed (Dickinson Bayou Tidal - 1103, Bensons Bayou - 1103A, Bordens Gully - 1103B, Geisler Bayou - 1103C, and Dickinson Bayou Above Tidal - 1104), in Galveston County.

**Effect on the:**

A) Regulated community: wastewater treatment facilities (WWTFs) in the watershed will receive effluent limits and will monitor for bacteria on a regular basis. Effluent limits would be set at 50% of the in-stream geometric mean water quality criterion, resulting in 63 most probable number (MPN)/100 milliliter (mL) as the *Escherichia coli* (*E. coli)* concentration limit for WWTFs discharging to freshwater tributaries and segment 1104 and 17 MPN/100 milliliter (mL) as the *Enterococcus* concentration limit for WWTFs discharging to tidal tributaries and segment 1103.
B) Public: The public are active participants in the stakeholder process.

C) Agency programs: TCEQ TMDL Program will continue to work with both TCEQ permitting staff and stakeholders to review the progress towards implementing activities in the I-Plan.

The ultimate goal of this I-Plan is the reduction of bacteria concentrations in Segments 1103, 1103A, 1103B, 1103C, and 1104 of the Dickinson Bayou watershed to levels established in the TMDL. This I-Plan includes seven management measures and four control actions that will be used to reduce the level of bacteria in the Dickinson Bayou watershed. The TMDL identifies potential regulated and unregulated sources of bacteria.

**Stakeholder Involvement:** Texas A&M AgriLife Extension Service's Coastal Watershed Program is providing coordination for public participation in this project. Several public meetings focusing primarily on the TMDL were conducted between April 2008 and August 2011. These meetings introduced the TMDL process, identified the impaired segments and the reason for the impairment, reviewed historical data, and described potential sources of bacteria within the watershed. In addition, the meetings gave TCEQ the opportunity to solicit input from all interested parties within the study area. Numerous meetings since February 2011 have been held during the development of the I-Plan.

On February 2011, stakeholders in the Dickinson Bayou watershed began working to develop an I-Plan to address indicator bacteria sources. The stakeholders organized a partnership and coordination committee to direct the development of the I-Plan. The coordination committee membership represents many interests, including city and county government, private landowners, agriculture, WWTFs, and local businesses. The coordination committee members formed four work groups that began to write the I-Plan:

- On-site sewage facilities (OSSFs);
- Animal sources;
- Stormwater; and
- WWTFs.

The members of the four work groups developed sections of the I-Plan, which were then compiled into a single document by Texas A&M AgriLife Extension Service. The I-Plan has seven stakeholder-developed management measures and four control actions that will be used to reduce bacteria contributions. The management measures and control actions identified in the I-Plan are:

**Management Measures (voluntary activities)**

1. Improve management of OSSFs
2. Improve WWTFs

3. Promote increased participation in existing conservation and cost share programs
4. Restore and repair riparian zones
5. Preserve and restore natural wetlands
6. Construct treatment wetlands
7. Provide demonstrations and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting

**Control Actions (regulatory activities)**

1. Implement stricter bacteria limits and stricter enforcement measures for WWTF effluents
2. Increase compliance and enforcement by the TCEQ
3. Revise penalties and violations for sanitary sewer systems (SSSs) and WWTFs
4. Improve reporting requirements for sanitary sewer overflows (SSOs)

Information on past and future meetings for the Dickinson Bayou Bacteria TMDL I-Plan is posted on the TCEQ Web site at *www.tceq.texas.gov/waterquality/tmdl/80-dickinsonbayoubacteria.html*. Project information can also be found AgriLife's Coastal Watershed Program Web site at *dickinsonbayou.org*.

**Potential controversial concerns and legislative interest:** We can identify no controversial concerns or legislative interest at this time.

**Key dates in the TMDL I-Plan schedule:** The I-Plan identifies responsible parties, technical and financial needs, monitoring and outreach efforts, and a schedule of activities for each of the management measures and control actions. It describes the process that the TCEQ and stakeholders will use to assess progress and adjust the plan periodically. The TCEQ will participate in annual stakeholder meetings, for a maximum time of five years, so that the group can evaluate progress of the I-Plan. The TCEQ and stakeholders will track the progress of the I-Plan using both programmatic and water quality indicators. The TCEQ will report results and evaluations from implementation tracking to stakeholders as needed.

**Key Points in the TMDL Proposal Schedule:**
Anticipated proposal date: August 21, 2013
Anticipated *Texas Register* publication date: September 6, 2013
Public meeting date: (TBA)
Public comment period: September 6, 2013 - October 7, 2013

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Docket No. 2013-0843-TML

Attachments

cc: Chief Clerk, 7 copies

For Public Comment, September 2013

# Implementation Plan for Eight Total Maximum Daily Loads for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries

## Segments 1103, 1103A, 1103B, 1103C, 1104

Assessment Units: 1103_02, 1103_03, 1103_04, 1103A_01, 1103B_01, 1103C_01, 1104_01, and 1104_02

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Distributed by the
Total Maximum Daily Load Team
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TMDLs and Implementation Plans are also available on our website:
<www.tceq.texas.gov/waterquality/tmdl/>

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

This Implementation Plan is based in large part on the work products submitted by five stakeholder groups organized by Texas A&M AgriLife Extension Service. The following reports were also used to guide the development of the Plan:

- "Eight TMDLs for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries"
- "Implementation Plan for Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region" prepared by the Houston-Galveston Area Council
- "Implementation Plan for One Total Maximum Daily Load for Bacteria in Gilleland Creek" prepared by the Lower Colorado River Authority
- "Bastrop Bayou Watershed Protection Plan" prepared by the Houston- Galveston Area Council

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 239-4488, or 1-800-RELAY-TX (TDD), or by writing P.O. Box 13087, Austin, TX 78711-3087.

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# List of Acronyms and Abbreviations

| | |
|---|---|
| AU | assessment unit |
| ATU | Aerobic Treatment Units |
| BMP | best management practices |
| cfu | colony-forming units |
| CIG | Conservation Innovation Grants |
| CMOM | Capacity, management, operation, and maintenance for sanitary sewer systems |
| CMP | Texas Coastal Management Program |
| CSP | Conservation Security Program |
| CTBS | Center for Texas Beaches and Shores |
| CWA | Clean Water Act |
| DBWP | Dickinson Bayou Watershed Partnership |
| *E. coli* | Escherichia coli |
| EPA | U.S. Environmental Protection Agency |
| EQIP | Environmental Quality Incentives Program |
| ft | feet |
| FRPP | Farm and Ranch Lands Protection Program |
| GBF | Galveston Bay Foundation |
| FROG | fats, roots, oils, and grease |
| GCHD | Galveston County Health District |
| GCWCID | Galveston County Water Control and Improvement District |
| GIS | geographic information system |
| GLO | General Land Office |
| GRP | Grassland Reserve Program |
| H-GAC | Houston-Galveston Area Council |
| HOA | home owners association |
| I-Plan | implementation plan |
| KDB | Keep Dickinson Beautiful |
| LA | load allocation |
| LDC | load duration curve |
| LID | Low Impact Development |
| MM | Management Measure |
| mL | milliliter |
| MGD | million gallons per day |
| MOS | margin of safety |
| MPN | most probable number |
| MS4 | municipal separate storm sewer system |
| NPS | nonpoint source |
| MUD | municipal utility district |
| NRCS | Natural Resources Conservation Service |
| OSSF | on-site sewage facility |
| QAPP | Quality Assurance Project Plan |
| SEP | Supplemental Environmental Project |
| SEPP | Supplemental Environmental Project Program |
| SSO | sanitary sewers overflow |

| | |
|---|---|
| SSOI | Sanitary Sewer Overflow Initiative |
| SSS | sanitary sewer systems |
| SWCD | Soil and Water Conservation District |
| SWMP | stormwater management plan |
| SWQM | surface water quality monitoring |
| SWQS | Surface Water Quality Standard |
| TAC | Texas Administrative Code |
| TAHC | Texas Animal Health Commission |
| TAMUG | Texas A&M University at Galveston |
| TCWP | Texas Coastal Watershed Program |
| TDA | Texas Department of Agriculture |
| TCEQ | Texas Commission on Environmental Quality |
| TMDL | total maximum daily load |
| TPDES | Texas Pollutant Discharge Elimination System |
| TPWD | Texas Parks and Wildlife Department |
| TREC | Texas Real Estate Commission |
| TSG | Texas Sea Grant |
| TSSWCB | Texas State Soil and Water Conservation Board |
| TWDB | Texas Water Development Board |
| TWDMA | Texas Wildlife Damage Management Association |
| UA | Census-designated urbanized area |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USFWS | United States Fish and Wildlife Service |
| WCID | Water Control and Improvement District |
| WEAT | Water Environment Association of Texas |
| WHIP | Wildlife Habitat Incentives Program |
| WLA | waste load allocation |
| WPP | watershed protection plan |
| WQMP | Water Quality Management Plan |
| WRP | Wetlands Reserve Program |
| WWTF | wastewater treatment facility |

# Implementation Plan for Eight TMDLs for Bacteria in Dickinson Bayou and Three Tidal Tributaries

## Executive Summary

On February 8th, 2012, the Texas Commission on Environmental Quality (TCEQ) adopted *Eight Total Maximum Daily Loads for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries* (Segments 1103, 1103A, 1103B, 1103C, 1104). The U.S. Environmental Protection Agency (EPA) approved the total maximum daily loads (TMDLs) on June 6th, 2012. This Implementation Plan (I-Plan) describes the strategy and activities watershed stakeholders and the TCEQ will carry out to improve water quality in Dickinson Bayou and three of its tidal tributaries.

This I-Plan is based on the TMDL report and its subsequent revisions, which are documented in updates to the state's Water Quality Management Plan (WQMP). The TMDL identified potential regulated and unregulated sources of indicator bacteria. Regulated dischargers in the Dickinson Bayou watershed include domestic wastewater treatment facilities, sanitary sewer overflows, industrial facilities, a municipal solid waste facility, and regulated stormwater dischargers. Potential unregulated bacteria sources identified in the TMDL include livestock, wildlife, exotic animals, domestic pets, and malfunctioning on-site sewage facilities.

This implementation plan, or I-Plan:

- describes the steps watershed stakeholders and the TCEQ will take to achieve the pollutant reductions necessary to restore and protect water quality,
- identifies the means by which these activities will be implemented,
- outlines the schedule for implementation of these activities, and
- describes how stakeholders and the TCEQ will track implementation of these activities and monitor improvements in water quality.

The ultimate goal of this I-Plan is the reduction of bacteria concentrations in each of the assessment units of Dickinson Bayou Tidal (Segment 1103), Bensons Bayou (1103A), Bordens Gully (1103B), and Geisler Bayou (1103C) and Dickinson Bayou Above Tidal (Segment 1104) to levels that meet the criteria defined in the state water quality standards to support contact recreation.

In concert with the TCEQ, the stakeholders of the Dickinson Bayou watershed developed seven management measures and four control actions that will be used to reduce bacteria contributions.

## Management Measures (Voluntary Activities)

1) Improve management of on-site sewage facilities (OSSFs).
2) Improve wastewater treatment facilities (WWTFs).
3) Promote increased participation in existing conservation and cost-share programs.
4) Restore and repair riparian zones.
5) Preserve and restore natural wetlands.
6) Construct treatment wetlands.
7) Provide demonstrations and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting.

## Control Action (Regulatory Activities)

1) Implement stricter bacteria limits and stricter enforcement measures for WWTF effluents.
2) Increase compliance and enforcement by the TCEQ.
3) Revise penalties and violations for sanitary sewer system (SSSs) and WWTFs.
4) Improve reporting requirements for sanitary sewer overflows (SSOs).

This I-Plan identifies responsible parties, technical and financial needs, monitoring and outreach efforts, and a schedule of activities for each management measure and control action. It describes the process that the TCEQ and stakeholders will use to assess progress and adjust the plan periodically.

The TCEQ will track the progress of this I-Plan in restoring the affected use. Water quality data will be collected for five years to identify trends and compliance with the water quality standards. If standards are not attained by the end of the monitoring period, the TCEQ and watershed stakeholders should reevaluate the TMDL and the I-Plan and take appropriate action. The TCEQ will report the results of implementation tracking and evaluation on its web site, at regional forums and to stakeholders as needed.

# Introduction

To keep Texas' commitment to restore and maintain water quality in impaired rivers, lakes, and bays, the TCEQ works with stakeholders to develop an I-Plan for each adopted TMDL. A 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

- sets limits on categories of sources that will result in achieving standards.

This I-Plan is designed to guide activities that will achieve the water quality goals for Dickinson Bayou as defined in the adopted TMDL. This I-Plan is a flexible tool that governmental and nongovernmental organizations involved in implementation use to guide their activities to reduce bacteria loads. The participating partners may accomplish the activities described in this I-Plan through rule, order, guidance, or other appropriate formal or informal action.

In all its projects, the TCEQ seeks to gather opinions and information from people who represent local government, permitted facilities, agriculture, business, environmental interests, and community and private interests in the watershed. This project was coordinated through the Galveston Bay Estuary Program, Texas A&M AgriLife Extension Service, and the Dickinson Bayou Watershed Partnership.

The Dickinson Bayou Watershed Partnership (DBWP) is a group of interested citizens, private organizations, local businesses and federal, state, and local governments (hereafter referred to as watershed stakeholders) who work together to protect the health of Dickinson Bayou and its watershed. The watershed stakeholders advised the TCEQ on the development of the TMDLs and continues to advise the TCEQ during development of the I-Plan.

This I-Plan contains the following components:

1) a description of control actions and management measures[1] that will be implemented to achieve the water quality target.
2) a schedule for implementing activities (Appendix A).
3) the legal authority under which the participating agencies may require implementation of the control actions.
4) a follow-up tracking and monitoring plan to determine the effectiveness of the control actions and management measures undertaken.
5) identification of measurable outcomes and other considerations the TCEQ and stakeholders will use to determine whether the I-Plan has been properly executed, water quality standards are being achieved, or the plan needs to be modified.
6) identification of the communication strategies the TCEQ will use to disseminate information to stakeholders.
7) a review strategy that stakeholders will use to periodically review and revise the plan to ensure there is continued progress in improving water quality.

[1] Control actions refer to regulated sources reduction strategies, generally Texas Pollutant Discharge Elimination System (TPDES) permits. Management measures refer to strategies for reducing unregulated pollutants, generally through voluntary best management practices (BMPs).

This I-Plan also includes brief descriptions of the causes and sources of the bacterial impairment, management measures, estimated potential load reductions, technical and financial assistance needed, educational components for each measure, schedule of implementation, measurable milestones, indicators to measure progress, monitoring components, and responsible organizations as outlined in the *Nonpoint Source Program Grants Guidelines for States and Territories* (EPA 2004). Consequently, projects developed to implement unregulated (nonpoint) source elements of this plan that meet the grant program conditions may be eligible for funding under the Clean Water Act (CWA) Section 319(h) grant program.

The TCEQ has primary responsibility for restoring water quality standards in all impaired water bodies in Texas. The TSSWCB has primary responsibility for managing programs and practices for the prevention and abatement of nonpoint sources of water pollution originating from agricultural and silvicultural (forestry) activities in Texas.

# Summary of TMDLs

This section summarizes sections of the Indicator Bacteria TMDL report for Dickinson Bayou and three tidal tributaries. Additional background information including the problem definition, endpoint identification, source analysis, linkages between sources and receiving waters, and pollutant load allocations can be found in the TMDL report (TCEQ 2012).

## Watershed Overview

Dickinson Bayou is a 23 mile long coastal stream located in Texas' San Jacinto-Brazos Coastal Basin south of Houston. The bayou originates south of the city of Alvin in Brazoria County and flows east through the city of Dickinson before joining Dickinson Bay, a sub-bay of the Galveston Bay system. The TCEQ has classified two segments of Dickinson Bayou based on their designated uses—the tidal portion, Segment 1103, and the portion above tidal influence, Segment 1104. Upstream of the tidal influence, Dickinson Bayou is a small coastal prairie stream. The tidal segment ranges from a relatively narrow, forested stream in the upper reaches to a very wide and relatively deep tidal stream at and downstream from the city of Dickinson.

The tidal portion of Dickinson Bayou is used by local residents for recreational boating, fishing, water skiing, canoeing, and other activities. The lower tidal portions support some commercial shrimp boat and barge traffic. Rice fields in the upper watershed receive irrigation water from beyond the watershed via canals. The irrigation water returns to Dickinson Bayou in the form of irrigation return flows. Although historically substantial in terms of flow contributions, rice farming has diminished significantly in the upper Dickinson watershed since the mid-1970s.

The Dickinson Bayou watershed encompasses 106 square miles of the Texas Gulf Coast in Galveston and Brazoria counties. It includes portions of the cities of Alvin, Dickinson, Manvel, Friendswood, Texas City, and Santa Fe (Figure 1). The climate of the Dickinson Bayou watershed is humid subtropical, with typical average temperatures ranging from 52.9°F in January to 83.3°F in August (NCDC, 2002). Typical annual rainfall totals range from 37.5 to 77.1 inches, with an average rainfall total of 48 inches. Precipitation patterns in Dickinson Bayou are typical of East Texas coastal watersheds, with rainfall more frequent in the spring and summer and less in the fall and winter seasons. Between 2002 and 2008, the amount of developed land more than doubled in the watershed due to increased urbanization and increases in population within the watershed. As of 2008, almost 40 percent of the watershed was developed (Figure 2). As of 2012, the total population of the watershed was approximately 75,000. Land use in the Dickinson Bayou watershed includes agricultural lands, natural areas, and commercial and residential development (Figure 2).

Like most of coastal Texas, the Dickinson Bayou watershed is prone to the effects of hurricanes, which occasionally make landfall in and around Galveston Bay. In addition to the physical devastation caused by high winds and heavy rainfall, hurricanes can have lasting effects on water quality, as environmental infrastructure can be damaged and sanitation services disrupted for long periods after these severe weather events occur.

## Watershed Characteristics

The Dickinson Bayou watershed is relatively flat with elevations ranging from zero to 17.5 feet (ft). The westernmost portions of the watershed are generally higher and the land continues to slope downward as one travels east toward Galveston Bay. Much of the tidal section of the watershed is below 10 feet in elevation. The soils throughout the watershed are moderately to very poorly drained loams, clays and clayey loams.

This I-Plan is designed for the entire Dickinson Bayou watershed, including all the assessment units (AUs) identified in Figure 1 and described below.

AU 1103_02 is the portion of Dickinson Bayou Tidal located between Gum Bayou and Bensons Bayou. TCEQ Surface Water Quality Station 11460, located at the SH 3 Bridge in Dickinson, is included in this AU.

AU 1103_03 is the portion of Dickinson Bayou Tidal located between Bensons Bayou and Bordens Gully.

AU 1103_04 is the portion of Dickinson Bayou Tidal located between Bordens Gully and the segment boundary with the fresh water portion of Dickinson Bayou (Figure 3). TCEQ Surface Water Quality Station 11465 is located at the uppermost portion of Dickinson Bayou Tidal at the tidal boundary.

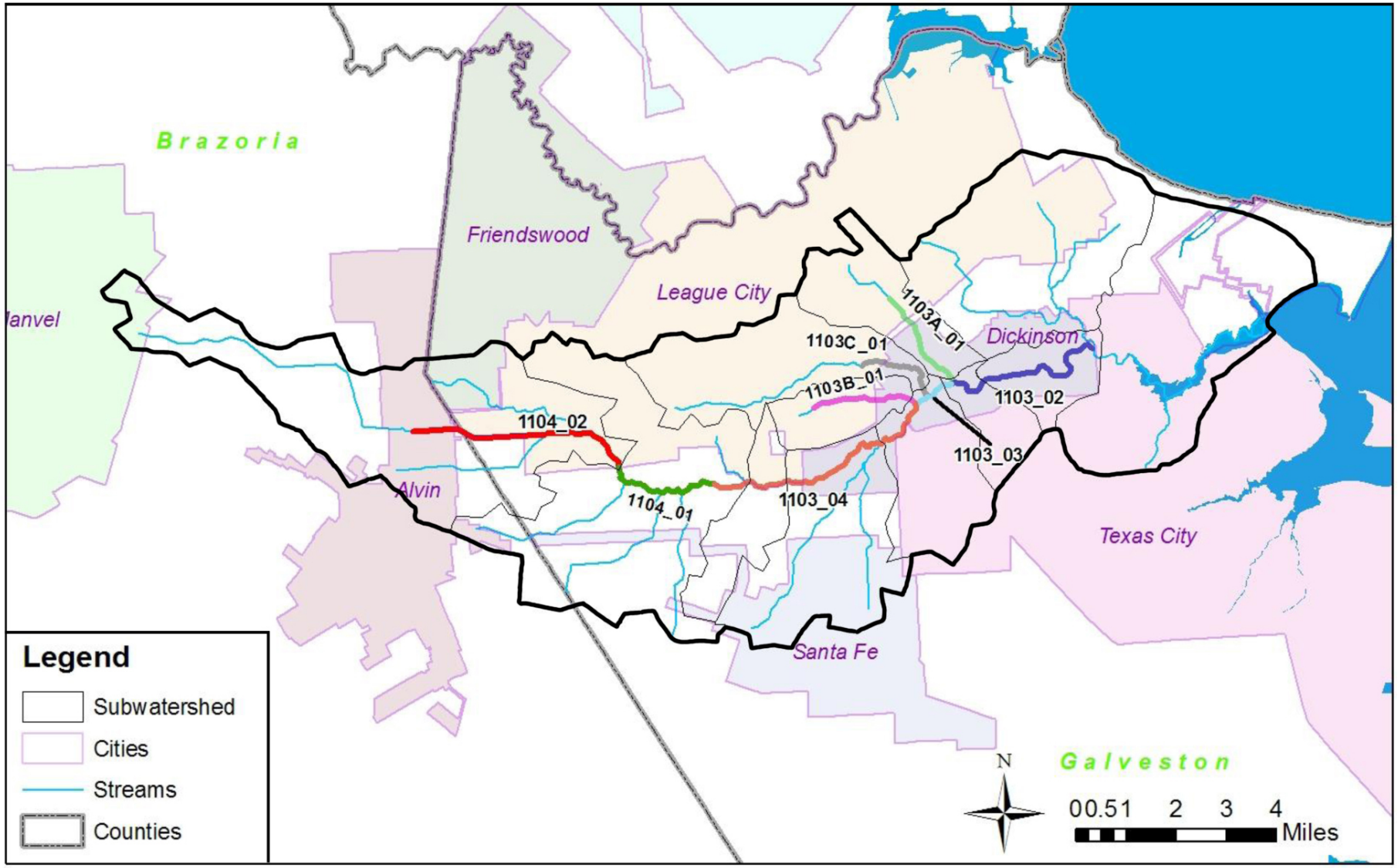


**Figure 1. The Dickinson Bayou watershed, outlined in black, and eight AUs for the project area**

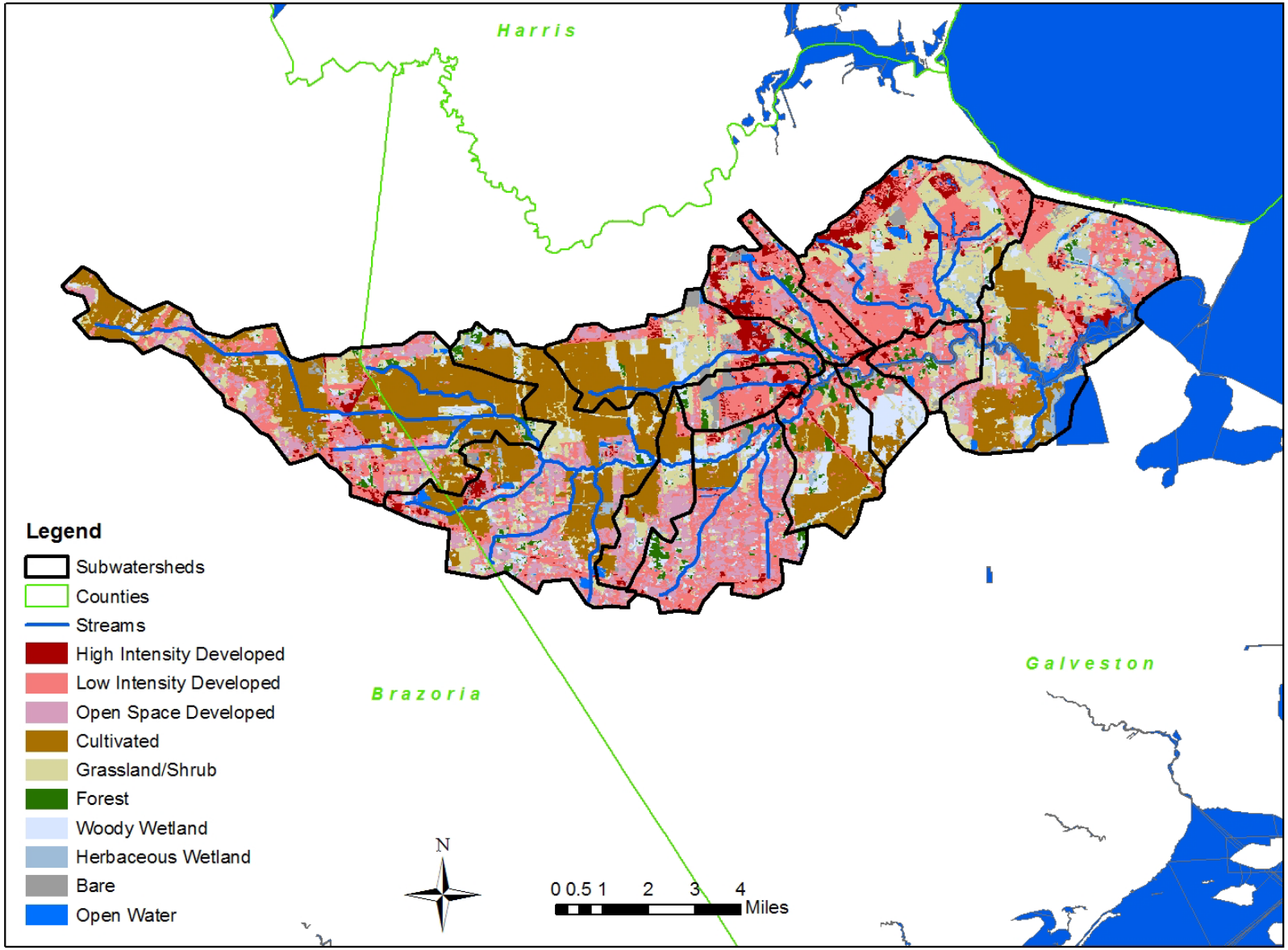


**Figure 2.** **Land use in the Dickinson Bayou watershed (HGAC 2008)**

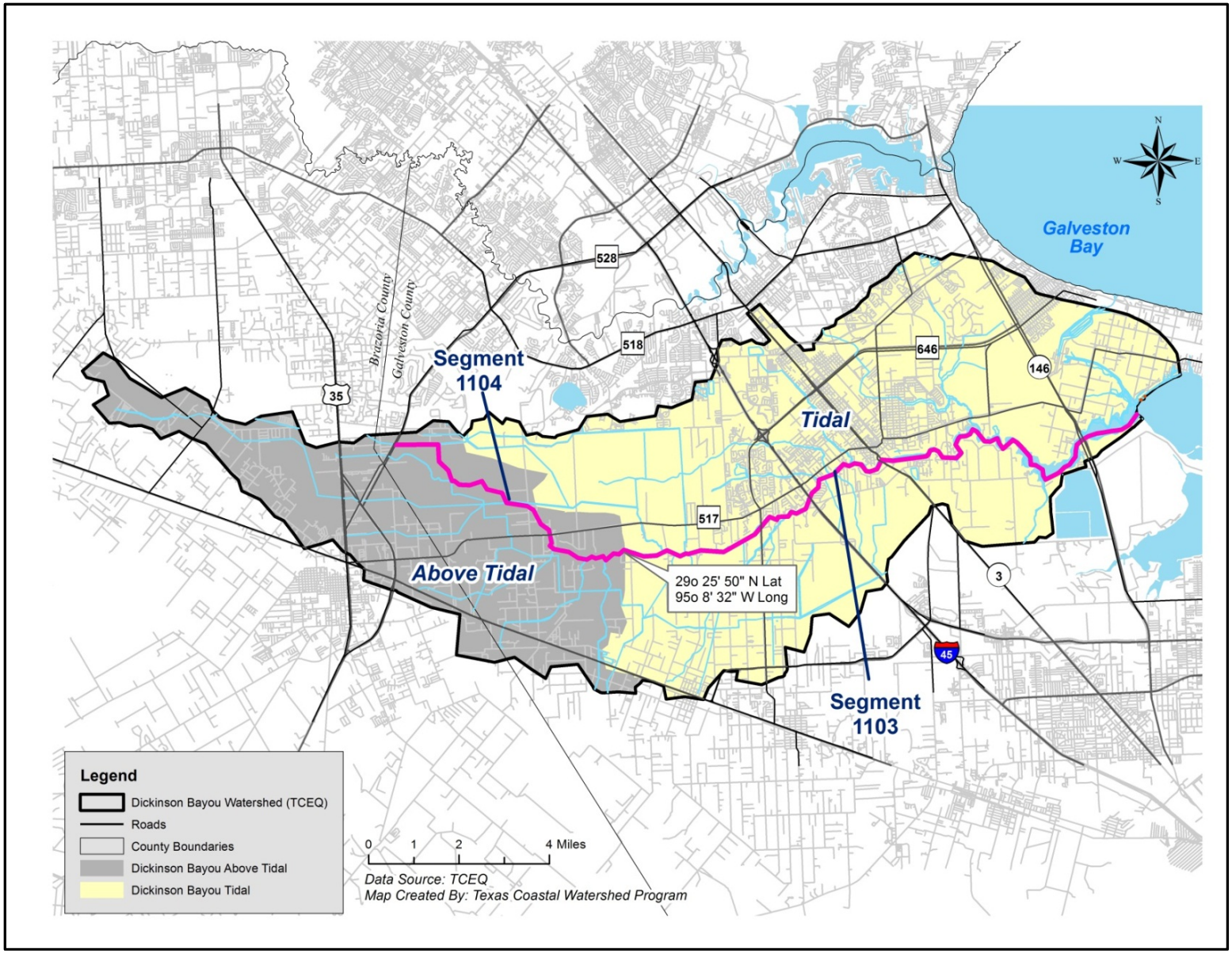


**Figure 3.** **Tidal Boundary of Dickinson Bayou**

AU 1103A_01, Bensons Bayou, is a tidal tributary to Dickinson Bayou. TCEQ Surface Water Quality Station 16471 is located directly upstream of the confluence of these two bayous in the city of Dickinson.

AU 1103B_01, Bordens Gully, is also a tidal tributary to Dickinson Bayou. TCEQ Surface Water Quality Station 16469 is located directly upstream of the confluence of these two water bodies at the FM517 Bridge in Dickinson.

AU 1103C_01, Geisler Bayou, is another tidal tributary to Dickinson Bayou. TCEQ Surface Water Quality Station 16470 is located directly upstream of the confluence of these two bayous at the FM517 Bridge in Dickinson.

AU 1104_01 is the portion of Dickinson Bayou Above Tidal located between the lower tidal boundary and where FM 517 crosses the bayou. TCEQ Surface Water Quality Station 11467 is located at the FM 517 Bridge east of Alvin.

AU 1104_02 is the portion of Dickinson Bayou Above Tidal located between FM 517 and the headwaters of the bayou.

Dickinson Bayou was first identified as not meeting contact recreation standards for bacteria in the 1996 Texas Water Quality Inventory and 303(d) List. This impairment was expanded in 2002 to include four major tributaries: Bensons Bayou, Bordens Gully, Geisler Bayou, and Gum Bayou. These water bodies remained on the 2006 and 2008 Texas 303(d) Lists, with the exception of Gum Bayou (Table 1).

**Table 1. Water Quality Inventory Assessment Data**

| Description | Segment | AU | Indicator Bacteria | Geometric Mean Criterion (mpn/100mL) | Single Sample Maximum Criterion (mpn/100mL) | % Single Sample Exceeded |
|---|---|---|---|---|---|---|
| Dickinson Bayou Tidal | 1103 | 1103_02 | Enterococci | 35 | 89 | 52 |
| | | 1103_03 | Enterococci | 35 | 89 | na |
| | | 1103_04 | Enterococci | 35 | 89 | 61 |
| Bensons Bayou | 1103A | 1103A_01 | Enterococci | 35 | 89 | 30 |
| Bordens Gully | 1103B | 1103B_01 | Enterococci | 35 | 89 | 74 |
| Geisler Bayou | 1103C | 1103C_01 | Enterococci | 35 | 89 | 42 |
| Dickinson Bayou Above Tidal | 1104 | 1104_01 | *E. coli* | 126 | 394 | 26 |
| | | 1104_02 | *E. coli* | 126 | 394 | 70 |

na = no data available for the period assessed

Gum Bayou was removed from the list in 2006 because water quality data collected subsequently indicated the contact recreation use was supported. More recent sur-

face water quality data showed increasing bacteria levels in Gum Bayou and, in 2010, Gum Bayou was again added to the Texas 303(d) List. Gum Bayou is not explicitly included in the TMDL because the relisting of Gum Bayou in 2010 occurred during the TMDL adoption and approval process after the TMDL analysis had been completed and, hence, it is not explicitly included in the adopted and approved TMDLs. However, bacteria loading to Gum Bayou is addressed in the TMDLs and the control actions and management measures described in this I-Plan include activities in the Gum Bayou watershed.

## Pollutant Sources and Loads

The TCEQ conducts routine water quality monitoring on a quarterly basis at five water quality stations located in Dickinson Bayou and nine water quality stations located in five tidal tributaries. Water quality data collected at these and other water quality stations between 1999 and 2008 was used in the TMDL analysis of 3 tidal AUs and three of their tributaries. Additionally, as part of the TMDL, the TCEQ partnered with the University of Houston to collect water quality samples at three additional tributaries, three wastewater treatment facilities and upstream and downstream of the Bayou Wildlife Park, an exotic animal park located along Dickinson Bayou near the tidal/non-tidal boundary.

In the freshwater segment, the minimum concentrations of *Escherichia coli (E. coli)* were typically below the detection limit, with maximum concentrations reaching a most probable number of 24,192 per 100 milliliters (24,192 mpn/100mL). The highest percent exceedance of the *E. coli* single sample criterion for any fresh water station was 70% (Table 1). Likewise, in the tidally-influenced portions of the bayou, the minimum Enterococci concentration was below 1 mpn/100mL. The highest percent exceedance of the single sample criterion for any tidal station was 74% (Table 1).

For Dickinson Bayou Above Tidal, the allowable pollutant loads were quantified using load duration curve (LDC) analysis. A mass-balance, tidal-prism model was used for tidal segments. LDCs define the relationship between flow (volume per time) and loadings (mass bacteria per time). The procedures for developing LDCs are explained more fully in the TMDL report. Results of the TMDL LDC analyses determined that bacteria loads for AUs 1104_01 and 1104_02 typically exceeded the geometric mean criteria at mid-range and high flow conditions. Reductions in source loadings are required in both of the Above Tidal AUs.

TMDLs estimated for the tidal segments were calculated using a tidal-prism model and were based on median annual flow. To meet the TMDL in the tidal segments, reductions in source loadings are required in all TMDL tidal AUs except 1103_02.

TMDLs represent the maximum amount of a pollutant that the stream can receive without exceeding the water quality standard. The TMDLs for indicator bacteria in Dickinson Bayou were allocated into broad categories using the following equation:

### *Equation 1*

$$TMDL = WLA + LA + MOS$$

Where:

WLA = waste load allocation (regulated source contributions)

LA = load allocation (non-regulated source contributions)

MOS = margin of safety

## Pollutant Sources

Pollutants may come from several sources, both point and nonpoint. Point source pollution comes from a single definable point, such as a pipe, and is regulated by permit under the TPDES. Wastewater and stormwater discharges from industries, construction, and the separate storm sewer systems of cities are considered point sources of pollution. Nonpoint source (NPS) pollution originates from multiple locations, usually washed into surface waters by rainfall runoff.

### *Wastewater Treatment Facilities*

As of January 2011, 11 TPDES-permitted WWTFs had the potential to discharge to Dickinson Bayou. Of these permitted facilities, six are domestic treatment facilities, four treat industrial wastewater or stormwater, and one treats groundwater extracted from a landfill. Only one facility has a permitted flow greater than 1 MGD and thus is considered a major facility.

### *On-Site Sewage Facilities*

Failing OSSFs are a source of fecal pathogens and indicator bacteria loading to streams. Loading from failing OSSFs can be transported to streams in a variety of ways, including runoff from surface discharge or from transport by stormwater runoff. While most septic systems are located outside city and drainage district boundaries, there are several older neighborhoods in the Dickinson Bayou watershed that remain on septic systems. It is important to note that malfunctioning septic systems are unauthorized discharges—*not* unregulated sources.

### *Sanitary Sewer Overflows*

SSOs are releases of untreated wastewater, including domestic, commercial, and industrial wastewater. They are permit violations that must be addressed by the responsible TPDES permittee. SSOs usually occur as the result of a break, stoppage, or exceedance of capacity in the sanitary sewer conveyance system. If not directly discharged into the bayou, the overflows typically drain to the stormwater conveyance system and are transported to the bayou.

### *Stormwater Sources*

Stormwater nonpoint sources of pollution are regulated by the state and federal government only in areas designated by the EPA as "Urbanized Areas" (UAs) belonging to organizations regulated as Municipal Separate Storm Sewer Systems (MS4s). For areas that fall outside of designated UAs, voluntary best management practices (BMPs) and participation in existing conservation and cost-share management programs is the most feasible option to control these sources of pollution.

Promoting the use of BMPs and expanding participation in management programs in rural areas can help lower bacteria levels in waterways. This is particularly the case in subwatersheds where substantial areas of land are devoted to pasture, range, or wildlife use, since runoff from these areas is generally not regulated under existing stormwater regulations. It should be noted, however, that, although the Dickinson Bayou watershed is comprised of more than 70% rural land, agricultural activity in the watershed is relatively low.

As in rural areas of the watershed, promotion of BMPs could also help lower bacteria levels in subwatersheds where substantial urbanization has occurred, as the density of pets (dogs and cats) is directly linked to population and urbanization.

### *Animal Sources*

Bacteria loads from animal sources (domesticated pets, livestock, wildlife, etc.) are identified in the Dickinson Bayou TMDL report as nonpoint sources of concern. Failure to properly manage these sources may increase bacterial loads to the bayou in the future. Areas of concern include the potential for bacteria to attach to sediments in stormwater runoff, and animals' direct deposition of fecal waste in waterway.

### *Domestic Pets*

The most common domestic pets are dogs and cats; however there are many other types of animals that are also kept as pets in the Dickinson Bayou watershed. There are over 14,000 dogs, 16,000 cats and numerous other animals (goats, sheep, rabbits, ponies, etc.) in the Dickinson Bayou watershed.[2] Pet waste contributes substantial amounts of bacteria to surface waters. Feces left in parks, yards or sidewalks gets washed off by rain water and carried into storm drains. These storm drains lead directly to Dickinson Bayou and its tributaries. Water carried through these drains deposits feces, bacteria and other harmful pollutants into waterways and into Dickinson Bayou.

[2] Texas Commission on Environmental Quality. 2011. *Eight Total Maximum Daily Loads for Bacteria in Dickinson Bayou and Three Tidal Tributaries*. pg. 28.

## Waste Load Allocation

The WLA is the waste load allocation for regulated source contributions in the watershed, including wastewater treatment facilities or WWTFs ($WLA_{WWTF}$) and regulated stormwater ($WLA_{Stormwater}$).

### *Waste Load Allocation - Wastewater Treatment Facilities*

WLAs were established for WWTFs using Equation 2. As shown in the equation, the WLA for dischargers in the non-tidal portion of the watershed was calculated using one-half of the *E. coli* concentration of 126 MPN/100mL (i.e., 63 MPN/100mL) multiplied by the permitted flow. For the tidal portion of the watershed, one-half the Enterococci concentration of 35 MPN/100mL (i.e., 17 MPN/100mL) was used to calculate the WLA. For WWTFs without permitted flow data (i.e., 03416-000 and 03479-000), the average reported flow for the WWTFs was used to calculate and assign a WLA.

### *Equation 2*

$$WLA_{WWTF} = \frac{1}{2} * swqs * flow * \text{unit conversion factor}$$

Where:

swqs (surface water quality standard) = 126 MPN/100mL *E. coli* or
35 MPN/100 mL Enterococci;

flow (in million gallons/day or MGD) = permitted flow; and

unit conversion factor = 37,854,120 100mL/MGD.

Table 2 presents a summary of the WWTFs in the Dickinson Bayou watershed as well as their flow characteristics and bacteria allocations. Consideration of future growth and its impacts on the WLA are discussed in a later section.

Waste Load Allocation – Regulated Stormwater discharges from MS4 areas are considered permitted sources. Therefore, the WLA calculations must also include an allocation for permitted stormwater discharges. The stormwater component of the WLAs, $WLA_{Stormwater}$, is calculated using the percentage of each AU's subwatershed that is designated an UA by the EPA.

Table 3 summarizes the percentage of each AU's subwatershed that is designated as an urbanized area. The proportions of the AU subwatershed areas included in urbanized areas range from 2% to 48%.

The percentages shown in Table 3 are used to derive the $WLA_{Stormwater}$ values as shown in Equation 3.

**Table 2. Waste Load Allocation for WWTFs in Dickinson Bayou Watershed**

| AU | TPDES ID | Facility name | Permitted Flow (MGD) | Average Self-Reported Flow (MGD) | *E. coli* Load (MPN/day) | Entero-cocci Load (MPN/day) |
|---|---|---|---|---|---|---|
| 1104_01 | 03416-000 | Waste Management of Texas | n/a[1] | 0.829[1] | 1.97E+09 | n/a[2] |
| 1104_02 | 13632-001 | Meadowland Utility | 0.023 | 0.009 | 5.48E+07 | n/a[2] |
| 1104_02 | 14440-001 | Brazoria County MUD No. 24 | 0.95 | n/a[4] | 2.26E+09 | n/a[2] |
| 1104_02 | 12935-001 | Pine Colony | 0.05 | 0.026 | 1.19E+08 | n/a[2] |
| 1103_02 | 00377-000 | Penreco | 0.075 | 0.057 | n/a[2] | 4.96E+07 |
| 1103_02 | 10173-001 | Galveston County WCID No. 1 | 4.8 | 2.759 | n/a[2] | 3.18E+09 |
| 1103D_01 | 14570-001 | Marlin Atlantis White, Ltd. | 0.5 | n/a[4] | n/a[2] | 3.31E+08 |
| 1103_01 | 03749-001 | Hillman Shrimp & Oyster Co. | 0.07 | 0.005 | n/a[2] | 4.63E+07 |
| 1103_01 | 04086-001 | Duratherm Inc. | n/a[3] | 0.091 | n/a[3] | n/a[3] |
| 1103_01 | 14326-001 | Via Bayou RV Park | 0.02 | 0.002 | n/a[2] | 1.32E+07 |
| 1103_01 | 03479-000 | Sea Lion Technology, Inc. | n/a[3] | 0.058 | n/a[3] | n/a[3] |

[1] No permitted flow specified; average daily flow from monthly self-reports was used to calculate WLA; average flow reported between November 1999 and February 2007

[2] Load calculated only for *E. coli* (in Segment 1104) or Enterococci (in Segment 1103)

[3] The industrial process associated with the facilities is not considered a source of indicator bacteria warranting a WLA

[4] Flows not reported in period that was evaluated for averaging

Abbreviations: MGD – million gallons per day; MPN – most probable number; MUD – municipal utility district; TPDES – Texas Pollutant Discharge Elimination System; WCID – water control and improvement district

### *Equation 3*

$$WLA_{Stormwater} = (TMDL - \Sigma WLA_{WWTF} - MOS - FG) * PctMS4$$

Where:

$WLA_{Stormwater}$ (MPN/day) = permitted stormwater WLA;

TMDL (MPN/day) = maximum allowable load (MPN/day);

$\Sigma WLA_{WWTF}$ (MPN/day) = Sum of permitted WWTF WLAs;

FG (MPN/day) = WWTF future growth WLA;

PctMS4 (%) = Percentage of the AU permitted for MS4 stormwater;

MOS (MPN/day) = 5% margin of safety

**Table 3. Percentages of Each AU Designated as an Urbanized Area**

| AU | Area under MS4 (acres) | Total subwater-shed area (acres) | Percentage AU Permitted for Stormwater |
|---|---|---|---|
| 1104_01 | 485 | 7,689 | 6% |
| 1104_02 | 5,378 | 13,065 | 41% |
| 1103_04 | 5,232 | 16,295 | 32% |
| 1103_03 | 26 | 986 | 27% |
| 1103_02 | 4,524 | 13,192 | 34% |
| 1103_01 | 181 | 9,806 | 2% |
| 1103A_01 | 1,675 | 3,466 | 48% |
| 1103B_01 | 484 | 1,346 | 36% |
| 1103C_01 | 613 | 2,315 | 26% |
| **Total** | **18,837** | **68,160** | **28%** |

As of December, 2012, eight stormwater dischargers in the watershed held MS4 permits (Table 4). Urban population growth trends and expanding residential/commercial development in the Greater Houston Metropolitan Area signal a shift from rural land uses to an urbanized land use. Changing land use percentages in the watershed will necessitate updates to the TMDL through WQMP updates to reflect the latest regulated stormwater loading areas.

**Table 4. MS4 Permittees in Dickinson Bayou Watershed**

| Permit Number | Permittee | Area (acres) |
|---|---|---|
| TXR040148 | Brazoria County Conservation and Reclamation No. 3 | 9,462 |
| TXR040271 | City of Dickinson | 4,158 |
| TXR040249 | City of League City | 14,435 |
| TXR040024 | City of Texas City | 4,631 |
| TXR040364 | Galveston County | 5,494 |
| TXR040067 | Galveston County Consolidated Drainage District | 6,022 |
| TXR040203 | Galveston County Drainage District No. 1 | 18,547 |
| TXR040203 | Galveston Country Drainage District No. 2 | 5,448 |

To the extent that the MS4 permittees are implementing their respective stormwater management plans (SWMPs), their permits are considered consistent with the Dickinson Bayou Bacteria TMDL and this I-Plan. The MS4 permittees are committed to a focus that optimizes implementation of measures within the Dickinson Bayou watershed. Each permittee will implement its SWMP, as necessary, to

target reductions in the waste load of bacteria from those portions of their MS4s that are located within the Dickinson Bayou watershed.

## Load Allocation

The Load Allocation (LA) is the sum of loading from all non-regulated sources. The LAs for each stream segment are calculated as the difference between the TMDL, MOS, $WLA_{WWTFs}$, and $WLA_{Stormwater}$. It is calculated as shown in Equation 4.

### *Equation 4*

$$LA = TMDL - \Sigma WLA_{WWTF} - \Sigma WLA_{Stormwater} - MOS$$

Where:

LA (MPN/day) = load allocation;

TMDL (MPN/day) = maximum allowable daily load;

$\Sigma WLA_{WWTF}$ (MPN/day) = permitted WWTF WLA;

$\Sigma WLA_{Stormwater}$ (MPN/day) = permitted stormwater WLA;

MOS (MPN/day) = 5% margin of safety.

As shown in Table 5, for the AUs of the above-tidal portion of Dickinson Bayou (1104_01 and 1104_02), the calculated *E. coli* TMDL ranged from 1.04E+10 MPN/day to 3.70E+10 MPN/day. The $WLA_{WWTF}$ ranged from 1.97E+09 to 2.44E+09 MPN/day and 2.06E+09 to 2.21E+09 MPN/day for $WLA_{Stormwater}$. The LAs for subwatersheds associated with AUs 1104_01 and 1104_02 ranged from 3.06E+09 to 3.16E+09 MPN/day.

For the tidal AUs, which include 1103A_01, 1103B_01, 1103C_01, 1103_02, 1103_03, and 1103_04, the Enterococci TMDL ranged from 1.65E+09 to 2.41E+11 MPN/day. The $WLA_{WWTF}$ for AUs in the tidal segment and tidal tributaries were established at 3.22E+ 09MPN/day. The $WLA_{Stormwater}$ for AUs in the tidal segment and in tidal tributaries ranged from 5.64E+08 to 3.06E+10 MPN/day and the LAs for these AUs ranged from 1.00E+09 to 2.21E+11 MPN/day.

**Table 5. TMDL Allocation for Dickinson Bayou Watershed (in MPN/day)**

| Stream Name | AU | Indicator Bacteria | TMDL[1] | $WLA_{WWTF}$[2] | $WLA_{Stormwater}$[3] | LA[4] | MOS[5] | Future Growth (FG)[6] |
|---|---|---|---|---|---|---|---|---|
| Dickinson Bayou Above Tidal | 1104_01 | *E. coli* | 3.70E+10 | 1.97E+09 | 2.06E+09 | 3.06E+10 | 1.82E+09 | 5.28E+08 |
| | 1104_02 | *E. coli* | 1.04E+10 | 2.44E+09 | 2.21E+09 | 3.16E+09 | 4.11E+08 | 2.19E+09 |
| Bensons Bayou | 1103A_01 | Enterococci | 9.26E+09 | 0.00E+00 | 4.25E+09 | 4.55E+09 | 4.63E+08 | 0.00E+00 |
| Bordens Gully | 1103B_01 | Enterococci | 1.65E+09 | 0.00E+00 | 5.64E+08 | 1.00E+09 | 8.25E+07 | 0.00E+00 |
| Geisler Bayou | 1103C_01 | Enterococci | 4.14E+09 | 0.00E+00 | 1.04E+09 | 2.89E+09 | 2.07E+08 | 0.00E+00 |
| Dickinson Bayou Tidal[7] | 1103_02 | Enterococci | 2.41E+11 | 3.22E+09 | 4.17E+09 | 2.21E+11 | 1.21E+10 | 8.03E+08 |
| | 1103_03 | Enterococci | 9.41E+10 | 0.00E+00 | 3.06E+10 | 5.87E+10 | 4.70E+09 | 0.00E+00 |
| | 1103_04 | Enterococci | 6.74E+10 | 0.00E+00 | 1.72E+10 | 4.68E+10 | 3.37E+09 | 0.00E+00 |

[1] TMDL calculated as sum of $WLA_{WWTF}$, $WLA_{Stormwater}$, LA, MOS and future growth (includes full permitted flow and no margin of safety); for above tidal segments, the TMDL was calculated by summing the median value of the LDC from the mid-range flow (between 20-80$^{th}$ percentile), MOS and future growth.

[2] $WLA_{WWTF}$ is sum of permitted loads discharging to impaired AUs

[3] $WLA_{Stormwater}$ is TMDL minus the sum of $WLA_{WWTF}$, MOS and future growth multiplied by the percentage of the AU watershed covered by MS4 permits

[4] LA is TMDL minus the sum of $WLA_{WWTF}$, $WLA_{Stormwater}$, MOS, and future growth

[5] MOS is a 5% margin of safety which is applied to the TMDL

[6] Future growth accounts for population growth through 2050 in permitted WWTF discharges

[7] Because it is not included on Texas' 2006 or *2008 Section 303(d) List*, a TMDL is not specified for AU 1103_01

# Implementation Strategy

This plan documents seven management measures and four control actions to reduce bacteria loads. Management measures are voluntary activities, such as restoring and improving wetlands. Control actions are regulatory activities, such as monitoring *E.coli* concentrations in WWTF effluent. Management measures were selected based on feasibility, costs, support, efficiency, and timing. Implementation activities can be conducted in phases based on the needs of the stakeholders and the progress made in improving water quality.

## Adaptive Implementation

I-Plans are implemented using an adaptive management approach in which measures are periodically assessed for efficiency and effectiveness. This adaptive management approach is one of the most important elements of the I-Plan. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals, and expresses stakeholder commitment to the process.

At annual meetings hosted by the TCEQ, the stakeholders will periodically assess progress using the schedule of implementation, interim measurable milestones, and water quality data. If periodic assessments find that insufficient progress has been made in improving water quality, the implementation strategy will be adjusted.

## Activities and Milestones

The DBWP began developing the I-Plan during the winter of 2011, concurrently with the effort to establish bacteria TMDLs. The Partnership formed three work groups to complete the I-Plan including a workgroup responsible for crafting solutions to problems associated with OSSFs, one that worked on WWTF issues, and a third work group addressing animal sources. Between winter 2011 and August 2011, the work groups met 16 times.

Each work group considered bacteria loading sources in the watershed, and developed detailed, consensus-based action plans. The management measures contained in this I-Plan are the products of the work groups. The reports of the work groups can be found on the DBWP website at: <*dickinsonbayou.org/meetings-events*>.

The Dickinson Bayou I-Plan includes the seven stakeholder-developed management measures and four control actions described in the following sections.

# Management Measures and Control Actions

Management measures are voluntary activities that are undertaken by facilities or local organizations to mitigate pollutant loading to a water body of concern. These

measures may be eligible for federal and state funding assistance. Control actions are actions that are required by permit or rule. Following is a summary of the management measures and control actions included in this I-Plan.

## Management Measures

1. *Improve management of on-site sewage facilities.*
   - *1.1. Identify and rank target areas by pollutant reduction priority and expand home owner OSSF education.*
   - *1.2. Hookup, upgrade, and/or fix identified failing OSSFs.*
   - *1.3. Improve enforcement to mitigate failing OSSFs.*
   - *1.4. Address maintenance of OSSFs through education efforts.*
   - *1.5. Incorporate OSSF criteria into standards of practice for home sale inspections.*
   - *1.6. Target areas for intensive water quality sampling based on OSSF pollution, upon completion of mapping conducted under Management Measure 1.1.*
2. *Improve wastewater treatment facilities.*
   - *2.1. Upgrade plants.*
   - *2.2. Consider regionalization of discharge effluent (WWTFs), especially for new development.*
   - *2.3. Develop and implement an improved sanitary sewer overflow initiative plan/program for individual SSSs.*
   - *2.4. Address fats, roots, oils, and grease (FROG).*
   - *2.5. Encourage appropriate mechanisms to maintain function at lift stations.*
3. *Promote participation in existing conservation and cost-share programs.*
   - *3.1. Promote the reduction of feral hog populations.*
   - *3.2. Expand pet owner education efforts.*
   - *3.3. Install pet waste stations in parks and public areas.*
   - *3.4. Improve home owners associations' bylaws and ordinances for pet waste control.*
   - *3.5. Increase awareness, development, and enforcement of pet waste control ordinances.*
   - *3.6. Promote BMPs for managing water quality for lands with large groups of animals not covered by other management measures such as a wildlife park, petting zoo or other animal feeding operations.*
4. *Restore and repair riparian zones.*
5. *Preserve and restore natural wetlands.*
6. *Construct treatment wetlands.*
7. *Provide demonstrations of and encourage installation of stormwater BMPs including rain gardens, bioswales, and rain water harvesting.*

## Control Action

1. *Implement stricter bacteria limits and enforcement measures for WWTF effluents.*
2. *Increase compliance and enforcement by the TCEQ.*
3. *Revise penalties and violations for SSSs and WWTFs.*
4. *Improve reporting capabilities for SSOs.*

## Management Measure 1.0: Improve management of on-site sewage facilities

A substantial percentage of households in the Dickinson Bayou watershed are served by OSSFs. Estimates in 2011 put the OSSF count at over 5,100 in the Dickinson Bayou watershed (Figure 4).[3] On-site sewage facilities treat wastewater by moving it through the soil, where it is cleaned through filtration and microbial processes. These systems can be quite effective in the right conditions. However, if the OSSF is not designed to match soil conditions, there is a very real risk of failure and the consequent surfacing of untreated wastewater, which could easily find its way into Dickinson Bayou.

Most of the Dickinson Bayou watershed is composed of soils that are either too wet or too clayey, or frequently both, for a standard gravity-fed leach-field system.

Before 1997, when the state of Texas instituted a soil inspection system, virtually all OSSFs installed in Galveston County were standard systems. The Galveston County Health District (GCHD) estimated 3,722 standard systems existed in the watershed in 2008.[4] Most, if not all, of these systems are likely to fail in some degree over time and, for many systems, failure means that some untreated wastewater comes to the surface or comes into contact with groundwater even though the system may be working properly from the home owner's perspective.

After 1997, Galveston County stopped issuing permits for the construction of standard drain field OSSF systems in clay soils or in areas where the shallow groundwater surface was less than 2 feet deep. However, older systems in the watershed have been "grandfathered" and home owners have not been required to replace them with alternative systems.

[3] Highfield, Wesley, Blessing, R., & Jacob, J. (2011). Dickinson Bayou On-Site Sewage Facility Alternatives Analysis (Contract Report #582-8-77058). College Station, TX: Texas A&M University.
[4] Ettringer, Martin. (2008) Galveston County Health District, Personal Communication.

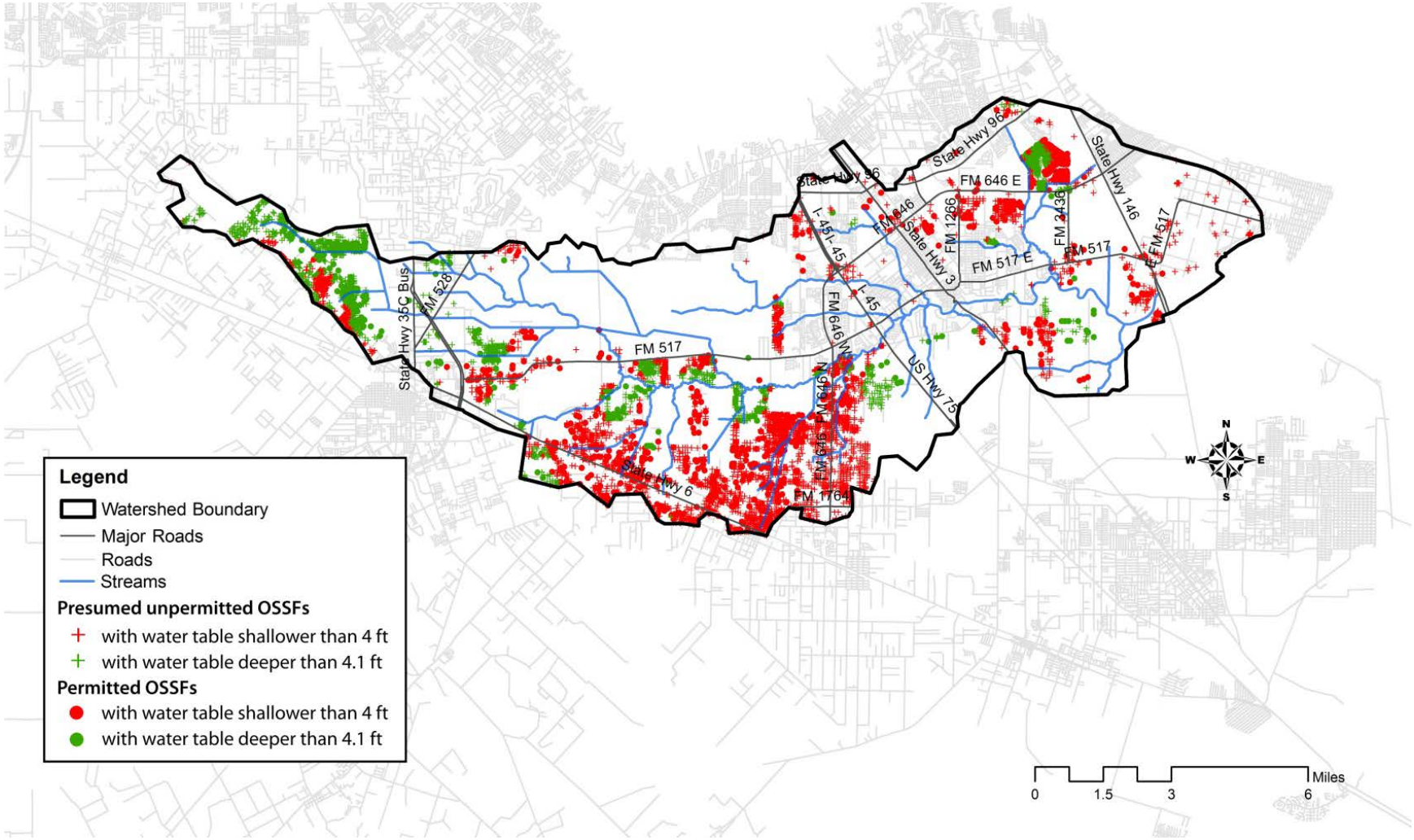


**Figure 4.** **Location of permitted and presumed non-permitted on-site sewage facilities in the Dickinson Bayou watershed. High concentrations of red symbols indicate areas where standard drain field systems may be a problem**

There are a variety of OSSF systems that can be designed for the soil conditions of the Dickinson Bayou watershed, including low pressure dosing, drip emitters, spray application, and mound systems. These advanced systems are substantially more expensive than standard drain field systems and there has been substantial resistance by home owners and developers, to their use. Local attitudes towards OSSFs, however, are changing. By 2003, about 50% of the permitted OSSFs in Galveston County were advanced design, and 77% by 2006.[5] As of 2011, almost all OSSFs permitted in the watershed are advanced design.

Virtually all of the advanced treatment units put in place in Galveston County since 1997 have been aerobic treatment units with chlorination (ATU). Aerobic treatment units can be notoriously unreliable.[6] There are many moving parts, and frequent maintenance is required. Until recently, Galveston County required that each new ATU installed have a home owner financed maintenance contract in place, with 3 or 4 maintenance visits yearly. In 2011, Galveston County instituted a system whereby home owners can be exempt from the yearly maintenance contract if they take an eight hour course on OSSF maintenance, but home owners are still responsible for submitting the required maintenance reports to the GCHD three times each year.

The Management Measures described below fall within the current realm of the feasible and probable for the Dickinson Bayou watershed. It is important to note that home owner education, and education of those involved in the sale of homes with OSSFs (primarily realtors and home inspectors), are relatively easy ways to increase the level of maintenance and compliance of OSSFs by home owners.

## Management Measure 1.1: Identify and rank target areas by pollutant reduction priority and expand home owner OSSF education

### *1.1.1 Create a GIS-based map identifying the location of permitted and non-permitted OSSFs in the watershed and additional parameters necessary to adequately rank areas*

It is important to identify the location of all OSSFs (both permitted and non-permitted) in the watershed to better determine a strategy for addressing them as a source of pollution. The managing organizations need to know which OSSFs are located on problem soils, their proximity to Dickinson Bayou, its tributaries, and the drainage networks that funnel septic pollution to the bayou. The map will be developed using a Geographic Information System (GIS), making it easily editable and facilitating frequent updates and revisions. This GIS-based map will be used to complete Management Measures 1.1.2 and 1.1.3. A current version of the map will

[5] Ettringer, Martin. (2008) Galveston County Health District, Personal Communication.
[6] Highfield, Wesley, Blessing, R., & Jacob, J. (2011) Dickinson Bayou On-Site Sewage Facility Alternatives Analysis (Contract Report #582-8-77058). College Station, TX: Texas A&M University.

be posted on the DBWP web page and distributed to Authorized Agents and high priority OSSF owners. It will be updated, at least once every year.

### *1.1.2 Identify and rank target areas for system upgrades*

The managing organizations will use the map described in Management Measure 1.1.1 to determine which portions of the watershed are most in need of OSSF upgrades. In order to determine target areas, a set of criteria will be developed by the OSSF workgroup and a team of local experts. Ranking criteria may include proximity to bayous or ditches, soil type, topography, number of non-permitted OSSFs in the area, etc. After these criteria are determined, the areas will be ranked, identifying those areas which are the highest priority for system upgrades and/or hookups to centralized wastewater treatment systems. The workgroup will work to keep an unbiased outlook and objectively create a ranking system that is best for Dickinson Bayou. The managing organizations, cities, and counties will use the ranking information to undertake Management Measure 1.2 and 1.3.

### *1.1.3 Utilize map created to identify and rank target areas for OSSF owner education*

The managing organizations will use the map described in Management Measure 1.1.1 to launch a targeted home owner education outreach campaign. This management measure will be used in conjunction with management measure 1.1.2. The same criteria will be used for prioritizing target areas for education. Education will focus on areas with aerobic (permitted) systems. These are likely to fail due to lack of maintenance rather than faulty equipment. This prioritization will allow the managing organizations to focus education efforts for a maximum return on investment. Information from this prioritization will be used to undertake Management Measure 1.4.

### *Responsible Parties and Funding*

The Center for Texas Beaches and Shores will seek CWA Section 319(h) funding to create the map described in Management Measure 1.1.1. The DBWP OSSF Workgroup will monitor progress and determine prioritization criteria, then prioritize target areas. The DBWP is responsible for education, including distributing the map to Authorized Agents and high priority OSSF owners. There are many existing factsheets and brochures about OSSFs in Texas that will be distributed at events, libraries, etc. Funding will be sought by watershed communities through the CWA Section 319(h) grant program. Matching funds may be obtained from the printing, mailing, and the distribution of these educational materials.

## Management Measure 1.2: Hookup, upgrade and/or fix identified failing OSSFs

Once the failing OSSFs and OSSFs with the highest risk of failure and the greatest potential for contributing untreated sewage to Dickinson Bayou are identified, DBWP will work with cities, counties, and home owners to seek funding for up-

grades or centralized connections. Funding for engineering designs and actual groundwork may be available through federal community block grants, the CWA 319(h) grant program, or other federal or state funding programs. When funding is available, GCHD will use the map created to help in identifying specific systems with a high probability of failure. Some cities in the watershed already have dedicated funding for these activities. For example, the City of League City has already begun efforts to remove older OSSFs using grant funded programs. Their success can be used as a model for system replacement activities within the Dickinson Bayou watershed.

### *Responsible Organizations and Funding*

GCHD will use the map to identify specific failing systems. Watershed cities and counties will be responsible for assisting home owners in locating funding to upgrade and/or fix their failing OSSFs. Cities and counties can apply for federal and state funding to incorporate these assistance programs into their current operating budgets. The GCHD has processes in place to distribute any grant funding that comes available for correction of substandard systems. GHCD and Houston-Galveston Area Council (H-GAC) will also provide technical assistance.

## Management Measure 1.3: Improve enforcement to mitigate failing OSSFs

It is illegal to discharge untreated sewage into waters of Texas or the United States. Stakeholders' consensus opinion is that there is little proactive enforcement of OSSFs in Galveston and Brazoria Counties. Funding levels limit the number of inspectors who can make random visits. Currently, calls from neighbors or others to report a discharge are the typical cause for an OSSF inspection.

An increased budget for better inspection and enforcement would result in better identification of malfunctioning OSSFs. This, in turn, would result in an increase in repairs or replacement of malfunctioning systems. The DBWP OSSF Workgroup believes that a budget increase for these activities would put watershed home owners on notice that they are subject to inspection to insure properly functioning OSSFs, providing an impetus to the home owner to keep OSSF systems working properly.

### *Responsible Organizations and Funding*

GHCD and Brazoria County Environmental Health Department are responsible for locating appropriate funding and hiring and training of new inspectors. DBWP will help solicit grant funding for the additional inspectors.

## Management Measure 1.4: Address maintenance of OSSFs through education efforts

This management measure is designed to improve maintenance of OSSFs by educating home owners and real estate professionals about proper OSSF operation and maintenance, including the consequences of improper OSSF maintenance.

### *1.4.1 Home owner education*

A number of household surveys indicate that home owners, even with some training, do not have a good record for properly maintaining OSSFs on their own, particularly those with complex advanced systems such as ATUs, many of which are currently permitted in the Dickinson Bayou watershed.[7] Given this history and the propensity for failure of ATU OSSFs, the Dickinson Bayou watershed may now be seeing an increase in polluted runoff emanating from OSSFs. Ironically, poorly maintained ATU units may result in untreated wastewater surfacing for much longer periods throughout the year than a system of older design. A standard OSSF will likely only fail during a few of the wettest months of the year, e.g., February and March while an ATU OSSF without proper maintenance could fail throughout the year.

Under current regulatory conditions, home owner education is the most effective tool for improving OSSF maintenance. The Texas A&M AgriLife Extension Service will hold OSSF workshops for home owners, create and distribute OSSF educational materials that outline maintenance needs, and stress responsibility towards improving water quality in the bayou as well as the health risks and economic burden of illnesses that can be caused by untreated effluent from malfunctioning OSSFs. The GCHD will continue existing OSSF education programs.

### *1.4.2 Create and distribute OSSF educational materials directed towards home buyers*

Few home buyers fully understand what is necessary to properly maintain OSSFs when they purchase new property. Educational materials such as informational pamphlets and fact sheets will be created by the DBWP and distributed to real estate professionals for circulation at their offices and to provide to potential homebuyers.

### *1.4.3 Develop a course for Real Estate professionals regarding OSSF maintenance requirements and seek approval from the Texas Real Estate Commission for continuing education credits*

Educating real estate professionals on the consequences of OSSF failure is a key strategy in mitigating this type of NPS pollution. The importance of sharing information on OSSF maintenance and inspection requirements with potential home

[7] Sexstone, Alan, et. al. "A Survey of Home Aerobic Treatment Systems Operation in Six West Virginia Counties," Small Flows Quarterly, Fall 2000, National Environmental Service Center. Accessed at: <www.nesc.wvu.edu/pdf/ww/publications/smallflows/magazine/SFQ_FA00.pdf>.

buyers has benefits to both the environment and the real estate business. The creation of an online training course directed towards real estate professionals is a useful tool for providing this information. After the course is created, the DBWP OSSF workgroup will seek approval from the Texas Real Estate Commission (TREC) for continuing education credits.

### *Responsible Organizations and Funding*

Texas A&M AgriLife Extension Service with the DBWP will be responsible for developing home owner and real estate professional education courses and materials. Texas AgriLife and DBWP will also conduct the training jointly. The DBWP OSSF workgroup will track the number of training materials developed and training sessions completed and will also record levels of attendance.

## Management Measure 1.5: Incorporate OSSF criteria into standards of practice for home sale inspections

Currently, home inspectors are not required to inspect OSSFs for home buyers, nor is there an accepted standard procedure for inspections. Without a standard procedure, the methods to determine the operational status of OSSFs may vary with the inspector's knowledge of OSSFs. Buyers may not be aware of an undersized, under-maintained, or improperly functioning system. In order to ensure consistency and competency of OSSF inspections at the a point of sale, rules specifying standardized procedures for OSSF inspections, at the sale of the home for all types of OSSF systems, must be developed, promulgated and enforced. A thorough inspection will provide the home buyer the information needed to determine if their lifestyle and water usage is within the capabilities of the OSSF associated with the home that is being sold. Until these rules are established, the Texas A&M AgriLife Extension Service is developing an inspection manual for conventional OSSFs. The manual provides step-by-step guidance for inspecting the septic tank and treatment area. A checklist is used to determine the operation status and identify inspection and maintenance frequencies. Texas A&M AgriLife Extension Service will recommend that inspectors in Galveston County follow the manual for conventional systems until such time that the rules required to standardize inspection of OSSFs are established (statewide or in Galveston County).

This measure will take several years of persistent effort as it requires changes at the state wide level. Therefore, the DBWP will work with the Galveston Bay Foundation, TREC and other watershed groups to advance this management measure.

### *Responsible Organizations and Funding*

The Galveston Bay Foundation (GBF) and the DBWP's OSSF workgroup will develop a task force and determine OSSF inspection criteria for home inspectors. Home inspectors will be responsible for incorporating the criteria into their inspections and the workgroup will collect the number of home inspections completed. The Watershed Partnership is responsible for education of inspectors and realtors

about the interim guidance manual from Texas A&M AgriLife and new criteria as developed.

## Management Measure 1.6: Target areas for intensive water quality sampling based on OSSF pollution

Based on the map created in Management Measure 1.1, the GCHD will select several ambient sampling locations on Dickinson Bayou and its tributaries near large groupings of OSSFs to collect intensive water quality data. These sites will be sampled for as long as funding is available or pollution problems from OSSFs are mitigated. Stakeholders expect to see decreases in bacteria counts as failing OSSFs are repaired or replaced.

### *Responsible Organizations and Funding*

DBWP will seek grant funding for the sampling and analysis. GCHCD will conduct the intensive sampling and analysis as funding becomes available. The H-GAC will help to complete sampling if GCHD is unable.

## Measurable Milestones

### *In Year One:*

- Creation of OSSF map.

### *In Years 1-5:*

- Determination of prioritization criteria,
- Areas prioritized,
- Number of OSSF owners contacted in prioritized target areas,
- The number of target areas addressed,
- Number of contacts with OSSF owners made by enforcement officials,
- The number of workshops offered and the number of attendees, and
- The number of educational materials created and disseminated.

### *As Funding Becomes Available*

- Course for OSSF maintenance developed,
- Approval sought for continuing education credits from Texas Real Estate Commission,
- Number of real estate professionals completing the course,
- Task Force developed,
- Home inspection criteria developed,
- Number of home inspections with the inclusion of new criteria,
- Number of points selected for intensive water quality sampling, and
- Number of samples collected.

**Table 6. Summary for Management Measure 1: Improve Management of OSSFs**

Causes and Sources: Malfunctioning or improperly maintained OSSFs

| Management Submeasure | Potential Load Reduction (cfu/day)[8] | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 1.1: Identify and rank target areas by pollutant reduction priority and expand home owner OSSF education | For all OSSF Measures (Management Measures 1.1-1.6):<br><br>*E. coli* $4.81 \times 10^9$ mpn/day<br><br>Enterococcus $1.34 \times 10^9$ mpn/day | Technical (Submeasure 1.1.1 and 1.1.2):<br><br>GIS data layers from HGAC and other sources. Expert GIS and planning assistance<br><br>Financial: Grant funding for staff to create map | Distribute maps to Authorized Agents and make maps available via DBWP Web page | Year One: Create map identifying location of permitted and non-permitted OSSFs in the watershed and parameters for risk of OSSF failure and pollutant loading to surface water | Technical team assembled<br><br>Data assembled<br><br>Map completed | Creation of map | Reports to DBWP OSSF Workgroup on map progress | TAMUG: Create map.<br><br>DBWP OSSF Workgroup: Provide feedback and monitor progress |
| | | Technical: (Submeasure 1.1.2) Expert GIS assistance and planning assistance<br><br>Financial: Funding for watershed coordinator to facilitate the prioritization process | Distribute maps to Authorized Agents and high priority OSSF owners<br><br>Make maps available via DBWP Web page | Year One: Utilize map created to identify and rank target areas *for system upgrades or hookups*<br><br>Update the map of priority areas, at least every six months | Criteria for prioritizing target areas for upgrades developed<br><br>Target areas for upgrades prioritized<br><br>Map of priority areas updated<br><br>OSSF owners in high priority target areas notified | Criteria determined<br><br>Areas prioritized<br><br>Priority map areas created<br>Number of OSSF Owners contacted | Reports to DBWP OSSF Workgroup on progress | DBWP OSSF Workgroup: Determine prioritization criteria and prioritize target areas<br><br>TAMUG: Create priority area map<br><br>DBWP: Responsible for education |

[8] See Appendix C for information on the methods and assumptions used to calculate Load Reductions

| Management Submeasure | Potential Load Reduction (cfu/day)[8] | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Measure 1.1, continued | | Technical (Submeasure 1.1.3): GIS Assistance and education and outreach assistance<br><br>Financial: Funding for watershed coordinator to facilitate the prioritization process | See Management Measure 1.4 | Year Two: Utilize map created to identify and rank target areas *for OSSF owner education* | Criteria for prioritizing target areas for education<br><br>Prioritize target areas for education<br><br>Begin education of OSSF owners in high priority target areas | Criteria determined<br><br>Areas Prioritized<br><br>Number of OSSF owners contacted in prioritized target areas | Reports to DBWP OSSF Workgroup on progress | DBWP OSSF Workgroup: Determine prioritization criteria and prioritize target areas<br><br>DBWP: Responsible for education |
| Management Measure 1.2: Hookup, upgrade and/or fix identified failing on-site sewage facilities | | Technical: Expert OSSF technical assistance<br><br>Financial: Funds for on the ground work as well as engineering and design (some costs may be covered by cities) | See Management Measure 1.4 | Years Two and Three: Beginning immediately after prioritization, work with OSSF owners to upgrade and/or fix failing OSSFs in order of identified priority | Target areas addressed. Number of OSSFs in areas addressed | The number of target areas addressed. Number of OSSFs in areas addressed | Reports to DBWP OSSF Workgroup on progress | OSSF Owners: Upgrade and/or fix failing OSSFs<br><br>Local Governments: Technical assistance identification of funding<br><br>DBWP: Responsible for education |

| Management Submeasure | Potential Load Reduction (cfu/day)[8] | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 1.3: Improve enforcement to mitigate failing OSSFs | | Technical: Additional inspectors and/or staff for Authorized Agents<br><br>Financial: Funding for watershed coordinator to apply for grants, and funds for additional GCHD inspectors | Educate Authorized Agent staff on proper inspection techniques for OSSF inspections and on the challenges of OSSF operation in local conditions | Years One through Five: Beginning immediately and increasing as funding allows: contact OSSF owners to complete OSSF inspections | Contacts with OSSF owners made by enforcement officials | Number of contacts with OSSF owners made by enforcement officials and number of enforcement orders issued and the percentage of the total potential problem OSSFs identified that these contacts represent. | DBWP OSSF Workgroup will request reports from Authorized Agents on number of inspections completed and enforcement orders issued | Authorized Agents: Acquire additional staff, educate staff, and conduct OSSF inspections<br><br>DBWP OSSF Workgroup: Apply for grant funding for additional staff for Authorized Agents. Request and collect reports from Authorized Agents |
| Management Measure 1.4: Address maintenance of OSSFs through education efforts | | Technical (Submeasure 1.4.1): Use existing resources for workshops and material development<br><br>Financial: Funding for Watershed Coordinator to organize and publicize workshops | Hold OSSF workshops for home owners<br><br>Creation and distribution of OSSF educational materials | Years One through Five: Beginning immediately educate home owners and continue for the life of the project | Workshops offered each year and educational materials created and disseminated | The number of workshops offered, the number of attendees and the number of educational materials created and disseminated | DBWP OSSF Workgroup will collect information regarding the total number of workshops held and the total number of attendees | DBWP: Responsible for education<br><br>DBWP OSSF Workgroup: Collection of information |

| Management Submeasure | Potential Load Reduction (cfu/day)[8] | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 1.4, continued | | Technical: (Submeasure 1.4.2): Use existing resources for education materials development<br><br>Financial: Funding for watershed coordinator to create educational materials and funds to print and distribute materials | Creation and distribution of OSSF educational materials directed to home buyers | Years One through Five: Begin educating home buyers immediately and continue for the life of the project | Educational materials created and disseminated | The number of educational materials created and disseminated | DBWP OSSF Workgroup will collect information regarding the total number of educational materials created and disseminated | DBWP: Creation of educational materials<br><br>Real Estate Professionals: Distribute information<br><br>DBWP OSSF Workgroup: Collection of information |
| | | Technical: (Submeasure 1.4.3): Use existing resources for course development.<br><br>Financial: Funding for staff/consultant to create course an complete CEU approval process | Develop a course for Real Estate professionals regarding OSSF maintenance requirements and seek approval from the Texas Real Estate Commission for continuing education credits | Years One through Five or as funding allows | Development of course<br><br>Seek approval for continuing education credits<br><br>Course offered | Course developed<br><br>Approval for continuing education credits or an alternative incentive sought<br><br>Number of Real Estate professionals completing the course | DBWP OSSF Workgroup will collect information regarding the total number of Real Estate professionals completing the course | DBWP: Creation of educational materials<br><br>AgriLife Extension Service: Creation of course and teaching of the course<br><br>DBWP OSSF Workgroup: Collection of Information |

| Management Submeasure | Potential Load Reduction (cfu/day)[8] | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 1.5: Incorporate OSSF criteria into standards of practice for home sale inspections | | Technical: Use existing resources for material development<br><br>Financial: Funding for Watershed Coordinator to facilitate Task Force process | Creation and distribution of educational materials relating to the OSSF inspection criteria | Years One through Five or as funding allows | Development of task force including representatives from the Texas Association of Real Estate Inspectors<br><br>Draft inspection criteria<br><br>Voluntary incorporation of inspection criteria by inspectors or efforts to educate legislators and/or agency heads | Task Force developed<br><br>Inspection criteria developed<br><br>Number of home inspections with the inclusion of new criteria | | DBWP OSSF workgroup: Develop task force and determine criteria<br><br>Inspectors: Incorporate criteria in inspections<br><br>DBWP OSSF Workgroup: Collection information regarding number of home inspections<br><br>DBWP: Responsible for education |
| Management Measure 1.6: Target areas for intensive water quality sampling based upon mapping in Management Measure 1 | | Technical: water quality monitoring professionals<br><br>Financial: Funding to contract with GCHD to conduct sampling and analysis. Funding for Watershed Coordinator to apply for grant funding (possible sources include EPA, TCEQ, GBEP, HGAC) | Data provided on Partnership website | Years Two through Five or as funding allows | Development of sampling plan. | Sampling plan or QAPP.<br><br>Number of sites monitored.<br><br>Number of data points collected | Water quality sampling and analysis | GCHD: Complete sampling as funding is available<br><br>EPA, TCEQ, GBEP, HGAC: provide funding and technical support |

# Management Measure 2.0: Improve wastewater treatment facilities

The principal objective of this management measure is to improve the level of treatment at facilities permitted by the TCEQ to treat domestic and industrial wastewater.

In 2008, the TCEQ instituted a state-wide requirement to include water quality-based bacteria effluent limitations and monitoring requirements for facilities permitted to treat domestic wastewater and discharge to surface waters of the state. All new permits issued after 2008 for these types of facilities will contain the new state-wide requirements. Facilities with existing permits to treat domestic sewage will be required to incorporate the new requirements when they seek permit renewals or amendments. As a result of the Dickinson Bayou bacteria TMDLs, facilities permitted by the TCEQ to discharge treated domestic wastewater into Dickinson Bayou or one of its tributaries, must meet half of the new state-wide effluent bacteria limitations.

There are 11 permitted WWTFs that discharge into Dickinson Bayou and its tributaries (Figure 5). Eight of the 11 WWTFs in the watershed treat domestic wastewater[9] and therefore have the potential to contribute to the bacteria load (Table 2). There are multiple places where issues with WWTFs and their collection systems could result in unintended releases of untreated or partially treated effluent that could reach Dickinson Bayou and its tributaries, contributing bacteria to the stream. Collection pipes can break as they age or as the ground shrinks or swells, lift stations can malfunction, treatment facilities can experience overflows and sludge and sewage debris can leak. None of these problems are allowable under TCEQ-issued permits and the WWTFs are required to report and fix these issues. A properly functioning WWTF should not be contributing bacteria to the receiving water body, including Dickinson Bayou. The TCEQ has issued notices of violations to WWTFs in the watershed and, as of 2012; two facilities are under enforcement orders issued by the TCEQ for violating their permits.

In 2011, the TCEQ's Small Business and Environmental Assistance Division worked with several wastewater facilities in the Dickinson Bayou watershed, providing technical assistance, performing non-regulatory site visits and providing targeted education to one industrial and two domestic wastewater treatment facilities.

## Management Measure 2.1: Upgrade WWTFs

Each WWTF owner and/or operator will be responsible for evaluating the effectiveness of their facility in removing bacteria to meet the new TMDL permit requirements, which were set at one half the state-wide bacteria effluent limits.

[9] Texas Commission on Environmental Quality. 2011. *Eight Total Maximum Daily Loads for Bacteria in Dickinson Bayou and Three Tidal Tributaries*. pg. 28).

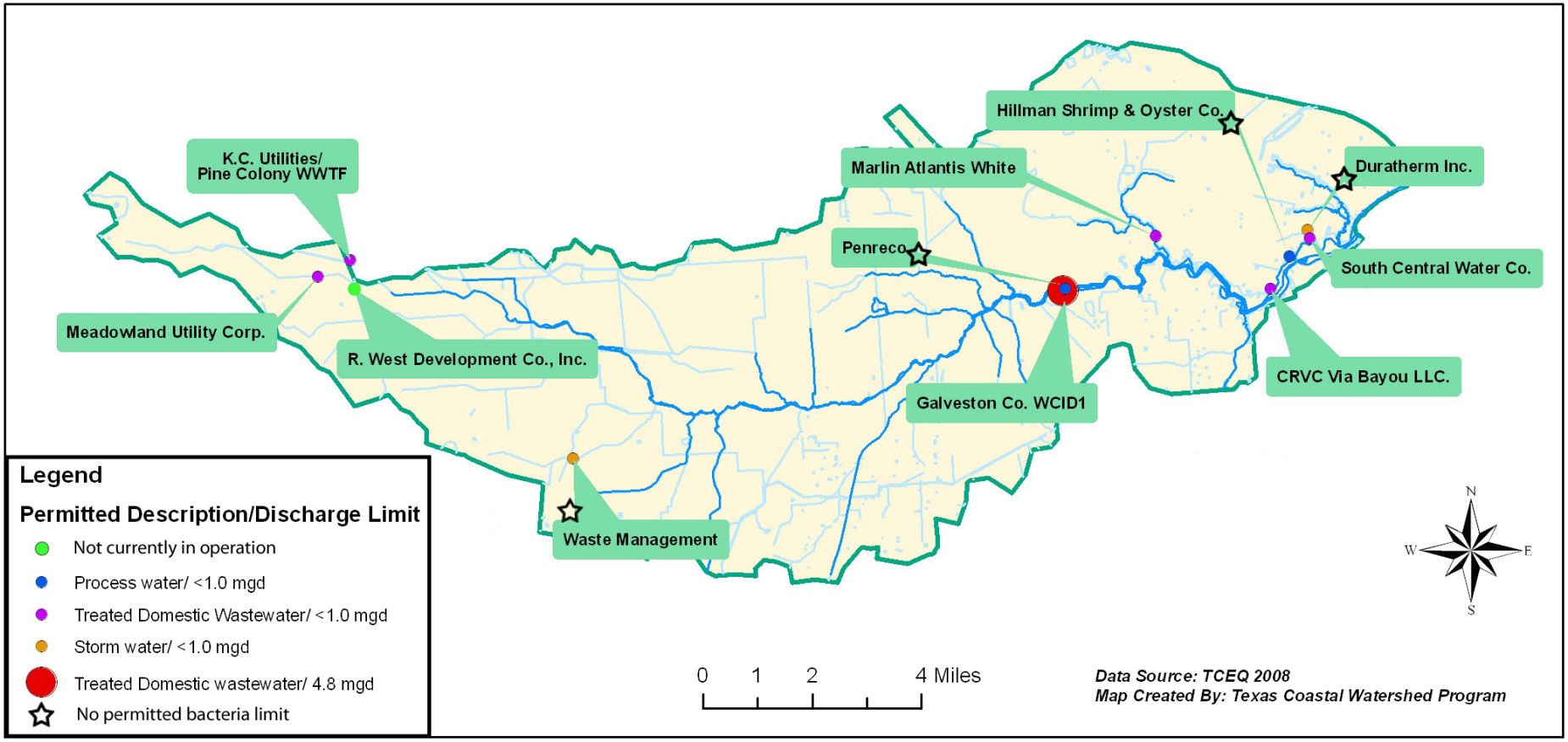


**Figure 5. Location, permitted capacity, and permit type for wastewater treatment facilities in the Dickinson Bayou watershed**

Information collected during the development of the TMDL revealed that several WWTFs in the watershed were unable to meet the effluent limits specified in their discharge permits. Also, as additional bacteria sampling is conducted, some currently compliant WWTFs may find that they are inadequately removing bacteria from their final effluent discharge under the new TMDL limits.

Facilities that are failing or fail to meet the requirements due to structural or design problems may need upgrades and/or repairs to bring the facility into compliance. As these facilities are upgraded and/or repaired, operators will need to be trained in the operations of any new components installed at each WWTF.

### *Responsible Organizations and Funding*

WWTF owners and operators will be responsible for monitoring compliance with bacteria limits and making appropriate upgrades. Upgrades may be funded through loans, grants, bonds, and local funding as appropriate for each facility. TCEQ Region 12, Houston, should provide reports to determine compliance with bacteria limits to the DBWD WWTF workgroup.

## Management Measure 2.2: Consider regionalization of discharge effluent (WWTFs and OSSFs), especially for new development

Beginning immediately, the TCEQ and local governments with jurisdictional authority will evaluate the possibility of regionalization, especially for new development. Regionalization is used here in a broad sense to include practices such as new development connections to existing WWTFs instead of installing OSSFs or new package plants; connecting homes with existing OSSFs to WWTFs; increasing capacity of existing WWTFs instead of adding new facilities to the system, etc. The Texas Water Development Board (TWDB) offers grants to political subdivisions of the state of Texas for studies and analyses to evaluate and determine the most feasible alternatives to meet regional wastewater facility needs, estimate the costs associated with implementing feasible regional wastewater facility alternatives, and identify institutional arrangements to provide regional water supply and wastewater services for areas in Texas.

It is important to use a standard set of criteria to determine the need for regionalization across the watershed. The DBWP WWTF workgroup will work with local experts to develop guidelines for regionalization and distribute it to local governments. The TCEQ Region 12 staff and local government staff with jurisdictional authority should be involved in developing guidelines as appropriate. The general public and local officials will be educated on the advantages of regionalization.

### *Responsible Organizations and Funding*

The DBWP WWTF Workgroup will work with local experts and appropriate regulatory agencies to develop guidelines and educate members of the public. The DBWP will seek grant funding for this activity. Local governments and the TCEQ

will help to distribute guidelines by including them in WWTF and OSSF permit applications and will also work to implement the recommendations themselves.

## Management Measure 2.3: Develop and implement an improved sanitary sewer overflow initiative plan/ program for individual SSSs

SSSs transport waste from homes and businesses to WWTFs. Breaks, leaks, and overflows in these systems, collectively referred to as sanitary sewage overflows, create a stream of untreated sewage that frequently travels though the stormwater system into Dickinson Bayou. Correcting the problems that cause SSOs can be difficult and costly, thus creating a plan to address SSO issues is the first step in solving the problem.[10]

The TCEQ already has a voluntary SSO initiative (SSOI). The DBWP proposes to work with owners/operators of WWTFs in the Dickinson Bayou watershed to develop one SSOI plan/program every 5 years for the life of this I-Plan, or until each WWTF in the watershed has a completed plan, or until each domestic WWTF in the watershed has a completed plan. Also, The DBWP proposes that one SSOI plan be implemented every 5 years for the life of the plan or until each WWTF in the watershed has an implemented plan.

### *Responsible Organizations and Funding*

The TCEQ is responsible for distributing educational materials about existing SSOI programs. SSS owners and operators are responsible for developing and implementing any SSOI plans. When appropriate, the DBWP WWTF Workgroup will help SSS owners and operators to develop the SSOI plans. The DBWP WWTF Workgroup will also monitor and report on the SSOI plans developed and implemented as a result of this management measure. The DBWP will seek funding for these activities from federal or state grant programs such as the CWA 319(h) grant program.

## Management Measure 2.4: Address fats, roots, oil, and grease (FROG)

FROG is a common problem that results in SSS failures. These constituents of concern clog and break pipes leading to overflows, malfunctions, and failures. It is important to address this issue to prevent failures from occurring. One way to address FROG is through developing regulations and policies that specifically address these issues.

It is important for communities to share existing regulations with one another to consolidate the regulations and policies across the watershed. Within 5 years, all existing regulations and policies in the watershed should be compiled and shared.

[10] Texas Commission on Environmental Quality. 2008. Sanitary Sewer Overflow (SSO) Initiative Information for Prospective Participants. TCEQ Regulatory Guidance, GI-389.

Communities in the watershed with existing FROG regulations and policies are committed to examining and updating them. If not currently in place, each community will consider creating and implementing an ordinance to address FROG.

FROG is an issue that spans all realms of the watershed from residential to commercial uses. The distribution of educational material related to FROG is important in informing people of the effects FROG can have on SSSs. Educational material is available through the TCEQ and other organizations. In addition to distributing educational material directed towards residential and commercial communities, FROG workshops will be held in the watershed or other local FROG workshops will be publicized to stakeholders in the Dickinson Bayou watershed.

### *Responsible Organizations*

Cities, counties, and watershed communities will provide existing regulations and policies, examine, establish and/or update regulations and policies as necessary, create ordinances to address FROG and distribute educational materials as appropriate. DBWP WWTF Workgroup will request and compile existing regulations and policies and will facilitate the harmonization of regulations and policies. DBWP and Water Environment Association of Texas (WEAT) will also assist with education as appropriate. The DBWP will seek grant funding for these activities.

## Management Measure 2.5: Encourage appropriate mechanisms to maintain function at lift stations

Given the relatively flat topography of the land in the Dickinson Bayou watershed, lift stations play an important role in pumping waste to facilities for treatment. Lift stations need to maintain function at all times to keep waste flowing. Currently, most lift stations in the watershed do not have mechanisms in place to maintain function during power failures or other unexpected failures. DBWP recommends that, every five years, 10 percent of the lift stations that need mechanisms to maintain function be upgraded in accordance with 30 Texas Administrative Code (TAC) Chapter 317 or 30 TAC Chapter 217, whichever is applicable to the situation. This 10 percent upgrade will occur every 5 years for the life of the I-Plan.

### *Responsible Organizations and Funding*

Cities, counties, and special purpose districts will upgrade lift stations with appropriate mechanisms to maintain functional lift stations and report progress to the WWTF Workgroup.

The DBWP WWTF Workgroup will collect and share information with the public every 5 years on the progress made upgrading lift stations.

The DBWP will be responsible for educating lift station owners about appropriate options and possible new technology. Upgrades will be funded by the lift station owner using grant funds, loans and local funding as appropriate for each owner.

# Control Action 1.0: Implement stricter bacteria limits and enforcement measures for WWTF effluent

As permit renewals, amendments, and new permits are written, the TCEQ will include limits that are consistent with the TMDLs for bacteria levels in effluent discharges for all WWTF permits in the Dickinson Bayou watershed (Table 7).

WWTF owners and operators will be informed that more stringent bacteria limits will be included in their new and updated permits. Knowing of these new requirements ahead of time will allow WWTF staff to begin sampling for bacteria early and allow them to identify any problems before they are in violation of the permit requirements. Violations should lead to enforcement actions from the TCEQ.

**Table 7. Current Limits for indicator bacteria in Wastewater Treatment Facility Effluent and Reductions in Effluent Concentrations Required under the TMDL**

| | Current Effluent Limit (mpn/100mL) | Effluent Limit after TMDL (mpn/100mL) |
|---|---|---|
| Non-Tidal (*E. coli*) | 126 | 63 |
| Tidal (Enterococci) | 35 | 17 |

## Responsible Organizations and Funding

The TCEQ will include lower bacteria limits in permits and inform WWTF owners/operators of these new more stringent requirements. WWTF owners and/or operators will meet the lower TMDL-based limits listed in their permit renewals or new permits.

The DBWP WWTF Workgroup will inform WWTFs operators of new requirements.

# Control Action 2.0: Increase compliance and enforcement by the TCEQ

Since 2000, the TCEQ conducted 49 inspections of WWTFs in the Dickinson Bayou watershed. However, stakeholders are concerned that there are insufficient quantities of investigations, reviews, and enforcement being performed by the TCEQ. The DBWP recommends that the TCEQ conduct unannounced and focused inspections with a goal to have all facilities inspected every two years. There are 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.

Currently, unannounced inspections can be performed at WWTFs that have been designated as poor performers or in response to complaints and other similar situations. Unannounced inspections have been shown to increase compliance. The DBWP assumes that unannounced WWTF inspections would yield similar results.

In addition to the restrictions on whether inspections must be announced, there are restrictions on the types of investigations that may be performed. For example, Comprehensive Compliance Inspections are required for inspections of mandatory facilities and can take days to complete. This severely limits the number of inspections that can be performed. The TCEQ should allow for and conduct focused investigations including inspections that just collect samples at all facilities. An investigator could then conduct numerous inspections in a single day.

For facilities that are not currently staffed, the DBWP recommends that the TCEQ develop a procedure to facilitate these inspections and investigations. For example, the TCEQ could require access within a defined, restricted period of time after providing notice by telephone to a posted number. The TCEQ should perform a workload analysis to correlate recent increases in wastewater fees from the regulated community to the allocation of staff for inspections and enforcement. If that analysis concludes that more staff is necessary, the TCEQ should hire additional employees. An alternative to hiring additional TCEQ employees would be for the TCEQ to consider contracting with a local program, as is done by the TCEQ for its air quality and waste management programs. Increasing the TCEQ staff or contracting with local programs would help ensure all plans and specifications are reviewed, a greater number of WWTFs are inspected each year, and Discharge Monitoring Reports are reviewed on a more frequent basis for effluent violations, non-submittal, and other issues.

## Responsible Organizations and funding

The TCEQ should determine staffing needs; conduct a workload analysis to determine the number of staff or contract funding needed; and explore the use of focused investigations, focused sampling investigations, and unannounced inspections at all WWTFs. The TCEQ may choose to contract with local programs to perform additional inspections and reviews, if additional TCEQ staff cannot be obtained.

DBWP WWTF Workgroup will collect reports from the TCEQ on the number and type of each inspection performed.

# Control Action 3.0: Revise penalties and violations for SSSs and WWTFs

The TCEQ revised its Penalty Policy to address concerns raised during its most recent Sunset review. The legislature added Texas Water Code Section 7.067 to allow the TCEQ discretion to approve a Supplemental Environmental Project (SEP) that would assist local governments that are respondents in enforcement actions to come into compliance with environmental laws or to remediate the harm caused by those violations. The statute requires the TCEQ to review the penalty policy regularly.

## Responsible Organizations and Funding

The TCEQ should revise penalty structures for all SSS and WWTF violations. DBWP WWTF Workgroup will evaluate progress.

# Control Action 4.0: Improve reporting capabilities for SSOs

The current electronic reporting system of SSS failures is not user friendly and a new system needs to be developed for better reporting. Within five years, the EPA and the TCEQ will have developed an appropriate database and technology for collecting and sharing information regarding SSOs. This database will allow for faster information exchange as SSS owners/operators will upload information regarding SSOs directly into a database via the internet instead of submitting forms to the TCEQ which are then input into the database. The reduction in TCEQ staff time to input data will free up staff for additional field inspections, increasing the number of reported SSOs.

## Responsible Organizations

The EPA and the TCEQ have been working on developing and deploying a SSO reporting database. Once the database is completed they should educate SSS owners/operators on how to use the database and report progress to the WWTF Workgroup. SSS owner/operators can then use the database to report SSOs. DBWP WWTF workgroup will collect and share information on the progress made each year.

## Measurable Milestones

### *Years 1 - 5*

- Increase compliance and enforcement by the TCEQ,
- Upgrade plants,
- Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new.

### *Year 2*

- The TCEQ will evaluate staffing needs and provide the resources needed to effectively perform inspections and reviews.

### *Years 4 - 5*

- Implement stricter bacteria limits and stricter enforcement measures for WWTF effluents in adherence with the TMDLs,
- Review penalty structure for SSS violations.

### *As Permits Come Up For Renewal/ As Resources Become Available*

- Develop and implement a SSOI plan/program for individual SSSs,
- Address FROG,
- Encourage appropriate mechanisms to maintain function at lift stations,
- Improve reporting capabilities for SSOs.

**Table 8: Summary for Management Measure 2: Improve WWTFs and Control Actions 1-4: WWTFs and SSSs**

Causes and Sources: WWTFs

| Management Submeasure or Control Action | Potential Load Reduction[11] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 2.1: Upgrade plants | For all WWTF Measures (Management Measures 2.1 and Control Action 1):<br><br>*E. coli* $4.33 \times 10^9$ mpn/day<br><br>Enterococcus $2.2 \times 10^9$ mpn/day | Technical: Engineering or other specialized technical help will be necessary.<br><br>Financial: WWTF owners fund monitoring | Operators will need to be trained in the operations of any new components at the WWTFs | Years One through Five: Beginning immediately, as individual WWTFs are found to be inadequate at bacteria removal | Beginning immediately, and continuing as appropriate: facilities requiring upgrades in order to meet bacteria limits in their permit will be upgraded within the five year implementation period | The number of non-compliant WWTFs upgraded | Reports from the TCEQ to determine compliance with bacteria limits | WWTF owners and operators: monitoring compliance with bacteria limits and making appropriate upgrades.<br><br>DBWP WWTF Workgroup: monitor compliance |
| Management Measure 2.2 Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new development | No immediate reduction of current loads foreseen. This measure will help prevent overloading in the future as communities within Dickinson Bayou watershed continue to grow | Technical: Engineering, legal, or other specialized technical help may be necessary<br><br>Financial: Funding for Watershed Coordinator to facilitate criteria development | TCEQ staff (compliance and enforcement) and local government staff with jurisdictional authority will need to be informed of newly developed criteria<br><br>Educate the public on the advantages of regionalization | Years One through Five: Beginning immediately, the TCEQ and local governments with jurisdictional authority will evaluate the possibility of regionalization, especially for new development | Develop and implement criteria for regionalization | Criteria developed.<br><br>Criteria implemented | Reports on local government's actions to regionalize | DBWP WWTF Workgroup: Develop criteria and educate public<br><br>Local Governments: Distribute criteria; including with permit applications<br><br>Implement criteria |

[11] See Appendix C for information on the methods and assumptions used to calculate Load Reductions

| Management Submeasure or Control Action | Potential Load Reduction[11] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 2.3: Develop and implement a SSOI plan/program for individual SSSs | For all SSS Failures (Management Measures 2.3-2.5):<br><br>*E. coli* $1.45 \times 10^9$ mpn/day<br><br>Enterococcus $4.03 \times 10^8$ mpn/day | Technical: Engineering, legal, or other specialized technical help may be necessary<br><br>Financial: SSS owners fund plans and on-the-ground projects through grants, loans, and existing local funding as available | The TCEQ should provide appropriate educational materials regarding SSOI program to SSS owners/operators | Years One through Five: As resources are available, implementation of this activity will begin immediately and will continue for the entire implementation process | One SSOI plan/program developed every 5 years<br><br>One SSOI plan/program implemented, every 5 years | Number of SSOI plans/programs developed<br><br>Number of SSOI plans/programs implemented | Monitor the number of SSOI plans/program developed and implemented each year in the Dickinson Bayou watershed | TCEQ: Education and permit requirements<br><br>SSS owners/operators: Develop and implement SSOI plan/program<br><br>WWTF Workgroup: Monitor and report on SSOI plans/programs |
| Management Measure 2.4: Address Fats, Roots, Oils and Grease (FROG) | | Technical:<br>-Regulations, ordinances, and orders of other communities, may serve as examples.<br>-Legal Assistance may be necessary.<br>-EPA, TCEQ, WEAT, and other agencies to offer some technical resources.<br><br>Financial: Funding for FROG workshop and Watershed Coordinator to liaise with communities. | Distribution of educational material related to FROG.<br><br>Hold FROG workshop or publicize other local workshops.<br><br>Public outreach for residential communities, home owners, and SSS owners. | Years One through Five<br>As resources are available, implementation of this activity will begin immediately and will continue for the entire implementation process. | Compile and share all existing regulations and policies with SSS owners in watershed within five years.<br><br>Each community should examine, update, and/or establish regulations and policies within 5 years.<br><br>Each community should create an ordinance to address FROG. | Number of flyers or other associated material distributed.<br><br>Number of Workshops publicized and held. | WWTF Workgroup will compile reports from watershed communities. | Watershed Communities:<br>-Provide existing regulations and policies.<br>-Examine, establish, and/or update regulations and policies as necessary.<br>-Create ordinances to address FROG.<br>-Distribute educational materials.<br><br>WWTF Workgroup: Request and compile existing regulations and policies.<br><br>DBWP: responsible for education |

| Management Submeasure or Control Action | Potential Load Reduction[11] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 2.5: Encourage appropriate mechanisms to maintain function at lift stations. | | Technical: Engineering, legal, or other specialized technical help may be necessary.<br><br>Financial: Lift station owners use grant, loans, and existing local funding as available to upgrade lift stations. | Educate responsible parties on all options available. | Years One through Five<br>As resources are available, implementation of this activity will begin immediately and will continue for the entire implementation process. | 10 percent of lift stations that need mechanisms to maintain function upgraded every 5 years for the life of the I-Plan. | Number of systems upgraded every five years.<br><br>Number of new systems with appropriate mechanisms installed. | WWTF Workgroup will compile reports from watershed communities | Cities, Counties, Special Purpose Districts and TCEQ: Should develop and deploy appropriate mechanisms, report progress to WWTF Workgroup.<br><br>WWTF Workgroup: collect and share information on the progress made every 5 years.<br><br>DBWP: responsible for education |
| Control Action 1.0: Implement stricter bacteria limits and stricter enforcement measures for WWTF effluents | For WWTF enforcement (Control Action 1.0)<br><br>*E. coli* $4.33 \times 10^9$ mpn/day<br><br>Enterococcus $2.20 \times 10^9$ mpn/day | Technical: None<br><br>Financial: Existing funding. If changes are needed by the facility to meet standard, additional local funds, loans or grant funds may be required. | Inform WWTF owners and operators that more stringent bacteria limits will be included in their permits. Inform WWTF owners and operators of funding opportunities and ways of securing loans | As permits come up for renewal or major amendments or as new permits are written, the TCEQ will include the new requirements in WWTF permits.<br><br>Within 5 years, the TCEQ should develop enhanced enforcement measure for bacteria violations. | Within five years all of the permits should have had renewals initiated with more stringent bacteria limits. | The number of permits which include more stringent bacteria limits. | Monitor the new, amended, and renewed permits issued each year in the Dickinson Bayou watershed containing more stringent bacteria limits. | TCEQ should: include lower limits in permits and inform WWTF owners/operators of more stringent requirements; develop enforcement measures for bacteria effluent violations.<br><br>WWTF owners and/or operators: meet the lower limits.<br><br>DBWP WWTF Workgroup: Inform all WWTFs of new requirements.<br><br>Monitor and report on updated permits. |

| Management Submeasure or Control Action | Potential Load Reduction[11] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Control Action 2.0<br>Increase compliance and enforcement by the TCEQ | For all WWTFs (Control Action 2):<br><br>*E. coli*<br>$1.72 \times 10^{11}$ mpn/day<br><br>Enterococcus<br>$4.78 \times 10^{10}$ | Technical: Training for TCEQ staff and/or local programs.<br><br>Financial: State or federal funding for additional staff or support of a local program to perform additional inspections and reviews. | New TCEQ staff or local programs conducting new activities will need to be trained. | Year One:<br>The TCEQ should determine the number of staff needed to perform inspections/ investigations at each WWTF every two years.<br>-the TCEQ should allow for additional types of investigations and more focused investigations in place of comprehensive compliance investigations.<br>-the TCEQ should allow for more unannounced inspections.<br><br>Years Two to Five: the TCEQ should reevaluate staffing needs and hire additional staff or contract with local programs, as needed, to perform inspections and reviews. | The ability of the TCEQ to conduct focused sampling investigation and unannounced inspections without cause.<br><br>An annual increase in:<br>-the number of unannounced inspections conducted each year.<br>-the number of focused sampling and focused investigations each year.<br>-the percent of plans and specifications reviewed.<br>-the number of other investigations conducted. | The number of unannounced inspections each year.<br><br>The number of focused sampling and focused investigations each year.<br><br>The percent of plans and specifications reviewed each year | Collection reports from the TCEQ including the number and types of inspections conducted, and the number of plans and specifications | Dickinson Bayou Watershed Partnership WWTF Workgroup:<br>Collection of reports.<br><br>TCEQ:<br>Should assess staffing needs; conduct a workload analysis to determine the number of staff needed, allow for focused investigations, focused sampling investigations and unannounced inspections at all WWTFs; contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. |

| Management Submeasure or Control Action | Potential Load Reduction[11] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Control Action 3.0<br>Restructure penalties for SSS violations | For all SSS Failures (Management Measures 2.3-2.5 and Control Actions 3 and 4)<br><br>*E. coli*<br>$1.45 \times 10^9$ mpn/day<br><br>Enterococcus<br>$4.03 \times 10^8$ mpn/day | Technical:<br>Legal assistance may be necessary.<br><br>Financial:<br>the TCEQ should use existing funding. | The TCEQ should offer a public participation process as appropriate. | Years Two through Five:<br>Within five years, have appropriate penalty structure revisions in place. | Within five years, have appropriate penalty structure revisions in place | Revised penalty structure for SSS violations | WWTF Workgroup will collect information from the TCEQ | TCEQ: should revise penalty structure.<br><br>WWTF Workgroup: evaluate progress. |
| Control Action 4.0<br>Improve Reporting capabilities for SSOs | | Technical:<br>EPA and the TCEQ will require technical assistance to develop appropriate database and reporting technologies. SSS owners/ operators may need broadband internet access or equivalent.<br><br>Financial:<br>existing local funding for the TCEQ and SSS owners/operators | The TCEQ and EPA should provide appropriate instructions to SSS operators for using statewide database. | Years One through Five:<br>As resources are available, implementation of this activity will begin immediately and will continue for the entire implementation process.<br><br>Within five years, EPA/TCEQ should have developed appropriate database and technology for collecting and sharing information regarding SSOs. Following the deployment of the database, SSS owners/operators shall begin using the database. | Deployment of appropriate database for tracking SSOs.<br><br>SSO reports available in five years from database | Creation of database.<br><br>Number of reports in the database.<br><br>Number of SSS owner /operators reporting SSOs | WWTF Workgroup will collect information from the TCEQ. | EPA/TCEQ:<br>Should develop and deploy database, educate SSS owners/ operators, report progress to WWTF Workgroup.<br><br>SSS owners/ operators:<br>report SSOs.<br><br>WWTF Workgroup:<br>Collect and share information on the progress made each year. |

## Management Measure 3.0: Promote participation in existing conservation and cost-share programs.

A variety of voluntary programs currently exist which provide landowners with the technical and/or financial assistance necessary to combine sustainable land stewardship activities with land production activities (e.g., livestock operations, wildlife habitat conservation operations, etc.). Landowner participation in these programs can reduce the amount of bacteria entering waterways by addressing issues related to water quality, soil erosion and sedimentation, livestock waste management, and other various issues.

The following is a list that highlights a number of programs available at the time this I-Plan was written:

- Environmental Quality Incentives Program (EQIP), administered by the Natural Resources Conservation Service (NRCS);
- Water Quality Management Plan Program (WQMP), a part of the Texas Non-Point Source Management Program administered by the Texas State Soil and Water Conservation Board (TSSWCB) through the soil and water conservation districts (SWCD);
- Conservation Innovation Grants (CIG), administered by the NRCS;
- Conservation Security Program (CSP), administered by the NRCS;
- Farm and Ranch Lands Protection Program (FRPP) , administered by the NRCS;
- Grassland Reserve Program (GRP), administered by the NRCS;
- Wetlands Reserve Program (WRP), administered by the NRCS; and
- Wildlife Habitat Incentives Program (WHIP), administered by the NRCS.

An outreach campaign can increase familiarity with, and promote subsequent participation in these programs. Public outreach efforts will be directed towards eligible landowners in the watershed and can include information on the types of programs available. Informational and promotional materials will be disseminated through a variety of means, including:

- Word of mouth from participants;
- Texas A&M AgriLife Extension Service agents' contact with the public;
- Public outreach from local SWCDs;
- Information disseminated through, rodeos, agricultural field days, the Texas Farm Bureau, the Texas and Southwestern Cattle Raisers Association, and the Independent Cattleman's Association of Texas;
- Information disseminated through local newspapers and radio stations; and
- Home Owners Associations (HOAs)

In addition to an outreach campaign, educational materials regarding BMPs for overall land stewardship will be disseminated to landowners in the watershed. Educational materials are currently available through several agencies, including the TCEQ, the TSSWCB, Texas A&M AgriLife Extension Service and SWCDs. Providing landowners access to these materials may increase the likelihood of adopting BMPs, whether independently or in conjunction with participation in one or more conservation and cost-share management programs.

## Responsible Organizations and Funding

The DBWP will distribute educational materials and facilitate communication between the organizations and potential participants when appropriate. The DBWP Animal Sources workgroup will also keep a tally of the number of landowners contacted through workshops who are interested in, and eligible for, participation in conservation programs. The TCEQ and TSSWCB, through the CWA Section 319(h) grant program, the TSSWCB, through the WQMP program, local SWCDs, NRCS, and Texas A&M AgriLife Extension Service will work with landowners to provide information, technical assistance, and/or financial assistance, as appropriate. These agencies are responsible for the existing voluntary programs in which landowners can participate.

## Management Measure 3.1: Promote the reduction of feral hog populations

Feral hogs are cited in the bacteria TMDL report as a potential source of bacterial loading to the Dickinson Bayou. With continuous effort, feral hog populations can be reduced to sustainable levels within the watershed. Along with habitat degradation due to their rooting and wallowing behavior, fecal waste from feral hogs increases the levels of bacteria and nutrients entering the environment and surrounding waterways. Increased participation in control efforts by both private and public landowners will help reduce the number of feral hogs living in the watershed, thus reducing their impact on the health of the bayou and its tributaries.

Feral hog control workshops for landowners, local governments, and other interested individuals will be organized by the DBWP. The Partnership will work collaboratively with various agencies to coordinate and conduct the workshops, including Texas Wildlife Damage Management Services, TPWD, Texas Animal Health Commission (TAHC), Texas Wildlife Damage Management Association (TWDMA), TSSWCB, and Texas A&M AgriLife Extension Service. Informational and promotional materials regarding workshops will be disseminated through a variety of means, including:

- Word of mouth from participants;
- Texas A&M AgriLife Extension Service agents' contact with the public;
- Public outreach from local SWCDs;

- Information disseminated through, rodeos, agricultural field days, and other commodities organizations; and
- Information disseminated through local newspapers and radio stations.
- HOAs

In addition to arranging training workshops, the DBWP will begin solicitation of municipal and county officials to hire a local trapper to cover the counties that fall in the Dickinson Bayou watershed. This trapper would be able to provide technical support to landowners and aid in the reduction of the feral hog population. The position would also serve as a spokesperson to educate landowners and other stakeholders on the importance of feral hog removal.

### *Responsible Organizations and Funding*

Educational materials will be created and distributed by the DBWP. This group will also be responsible for arranging feral hog training workshops. TSSWCB, local SWCDs, TPWD, TAHC, Texas Department of Agriculture (TDA), TWDMA and Texas A&M AgriLife Extension Service will work with landowners, and provide information, and technical assistance for feral hog control. The DBWP will begin soliciting regional government officials to hire a local trapper. Local government officials will be responsible for hiring the proposed local trapper and individual landowners will be responsible for reducing feral hog populations on private land.

## Management Measure 3.2: Expand pet owner education efforts.

Pet owner education is a crucial component of removing pet waste and preventing it from entering into nearby storm drains and waterways. A pet waste education campaign will be established, increasing the public's awareness of the negative effects pet waste can have on the environment. The campaign should also stress the proper ways of handling and disposing of pet and animal waste. This campaign should focus on all domestic pets and not solely on dogs and cats and can target specific neighborhoods and schools.

Educational material is currently available through several agencies, including the TCEQ, EPA, and Texas A&M AgriLife Extension Service. Providing pet owners access to this material may increase the likelihood of adopting appropriate pet waste management practices, whether at home or in public areas such as parks.

### *Responsible Organizations and Funding*

The DBWP will create and distribute educational materials through partnerships with cities, counties, HOAs, veterinarians, pet stores, and other interested groups. This campaign will focus on all domestic animals and not solely on dogs and cats. Some factsheets, posters, and educational materials have already been developed and will be printed and distributed by communities as part of their MS4 permit requirements. Additional funding will be sought from the Texas General Land Office Coastal Management Program (CMP), CWA Section 319(h), and additional sources as they arise.

## Management Measure 3.3: Install pet waste stations in parks and public areas

Providing the public with access to convenient and easy to use pet waste stations encourages pet owners to pick up and dispose of pet waste appropriately when in public. Installation of pet waste stations in common areas can play a key role in preventing bacteria from entering stormwater conveyance systems.

Promotional materials addressing the importance of pet waste stations will be distributed by the DBWP to managing organizations of parks and public areas, including city and county officials. Encouraging these organizations to install pet waste stations and getting pet owners to pick up after their pets are key components to reducing bacteria loads from pet waste. The DBWP will also work to help interested organizations apply for grant funding, such as CWA Section 319(h) grants, to help offset the costs of these stations. Funding will also be sought to design and purchase a standard placard to be placed on all pet waste stations in the watershed to increase education and usage of the stations. By educating pet owners and managing organizations on the affects pet waste has on the environment Management Measures 3.2 and 3.3 work together to achieve the goal of reducing bacteria loads deposited in the watershed by domestic animals.

### *Responsible Organizations and Funding*

Educational materials will be created and distributed by the DBWP. Managing organizations for parks or public areas with help from the DBWP, when appropriate, will acquire and install pet waste stations. Pet owners are responsible for picking up after their pets. Funding is available from the Texas General Land Office CMP, CWA 319(h), and additional sources that may arise.

## Management Measure 3.4: Improve HOA bylaws and ordinances for pet waste control

The density of pets is directly linked to population and urbanization. Heightened community awareness and local ordinance adoption and enforcement will help decrease the amount of pet waste allowed to enter waterways. Through educational efforts, HOAs can be encouraged by stakeholders, residents, and local businesses to include pet waste control provisions in new and existing bylaws. As no structural provisions are required for this specific measure, bylaws could easily be adopted.

HOAs have the ability to provide restrictions of animals per household in their coverage area. The number, type, and confinement of animals allowed at each household have a direct impact on the amount and distribution of fecal matter that can potentially enter stormwater conveyance systems. These bylaws and ordinances can address dogs, cats, and any animal that is not part of an agricultural operation. For example, rabbits being raised in a backyard pen or yard chickens used to produce eggs for personal use are two types of other (non-dog and cat) animals that these pet waste controls should address. These examples are not

intended to be exhaustive but only illustrative of the other types of pets that HOA's should address.

### *Responsible Organizations and Funding*

The DBWP will create and distribute educational materials and solicit local HOAs to adopt pet waste control bylaws or ordinances. Information will target HOAs and focus on the importance of having HOA bylaws in place. HOAs, with technical assistance from the DBWP when appropriate, will draft, implement, and enforce ordinances within their specific coverage area. Funding is available from the Texas General Land Office CMP, CWA Section 319(h), and additional sources that may arise.

## Management Measure 3.5: Increase awareness, develop, and enforce pet waste control ordinances

Municipalities within the watershed can adopt enforceable pet waste ordinances. Dickinson, League City, Alvin, and Friendswood have already passed ordinances however Kemah, Texas City and Santa Fe have not. Without having enforceable ordinances in place, pet waste collection is completely voluntary. These ordinances are critical, especially in high use public areas or areas that produce increased runoff during rains. Enforcement by local governments is necessary after ordinances have been adopted. Having "pooper scooper" laws, without enforcement, has not been effective as a sole approach in many communities.

Example Ordinances:

- City of Houston Department of Health and Human Services: Pooper Scooper Law – Section 6-24[12]
- City of Austin's Scoop the Poop Program: City Code 3-4-6 Defecation by Dog or Cat[13]

### *Responsible Organizations and Funding*

The DBWP will create and distribute educational materials. Information will need to be disseminated to local governments and elected officials focusing on the importance of adopting ordinances regarding pet control and actively enforcing the ordinances. Governmental officials will be responsible for drafting, adopting, implementing, and enforcing ordinances within their specific coverage area. Although no specific commitment to implement or enforce such ordinances has been made by the communities in the watershed, the DBWP is confident that the educational materials will help to gain these commitments. Funding is available from the Texas General Land Office CMP, CWA Section 319(h), and additional sources may arise.

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[12] Houston Department of Health and Human Services – Pooper Scooper Law: <www.houstontx.gov/health/quicktips/scooper%20law.pdf>

[13] City of Austin Scoop the Poop Program: <www.ci.austin.tx.us/watershed/downloads/scoop_the_poop_program_background.pdf>

## Management Measure 3.6: Promote BMPs for managing water quality for lands with large groups of animals not covered by other management measures such as a wildlife park, petting zoo or other animal feeding operations

A number of exotic animals can be found in the Dickinson Bayou watershed and most of these are located in petting zoos or the Bayou Wildlife Park. Since many of these exotic animals are larger than cattle and horses or are found in herds, they are potentially contributing large amounts of fecal matter to the bayou. The DBWP Animal Sources Workgroup consists of local experts who will work with land managers to create individual plans and help secure funding to reduce bacteria runoff. These plans may include exclusion fencing to keep animals out of the bayou and its tributaries to limit direct deposition of feces into the water ways and/or alternative sources of water and shade areas especially around ponds so animals will spend less time in drainage ditches, creeks, and streams. Finally, a treatment wetland demonstration project will be undertaken to capture and treat runoff from such sites.

Through site visits and information provided by the Bayou Wildlife Park, it is estimated that only 20% of the animal waste generated at the park is treated by existing BMPs. The goal of Management Measure 3.6 is to increase this percentage to 80% within the 5-year implementation period of this I-Plan.

### *Responsible Organizations and Funding*

DBWP Animal Sources Workgroup will provide technical assistance in BMP selection and design as well as assistance in applying for funding. Landowners are responsible for installing BMPs. Facilities such as wildlife parks and petting zoos fall between the cracks of traditional funding sources as they are not considered agriculture operations or zoos, and therefore cannot apply for funding in these categories. CWA Section 319(h) funding is the only source currently identified for these groups. For-profit facilities will help cost-share installation costs.

## Measurable Milestones

### *In Years 1-5*

- Number of landowners attending workshops who meet eligibility requirements for participation in conservation and cost-share programs. This data will be collected by the DBWP Animal Sources workgroup (Management Measure [MM] 3.0),
- The number of eligible landowners attending workshops and participating in new and expanded programs. This data will be collected by the DBWP Animal Sources workgroup (MM 3.0),
- Number of pet owner contacts and the number of promotional materials distributed (MM3.2),
- Number of pet waste stations installed (MM 3.3),
- Number of HOAs who adopted pet waste control by-laws (MM 3.4),

- Number of pet waste control ordinances adopted, educational materials created and disseminated, public education conducted (MM 3.5),
- The number of feral hog workshops offered,
- The number of attendees at feral hog workshops,
- Number of meetings with landowners and HOAs held,
- Number of conservation plans developed,
- Number of BMPs installed (MM 3.6).

**Table 9: Summary for Management Measure 3: Promote participation in existing conservation and cost-share programs**

Causes and Sources: Domestic and Wild Animals

| Management Measure | Potential Load Reduction[14] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 3.0: Promote participation in existing conservation programs. | For existing conservation programs:<br><br>*E. coli* $1.49 \times 10^8$ mpn/day<br><br>Enterococcus $4.14 \times 10^7$ mpn/day | Technical: Assistance will be provided to landowners by the TSSWCB, Waters Davis SWCD, Texas A&M AgriLife Extension Service, and the NRCS.<br><br>Financial: Costs depend on the goals for the property, the size of the management area, the existing condition of the property and the plan that is collaboratively developed with the various resource agencies. The SWCD's financial incentive for a Water Quality Management Plan is capped at $5,000. | Information will be disseminated via word of mouth from participants; Texas A&M AgriLife Extension Service agents' contact with the public; public outreach from local Soil and Water Conservation Districts; and through, rodeos, agricultural field days and other commodities organizations | Years One through Five: Beginning immediately, start efforts to identify eligible landowners in the watershed. | Of landowners who attend workshops, identification of those interested in participating in conservation projects and number of conservation plans developed. | Number of eligible landowners (who attend workshops) identified.<br><br>The number of eligible landowners participating in new and expanded programs.<br><br>The number of conservation plans developed. | Collect reports from participating agencies. | TSSWCB, NRCS, and Texas A&M AgriLife Extension Service: Work with landowners and provide information, and technical assistance. |

[14] See Appendix C for information on the methods and assumptions used to calculate Load Reductions

| Management Measure | Potential Load Reduction[14] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 3.2: Expand pet owner education efforts | For all pet waste reduction measures:<br><br>*E. coli* $1.59 \times 10^{13}$ mpn/day<br><br>Enterococcus $4.41 \times 10^{12}$ mpn/day | Technical:<br>Use existing technical resources for material development.<br><br>Financial:<br>Funding for educational programs and to distribute promotional materials | Promotional materials directed towards pet owners and school programs. | Years One through Five: Beginning immediately and ongoing. | Educational materials created and disseminated, public education conducted. | Number of pet owner contacts and the number of promotional materials distributed. | Educational materials created and disseminated, public education conducted. | Watershed Partnership: responsible for education. |
| Management Measure 3.3: Install Pet Waste Stations in Parks and Public Areas. | | Technical:<br>Use existing technical resources for material development.<br><br>Financial:<br>Funding for educational programs and to distribute promotional materials. Funding may be needed to purchase pet waste stations | Promotional materials directed towards managing organizations of park and public areas. | Years One through Five: Beginning immediately and ongoing. | Number of park organizations contacted. | Number of pet waste stations installed. | Routine monitoring. | Watershed Partnership: responsible for education.<br><br>Installation: Park organizations |
| Management Measure 3.4: Improve HOA bylaws and model ordinances. | | Technical:<br>Use existing technical resources for material development.<br><br>Financial:<br>Funding for Watershed Coordinator to put on educational programs and distribute promotional materials | Promotional materials and meetings with community representatives | Years One through Five: Beginning immediately and ongoing. | Bylaws/ ordinances developed, promoted, and presented. | Number of HOAs which adopted the measures. | Routine monitoring | Watershed Partnership: responsible for education.<br><br>HOA: Implementation |

| Management Measure | Potential Load Reduction[14] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 3.5: Increase awareness, development and enforcement of pet control ordinances | | Technical: Use existing technical resources for material development.<br><br>Financial: Funding for Watershed Coordinator to conduct educational programs and distribute promotional materials | Public awareness and education.<br><br>Information provided to community officials. | Years One through Five: Beginning immediately and ongoing. | Ordinances adopted, educational materials created and disseminated, public education conducted. | Number of ordinances adopted, educational materials created and disseminated, public education conducted. | Routine monitoring | Watershed Partnership: responsible for education.<br><br>Cities and Counties: Implementation |
| Management Measure 3.1: Promote the reduction of feral hog populations. | For feral hog management:<br><br>*E. coli* $1.57 \times 10^{11}$ mpn/day<br><br>Enterococcus $4.35 \times 10^{10}$ mpn/day | Technical: Existing technical resources such as feral hog management trainings offered by the Texas Wildlife Damage Management Service and others.<br><br>Financial: Funding to host workshop.<br><br>Funding for trapper position. | Trainings will be offered to landowners, land managers, local governments, and other interested parties on feral hog management and reduction methods. | Years One through Five: Beginning immediately, offer feral hog management workshops.<br><br>Solicit local officials to hire a local trapper. | The number of workshops offered each year. | The number of workshops offered.<br><br>The number of attendees at workshops. | Routine monitoring. | TSSWCB, local SWCDs, TPWD, TAHC, TDA, and Texas A&M AgriLife Extension Service: work with landowners and provide information, and technical assistance. |

| Management Measure | Potential Load Reduction[14] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 3.6<br>Promote BMPs for managing water quality for lands with large groups of animals not covered by other management measures such as a wildlife park, petting zoo or other animal feeding operation | For other animal operations:<br><br>*E. coli*<br>$5.81 \times 10^{11}$ mpn/day<br><br>Enterococcus<br>$1.61 \times 10^{11}$ mpn/day | Technical:<br>Use existing technical resources for plan development.<br><br>Financial:<br>Funding for project coordination, BMP design, and on-the-ground work. Some funds should come from land owner cost-share. | On-site meeting offered to landowners to discuss BMP options | Years One through Five:<br>Beginning immediately and continuing as funding allows | DBWP Animal Sources Workgroup works with land managers to create a plan to reduce bacteria runoff<br><br>BMPs implemented in riparian areas surrounding the bayou and tributaries. Alternative shade, especially around ponds.<br><br>Treatment wetland demonstration | Number of meetings held<br><br>Number of plans produced<br><br>Number of BMPs installed | Water quality monitoring, pre and post assessments for BMPs | Technical assistance:<br>DBWP animal sources workgroup<br><br>BMP installation:<br>Landowners |

# Management Measure 4.0: Restore and repair riparian zones

Vegetated riparian zones are an important component of our bayous that provide functional and esthetic value. Vegetated shorelines minimize soil erosion and naturally increase filtration of surface water runoff. In many areas of the watershed, Dickinson Bayou has little natural riparian buffer remaining. Much of the Bayou's shore line is mowed lawn with bulk heads which provides little water filtration. Adequate filtration is typically achieved when a riparian buffer of 5o feet or more exists along surface waterways.

There are programs available that assist landowners in evaluating their property and installing a natural alternative to bulk heads, often called a "living shoreline." In addition to the previously mentioned functions, these living shorelines also provide areas for fish to spawn and safe spots for fry to hide and grow, often improving fisheries in the areas where they are installed. GBF is the leader in local living shoreline programs. GBF typically works with home owners or HOA groups to plan, fund and execute smaller scale projects.

Larger scale restoration projects on public lands require development of extensive partnerships between, cities, counties, drainage districts, and agencies such as Texas A&M AgriLife Extension Service, TPWD, and USFWS. The DBWP will work with GBF to conduct workshops for home owners on living shorelines and other riparian restoration activities. The DBWP will also take a lead role in developing and maintaining partnerships to conduct restoration projects and will seek funding for these activities. The DBWP will set a goal of repairing and restoring 20% of all damaged or affected riparian zones within the first five years of implementation of this I-Plan.

## Responsible Organizations and Funding

Natural resource agencies and/or organizations provide technical assistance and financial assistance when available. TCEQ 139(h) grant funding is also available for work on public lands. Landowners are responsible for participating in programs and DBWP is responsible for leading partnership efforts and working with communities to submit grant applications.

## Measurable Milestones

### *In Years 1-5*

- Number of landowners participating in the workshops,
- Number of landowner workshops completed.

# Management Measure 5.0: Preserve and restore natural wetlands

Wetlands are a key part of the Upper Texas Gulf Coast ecosystem and add to the subtle beauty of coastal prairies. They are also an integral part of the hydrologic system that naturally cleans and detains stormwater as it makes its way to Galveston Bay. For these reasons, conservation and restoration of wetlands is a necessary component of water quality management. Preservation of wetlands in their natural state is one of the best ways to allow for natural filtration of bacteria from surface waters.

In 2008, the City of League City created a nature park on FM 96 near Highway 146 that protects tracts of native prairie pothole wetlands in a rapidly developing area. The DBWP will work to encourage preservation of wetlands through parks like this as well as the creation of conservation easements and other land acquisitions throughout the watershed. Protecting these natural lands is essential to improving the water quality in Dickinson Bayou. The DBWP will also conduct workshops for landowners and residents living in neighborhoods located within, or adjacent to, coastal prairie wetland areas to educate them on the advantageous of preserving coastal wetlands.

## Responsible Organizations and Funding

DBWP will encourage preservation and restoration. Cities, counties, and local land trusts will help landowners protect their lands. Some funding is available from land trusts for land acquisition and preservation, as well as incentives for creating conservation easements. Funding for restoration on public lands is available through a number of sources including the Texas General Land Office, Galveston Bay Estuary Program, Supplemental Environmental Project Program (SEPP), National Oceanic and Atmospheric Administration, USFWS, TPWD, and the National Fish and Wildlife Foundation.

## Measurable Milestones

### *In Years 1-5*

- Number of landowners participating in the workshops,
- Number of landowner workshops completed,
- Number of wetlands restored/preserved.

# Management Measure 6.0: Construct treatment wetlands

Constructed treatment wetlands clean water in the same ways as natural wetlands; wetland plants filter water as it passes through them and chemical and biological processes unique to wetlands render many pollutants harmless, making the water exiting the wetland much cleaner than when it entered. A local example is the Ma-

son Park stormwater wetland in Houston, Texas located along Brays Bayou. This wetland was designed to treat stormwater runoff from a 23 acre urban watershed while also providing natural habitat and esthetic beauty. The Mason Park wetland consistently removes 99% of bacteria from stormwater. This wetland has survived several severe floods and significant storm surges from hurricanes. It continues to provide all its design functions, especially improving water quality.[15]

Installation of a demonstration constructed treatment wetland was completed in the Dickinson Bayou watershed at the Clear Creek Independent School District's Education Village on FM 96 near Highway 146. This TCEQ-funded project retrofitted a treatment wetland into an existing detention basin to improve the quality of stormwater before it drains into Gum Bayou. The project was completed in 2011.

These two projects are real life, local examples of what can be accomplished through focused efforts. Projects of this scale require extensive partnerships between, cities, counties, drainage districts, and agencies such as the TCEQ, Texas A&M AgriLife Extension Service, TPWD, and USFWS. But, as with all enterprises subject to the effects of "economies of scale," installation of these systems becomes easier and less expensive with each project. The DBWP estimates that with adequate level of funding it may be feasible to increase the number of acres of constructed wetlands in the watershed by 200 acres per year over the five year implementation period of this I-Plan, a total of 100o acres over 5 years.

The DBWP will take a lead role in developing and maintaining partnerships and seeking funding for these projects. DBWP will work to provide workshops that include visits to these project sites and will encourage local officials to support and undertake these projects at their facilities and within their communities. The Texas A&M AgriLife Extension Services' Texas Coastal Watershed Program (TCWP) will work to provide expertise in technical and financial assistance and coordinate with other Texas A&M AgriLife Extension Service staffers as appropriate.

## Responsible Organizations and Funding

Natural resource management agencies and/or organizations such as the Texas A&M AgriLife Extension Service, USFWS, TPWD, Galveston Bay Estuary Program and the Texas General Land Office will provide technical assistance and financial assistance when available. CWA Section 319(h) grant funding is also available through the TCEQ for wetland construction work on public and private lands. Landowners will be responsible for participating in programs; DBWP is responsible for leading partnership efforts and coordination between interested parties when appropriate and assisting with funding applications.

[15] Sipocz, Marissa. (2008) Innovative Wetland on Brays Bayou Effectively Removes Bacteria from Polluted Stormwater Runoff [Press release]. Retrieved from <www.urban-nature.org/ urbanwet/documents/ e_coliarticle-master.pdf>

## Measurable Milestones

***In Years 1-5***

- Number of landowners participating in the workshops,
- Number of landowner workshops completed,
- Number of wetlands created.

# Management Measure 7.0: Provide demonstrations and encourage installation of stormwater BMPs including rain gardens, bioswales, and rain water harvesting

Low impact development (LID) BMPs are tools that mimic the natural hydrology of an area, allowing water to soak into the soil and as much as possible minimize runoff. The design of these BMPs is site-specific and most are intended to be small scale projects that can easily be incorporated into a new or existing yards, parking lots, or landscapes. Several local examples of BMPs exist including a rain garden at the City of Dickinson Public Library and a rain water harvesting system at San Leon Elementary School.

The DBWP will continue to distribute educational materials about BMPs and facilitate communication between organizations such as city governments, school districts, developers and other likely participants when appropriate. An outreach campaign will be established to increase familiarity with BMPs, and increase installation of these practices. Public outreach efforts will be directed towards eligible landowners in the watershed with informational and promotional materials disseminated through a variety of means, including:

- Word of mouth from participants;
- Information disseminated through local newspapers and radio stations;
- County Extension agents;
- Community newsletters;
- Hands-on workshops.

Many of these BMPs can be installed on public and private lands with little expense to the landowners. Many volunteer organizations including Master Naturalists, Master Gardeners, Keep Dickinson Beautiful, Girl Scouts, and Boy Scouts are willing to provide labor to install BMPs if they are asked.

## Responsible Organizations and Funding

Landowners are responsible for developing and implementing projects on private land. DBWP will help landowners consult with local natural resource and/or not-for-profit organizations to seek technical assistance, planning information and financial assistance.

## Measurable Milestones

### *In Years 1-5*

- Number of landowners participating in the workshops,
- Number of landowner workshops completed.

**Table 10: Summary for Management Measures 4-7: Riparian Zones, Wetlands, and BMPs**

Causes and Sources: Stormwater and Other Sources

| Management Measure | Potential Load Reduction[16] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 4.0: Restore and repair riparian zones | For restoring and repairing 20% of riparian zones<br><br>*E. coli*<br>$1.47 \times 10^{10}$ mpn<br><br>Enterococcus<br>$4.08 \times 10^{9}$ mpn | Technical:<br>Natural resource management and technical expertise is needed from partner agencies/organizations to landowners in the watershed.<br><br>Financial:<br>The costs depend on the goals for the property, the size of the management area, the existing condition of the property, and the plan that is collaborate developed with the various resource agencies/organizations. Grant funding for various programs may be available. | Landowner workshops and education addressing riparian area management.<br><br>Organizations work with landowners to develop plans, educational materials, and landowner workshop. | Years One through Five: Begin efforts to identify and recruit eligible landowners in the watershed. | Identification of interested landowners to participate in projects. | Number of landowners participating in the workshops.<br><br>Number of landowner workshops completed.<br><br>Number of projects completed or feet of riparian corridor re-stored/repaired. | Routine water quality monitoring<br><br>Targeted monitoring | Natural Resource Agencies and/or Organizations such as the Texas A&M AgriLife Extension Service, US Fish and Wildlife Service, TPWD, Galveston Bay Estuary Program and the Texas General Land Office<br><br>Landowners: Participation |

[16] See Appendix C for information on the methods and assumptions used to calculate Load Reductions

| Management Measure | Potential Load Reduction[16] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 5.0: Preserve and restore natural wetlands | Restoration of natural wetlands is typically a long-term activity. Although the DBWP will promote this activity, restoration of natural wetlands is not likely to happen within the 5-year I-Plan implementation window. Preservation of existing natural wetlands will provide no reduction to current bacteria loads, but without wetland preservation the bacteria load will increase. | Technical:<br>Natural resource management and technical expertise is needed from partner agencies/organizations to landowners in the watershed.<br><br>Financial:<br>The costs depend on the goals for the property, the size of the management area, the existing condition of the property, and the plan that is collaboratively developed with the various resource agencies/organizations. | Landowner workshops and education addressing wetland restoration and treatment wetlands.<br><br>Organizations work with landowners to develop plans, educational materials, and landowner workshop. | Years One through Five: Beginning immediately, start efforts to identify and recruit eligible landowners in the watershed. | Identification of interested landowners to participate in projects. | Number of landowners participating in the workshops. Number of landowner workshops completed.<br><br>Number of wetlands restored/created. | Routine water quality monitoring | Texas Coastal Watershed Program: Education; assist with grant applications for wetland restoration<br><br>Landowners: Participation |

| Management Measure | Potential Load Reduction[16] (cfu/day) | Technical and Financial Assistance | Education Component | Schedule of Implementation | Interim Measurable Milestones | Progress Indicators | Monitoring Component | Responsible Organizations |
|---|---|---|---|---|---|---|---|---|
| Management Measure 6.0: Construct treatment wetlands | *E. coli* $2.10 \times 10^{12}$ mpn<br><br>Enterococcus $5.85 \times 10^{11}$ mpn | Technical:<br>Resource management and technical expertise is needed from partner agencies/organizations to landowners in the watershed.<br><br>Financial:<br>Grant funding for demonstrations and installations when available. Additional funding/resources from landowners. | Landowner workshops and education addressing wetland restoration and treatment wetlands.<br><br>Organizations work with landowners to develop plans, educational materials, and landowner workshop. | Years One through Five: Demonstration treatment wetland in progress.<br><br>Additional projects as sites are identified and funding obtained. | Identification of interested landowners to participate in projects. | Number of landowners participating in the workshops.<br><br>Number of landowner workshops completed.<br><br>Number of treatment wetlands installed. | Routine water quality monitoring | Texas Coastal Watershed Program: Education; assist with grant applications for wetland construction projects<br><br>Landowners: participation |
| Management Measure 7.0: Provide demonstrations of and encourage installation of stormwater best management practices including rain gardens, bioswales and rain water harvesting | *E. coli* $1.05 \times 10^{12}$ mpn/day<br><br>Enterococcus $2.92 \times 10^{11}$ mpn/day | Technical:<br>Resource management and technical expertise is needed from partner agencies/organizations to landowners in the watershed.<br><br>Financial:<br>Grant funding for demonstrations and installations when available. Additional funding/ resources from landowners. | Landowner workshops and education Addressing LID BMPs.<br><br>Organizations work with landowners to develop plans, educational materials, and landowner workshop. | Years One through Five: Demonstrations currently in process.<br><br>Begin recruiting landowners for additional projects and continue for the life of the plan. | Identification of interested landowners to participate in projects. | Number of landowners participating in the workshops.<br><br>Number of landowner workshops completed.<br><br>Number of BMPs installed. | Routine water quality monitoring | Texas Coastal Watershed Program: Education; assist with grant applications for BMP demonstration projects<br><br>Landowners: Participation |

# Sustainability

The TCEQ and stakeholders in TMDL implementation projects periodically assess the results of the planned activities and other sources of information to evaluate the efficacy of the I-Plan. Stakeholders evaluate several factors, such as the pace of implementation, the effectiveness of BMPs, load reductions, and progress toward meeting water quality standards. The TCEQ will document the results of these evaluations and the rationale for maintaining or revising elements of the I-Plan, and will present them as summarized in the following section.

The TCEQ and stakeholders will track the progress of the I-Plan using both implementation milestones and water quality indicators. These terms are defined as:

- **Water Quality Indicator** – A measure of water quality conditions for comparison to pre-existing conditions, constituent loadings, and water quality standards.
- **Implementation Milestones** – A measure of administrative actions undertaken to effect an improvement in water quality.

## Water Quality Indicators

Water quality monitoring staff from the TCEQ and its Clean Rivers Program partners (H-GAC and University of Houston – Clear Lake) will continue to monitor the status of water quality during implementation of this plan as part of the TCEQ's Surface Water Quality Monitoring (SWQM) and Clean Rivers Programs. The following summary describes routine water quality monitoring activities for each of the eight AUs in the Dickinson Bayou watershed. The purpose of this monitoring is to collect *E. coli* and Enterococci data to determine water quality standards attainment throughout the watershed.

### AU 1103_02 Dickinson Bayou Tidal

Site 11462, Dickinson Bayou Tidal at IH 45 Bridge is located 9.81 mi upstream of the confluence of Dickinson Bayou and Dickinson Bay. This is a current and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1103_02.

### AU 1103_03 Dickinson Bayou Tidal

Site 11460, Dickinson Bayou Tidal at SH 3 Bridge in Dickinson, is 7.61 mi upstream of the confluence of Dickinson Bayou and Dickinson Bay. This is a current and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1103_03.

### AU 1103_04 Dickinson Bayou Tidal

Site 11455, Dickinson Bayou Tidal at SH 146 Bridge east of Dickinson, is 1.46 mi upstream of the confluence of Dickinson Bayou and Dickinson Bay. This is a cur-

rent and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1103_04.

### AU 1103A_01 Bensons Bayou

Site 16471, Bensons Bayou on Wagon Rd. is located 0.22 miles South of FM 517 in Dickinson, 0.10 mi upstream of Dickinson Bayou. This is a current and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1103A_01.

### AU 1103B_01 Bordens Gulley

Site 16469, Bordens Gulley at FM 517 Bridge in Dickinson is located 0.10 miles upstream of Dickinson Bayou. This is a current and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1103B_01.

### AU 1103C_01 Geisler Bayou

Site 16470, Geisler Bayou at FM517 Bridge in Dickinson, is 0.19 miles upstream of Dickinson Bayou. This is a current and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1103C_01.

### AU 1104_02 Dickinson Bayou Above Tidal

Site 11467, Dickinson Bayou at FM 517 is located east of Alvin, 16.59 mi upstream of the confluence of Dickinson Bayou and Dickinson Bay. This is a current and historical site monitored quarterly by the TCEQ and will provide quality assured data on bacteria for AU 1104_02.

The TCEQ will assess Dickinson Bayou every two years as part of updating the Integrated Report. Revisions to the Texas Surface Water Quality Standards criteria for contact recreation were under consideration at the time this plan was written. If the standards are revised or changes in the bayou's water quality are observed, this plan will be modified. This management strategy allows stakeholders to learn and adapt the plan as progress is made. The ultimate goal is for Dickinson Bayou's five AUs and three of its tidal tributaries to have sufficiently low indicator bacteria loading so that it meets water quality standards for contact recreation.

If sufficient reductions in indicator bacteria are not observed, the stakeholders will reevaluate the potential sources identified in the TMDL and adapt the I-Plan as appropriate.

## Implementation Milestones

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 get the plan back on tar-

get. Schedules of implementation activities and milestones for this I-Plan are included in Appendix A: The I-Plan Matrix.

# Communication Strategy

Communication is necessary to ensure all stakeholders understand the I-Plan and its progress in restoring water quality conditions. The TCEQ will disseminate the information derived from tracking I-Plan activities to interested parties, including watershed stakeholders, state leadership, government agencies, non-governmental organizations, and individuals.

The TCEQ will make information available on its web site regarding TMDL implementation activities in the Dickinson Bayou watershed. The TCEQ will also co-host annual meetings with the DBWP to review the progress of TMDL implementation with stakeholders and the general public. Responsible parties are committed to providing appropriate information to the TCEQ to update these progress assessments and communicating information at annual meetings. In accordance with CWA Section 319(h), the state must annually report to EPA on success in achieving the goals and objectives of the *Texas Nonpoint Source Management Program*, including progress in implementing the NPS portion of TMDLs. The TCEQ and TSSWCB jointly publish *Managing Nonpoint Source Water Pollution in Texas: Annual Report*, which highlights the state's efforts during each fiscal year to collect data, assess water quality, implement projects that reduce or prevent NPS pollution, and educate and involve the public to improve the quality of water resources. Information derived from tracking and review activities of this *I-Plan for Dickinson Bayou and Three Tidal Tributaries* will be reported in each annual report. Previously published annual reports are available at:

<www.tceq.texas.gov/waterquality/nonpoint-source/mgmt-plan/annual-reports.html>.

The TCEQ will be responsible for hosting annual meetings so stakeholders may evaluate their progress. Stakeholders will continue to take part in annual meetings for up to the next five years to evaluate implementation efforts. At the completion of the scheduled I-Plan activities, stakeholders will assemble and evaluate the actions, overall impacts, and results of their implementation efforts.

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# Appendix A.
# I-Plan Matrix

**Table A-1: OSSF Measures — Implementation Schedule and Tasks**

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 1** | | | |
| | TAMUG: Create OSSF Map<br><br>DBWP OSSF Workgroup: Monitor Progress. | Identify and rank target areas by need to upgrade systems and expand home owner education. | Creation of map. |
| | DBWP OSSF Workgroup: Determine prioritization criteria and prioritize target areas.<br><br>Watershed Partnership: Responsible for education. | | Criteria determined.<br>Areas Prioritized.<br>Number of OSSF Owners contacted in prioritized target areas. |
| | OSSF Owners: Upgrade and/or fix failing OSSFs.<br><br>Local governments: Technical assistance and seek funding<br><br>DBWP: Responsible for education. | Upgrade and/or fix identified failing systems. | The number of target areas addressed. |
| | Authorized Agents:<br>Acquire additional staff, educate staff, and conduct OSSF inspections.<br><br>DBWP OSSF Workgroup:<br>Request and collect reports from Authorized Agents. | Improve enforcement on failing systems. | Number of contacts with OSSF owners made by enforcement officials. |
| | Watershed Partnership: responsible for education.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of workshops offered, the number of attendees and the number of educational materials created and disseminated |
| | DBWP:<br>Creation of educational materials.<br><br>Real Estate Professionals:<br>Distribute information.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of educational materials created and disseminated. |
| **Year 2** | | | |
| | DBWP OSSF Workgroup:<br>Determine prioritization criteria and prioritize target areas.<br><br>Watershed Partnership:<br>Responsible for education. | Identify and rank target areas by need to upgrade systems and expand home owner education. | Criteria determined.<br>Areas Prioritized.<br>Number of OSSF Owners contacted. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 2, cont. | OSSF Owners:<br>Upgrade and/or fix failing OSSFs.<br><br>Local governments:<br>Technical assistance and seek funding<br><br>Watershed Partnership:<br>Responsible for education. | Upgrade and/or fix identified failing systems. | The number of target areas addressed. |
| | Authorized Agents:<br>Acquire additional staff, educate staff, and conduct OSSF inspections.<br><br>DBWP OSSF Workgroup:<br>Request and collect reports from Authorized Agents. | Improve enforcement on failing systems. | Number of contacts with OSSF owners made by enforcement officials. |
| | Watershed Partnership:<br>Responsible for education.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of workshops offered, the number of attendees and the number of educational materials created and disseminated |
| | Watershed group:<br>Creation of educational materials.<br><br>Real Estate Professionals:<br>Distribute information.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of educational materials created and disseminated. |
| **Year 3** | | | |
| | DBWP OSSF Workgroup:<br>Determine prioritization criteria and prioritize target areas.<br><br>Watershed Partnership:<br>Responsible for education. | Identify and rank target areas by need to upgrade systems and expand home owner education. | Criteria determined.<br>Areas Prioritized.<br>Number of OSSF Owners contacted in prioritized target areas. |
| | OSSF Owners: Upgrade and/or fix failing OSSFs.<br><br>Local governments:<br>Technical assistance and seek funding<br><br>Watershed Partnership:<br>Responsible for education. | Upgrade and/or fix identified failing systems. | The number of target areas addressed. |
| | Authorized Agents:<br>Acquire additional staff, educate staff, and conduct OSSF inspections.<br><br>DBWP OSSF Workgroup:<br>Request and collect reports from Authorized Agents. | Improve enforcement on failing systems. | Number of contacts with OSSF owners made by enforcement officials. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 3, cont. | Watershed Partnership:<br>Responsible for education.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of workshops offered, the number of attendees and the number of educational materials created and disseminated |
| | Watershed group:<br>Creation of educational materials.<br><br>Real Estate Professionals:<br>Distribute information.<br><br>DBWP OSSF Workgroup: Collection of information. | | The number of educational materials created and disseminated. |
| **Year 4** | | | |
| | DBWP OSSF Workgroup:<br>Determine prioritization criteria and prioritize target areas.<br><br>Watershed Partnership:<br>Responsible for education. | Identify and rank target areas by need to upgrade systems and expand home owner education. | Criteria determined.<br>Areas Prioritized.<br>Number of OSSF Owners contacted in prioritized target areas. |
| | OSSF Owners:<br>Upgrade and/or fix failing OSSFs.<br><br>Local governments:<br>Technical assistance and seek funding<br><br>Watershed Partnership:<br>Responsible for education. | Upgrade and/or fix identified failing systems. | The number of target areas addressed. |
| | Authorized Agents:<br>Acquire additional staff, educate staff, and conduct OSSF inspections.<br><br>DBWP OSSF Workgroup:<br>Request and collect reports from Authorized Agents. | Improve enforcement on failing systems. | Number of contacts with OSSF owners made by enforcement officials. |
| | Watershed Partnership:<br>Responsible for education.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of workshops offered, the number of attendees and the number of educational materials created and disseminated |
| | Watershed group:<br>Creation of educational materials.<br><br>Real Estate Professionals:<br>Distribute information.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | | The number of educational materials created and disseminated. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 5** | | | |
| | DBWP OSSF Workgroup:<br>Determine prioritization criteria and prioritize target areas.<br><br>Watershed Partnership:<br>Responsible for education. | Identify and rank target areas by need to upgrade systems and expand home owner education. | Criteria determined.<br>Areas Prioritized.<br>Number of OSSF Owners contacted. |
| | OSSF Owners:<br>Upgrade and/or fix failing OSSFs.<br><br>Local governments:<br>Technical assistance and seek funding<br><br>Watershed Partnership:<br>Responsible for education. | Upgrade and/or fix identified failing systems. | The number of target areas addressed. |
| | Authorized Agents:<br>Acquire additional staff, educate staff, and conduct OSSF inspections.<br><br>DBWP OSSF Workgroup:<br>Request and collect reports from Authorized Agents. | Improve enforcement on failing systems. | Number of contacts with OSSF owners made by enforcement officials. |
| | Watershed Partnership:<br>Responsible for education.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | The number of workshops offered, the number of attendees and the number of educational materials created and disseminated |
| | Watershed group:<br>Creation of educational materials.<br><br>Real Estate Professionals:<br>Distribute information.<br><br>DBWP OSSF Workgroup:<br>Collection of information. | | The number of educational materials created and disseminated. |
| **As Funding Becomes Available** | | | |
| | Watershed group:<br>Creation of educational materials.<br><br>Texas A&M AgriLife Extension Service:<br>Creation of course<br><br>DBWP OSSF Workgroup:<br>Collection of information. | Address maintenance of OSSFs. | Course developed.<br>Approval sought.<br>Number of Real Estate professionals completing the course. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| As funding availa-ble, cont. | OSSF workgroup: develop task force and determine criteria.<br><br>Inspectors: Incorporate criteria in inspections.<br><br>OSSF Workgroup: collection in-formation regarding number of home inspections.<br><br>Watershed group: responsible for education. | Incorporate OSSF criteria into standards of practice for home sale inspections | Task Force developed.<br>Inspection criteria developed.<br>Number of homes inspection with the inclusion of new crite-ria. |
| | GCHD: complete sampling as funding is available<br><br>HGAC, TCEQ: complete sampling if GCHD is unable | Target areas for intensive water quality sampling based upon mapping in Manage-ment Measure 1 | Number of points selected.<br>Number of samples collected |

**Table A-2: WWTF Measures — Implementation Schedule and Tasks**

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 1** | | | |
| | Dickinson Bayou Watershed Partnership WWTF Workgroup: Collection of reports.<br><br>TCEQ:<br>Staffing needs, conduct a workload analysis to determine the number of staff, allow for focused investigations, focused sampling investigations and unannounced inspections of all WWTFs. Contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. | Increase compliance and enforcement by the TCEQ | The number of unannounced inspections each year.<br>The number of focused sampling and focused investigations each year.<br>The percent of plans and specifications reviewed each year. |
| | WWTF owners and operators: Monitoring compliance with bacteria limits and making appropriate upgrades.<br><br>DBWP WWTF Workgroup: Monitor compliance. | Upgrade plants | All facilities requiring upgrades in order to meet bacteria limits in their permit will be upgraded. |
| | DBWP WWTF Workgroup: Develop criteria and educate public.<br><br>Local Governments:<br>Distribute criteria; including with permit applications. Implement criteria. | Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new. | Develop and implement criteria for regionalization. |
| **Year 2** | | | |
| | Dickinson Bayou Watershed Partnership WWTF Workgroup: Collection of reports.<br><br>TCEQ:<br>Staffing needs, conduct a workload analysis to determine the number of staff, allow for focused investigations, focused sampling investigations and unannounced inspections of all WWTFs. Contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. | The TCEQ will reevaluate staffing needs and hire additional staff or contract with local programs, as needed, to perform inspections and reviews. | The ability of the TCEQ to conduct focused sampling investigation and unannounced inspections without cause.<br>An annual increase in:<br>- the number of unannounced inspections conducted each year.<br>- the number of focused sampling and focused investigations each year.<br>-the percent of plans and specifications reviewed.<br>- the number of other investigations conducted |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 2, cont. | Dickinson Bayou Watershed Partnership WWTF Workgroup: Collection of reports.<br><br>TCEQ:<br>Staffing needs, conduct a workload analysis to determine the number of staff, allow for focused investigations, focused sampling investigations and unannounced inspections as all WWTFs. Contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. | Increase compliance and enforcement by the TCEQ | The number of unannounced inspections each year.<br>The number of focused sampling and focused investigations each year.<br>The percent of plans and specifications reviewed each year. |
| | WWTF owners and operators: Monitoring compliance with bacteria limits and making appropriate upgrades.<br><br>DBWP WWTF Workgroup: Monitor compliance. | Upgrade plants | All facilities requiring upgrades in order to meet bacteria limits in their permit will be upgraded. |
| | DBWP WWTF Workgroup: Develop criteria and educate public.<br><br>Local Governments:<br>Distribute criteria; including with permit applications. Implement criteria. | Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new. | Develop and implement criteria for regionalization. |
| **Year 3** | | | |
| | Dickinson Bayou Watershed Partnership WWTF Workgroup: Collection of reports.<br><br>TCEQ:<br>Staffing needs, conduct a workload analysis to determine the number of staff, allow for focused investigations, focused sampling investigations and unannounced inspections as all WWTFs. Contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. | Increase compliance and enforcement by the TCEQ | The number of unannounced inspections each year.<br>The number of focused sampling and focused investigations each year.<br>The percent of plans and specifications reviewed each year. |
| | WWTF owners and operators: monitoring compliance with bacteria limits and making appropriate upgrades.<br><br>DBWP WWTF Workgroup: Monitor compliance. | Upgrade plants | All facilities requiring upgrades in order to meet bacteria limits in their permit will be upgraded. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 3, cont. | DBWP WWTF Workgroup: Develop criteria and educate public.<br><br>Local Governments: Distribute criteria; including with permit applications. Implement criteria. | Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new. | Develop and implement criteria for regionalization. |
| **Year 4** | | | |
| | TCEQ: Include lower limits in permits and inform WWTF owners/operators of more stringent requirements. Develop enforcement measure for bacteria violation.<br><br>WWTF owners and/or operators: Meet the lower limits.<br><br>DBWP WWTF Workgroup: Inform all WWTFs of new requirements. Monitor and report on updated permits. | Implement stricter bacteria limits and stricter enforcement measures for wastewater treatment facility effluents | The number of permits which include more stringent bacteria limits. |
| | Dickinson Bayou Watershed Partnership WWTF Workgroup: Collection of reports.<br><br>TCEQ: Staffing needs, conduct a workload analysis to determine the number of staff, allow for focused investigations, focused sampling investigations and unannounced inspections of all WWTFs. Contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. | Increase compliance and enforcement by the TCEQ | The number of unannounced inspections each year.<br>The number of focused sampling and focused investigations each year.<br>The percent of plans and specifications reviewed each year. |
| | WWTF owners and operators: monitoring compliance with bacteria limits and making appropriate upgrades.<br><br>DBWP WWTF Workgroup: Monitor compliance. | Upgrade plants | All facilities requiring upgrades in order to meet bacteria limits in their permit will be upgraded. |
| | DBWP WWTF Workgroup: Develop criteria and educate public.<br><br>Local Governments: Distribute criteria; including with permit applications. Implement criteria. | Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new. | Develop and implement criteria for regionalization. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 4, cont. | TCEQ:<br>Revise penalty structure.<br><br>WWTF Workgroup:<br>Evaluate progress. | Revised penalty structure for SSS violations | Revised penalty structure for SSS violations |
| **Year 5** | | | |
| | TCEQ:<br>Include lower limits in permits and inform WWTF owners/operators of more stringent requirements. Develop enforcement measure for bacteria violation.<br><br>WWTF owners and/or operators:<br>Meet the lower limits.<br><br>DBWP WWTF Workgroup:<br>Inform all WWTFs of new requirements. Monitor and report on updated permits. | Implement stricter bacteria limits and stricter enforcement measures for Wastewater treatment facility effluents | The number of permits which include more stringent bacteria limits. |
| | Dickinson Bayou Watershed Partnership WWTF Workgroup:<br>Collection of reports.<br><br>TCEQ:<br>Staffing needs, conduct a workload analysis to determine the number of staff, allow for focused investigations, focused sampling investigations and unannounced inspections of all WWTFs. Contract with local programs to perform additional inspections and reviews if additional TCEQ staff cannot be obtained. | Increase compliance and enforcement by the TCEQ | The number of unannounced inspections each year.<br>The number of focused sampling and focused investigations each year.<br>The percent of plans and specifications reviewed each year. |
| | WWTF owners and operators:<br>monitoring compliance with bacteria limits and making appropriate upgrades.<br><br>DBWP WWTF Workgroup:<br>Monitor compliance. | Upgrade plants | All facilities requiring upgrades in order to meet bacteria limits in their permit will be upgraded. |
| | DBWP WWTF Workgroup:<br>Develop criteria and educate public.<br><br>Local Governments:<br>Distribute criteria; including with permit applications. Implement criteria. | Consider regionalization of discharge effluent (WWTFs and OSSFs), especially new. | Develop and implement criteria for regionalization. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 5, cont. | TCEQ:<br>Revise penalty structure.<br><br>WWTF Workgroup:<br>Evaluate progress. | Revised penalty structure for SSS violations | Revised penalty structure for SSS violations |
| **As Permits Come Up For Renewal/ As Resources Become Available** | | | |
| | TCEQ:<br>Include lower limits in permits and inform WWTF owners/operators of more stringent requirements. Develop enforcement measure for bacteria violation.<br><br>WWTF owners and/or operators:<br>Meet the lower limits.<br><br>DBWP WWTF Workgroup:<br>Inform all WWTFs of new requirements.<br>Monitor and report on updated permits. | Implement stricter bacteria limits and stricter enforcement measures for Wastewater treatment facility effluents | The number of permits which include more stringent bacteria limits. |
| | TCEQ:<br>Education and permit requirements.<br><br>SSS owners/operators:<br>Develop and implement SSOI plan/program.<br><br>WWTF Workgroup:<br>Monitor and report on updated permits. | Develop and implement a SSOI plan/program for individual SSSs. | Number of SSOI plans/programs developed.<br>Number of SSOI plans/programs implemented.<br>Number of permits containing SSOI plan/programs |
| | Watershed Communities:<br>-Provide existing regulations and policies.<br>-Examine, establish and/or update<br>regulations and policies as necessary<br>-Create ordinances to address FROG.<br>-Distribution of educational materials.<br><br>WWTF Workgroup:<br>Request and compile existing regulations and policies.<br><br>Watershed Partnership:<br>Responsible for education | Address Fats, Roots, Oils and Grease (FROG) | Number of flyers or other collateral material distributed. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| As permits renew / as funding is available, cont. | Cities, Counties, Special Purpose Districts, and TCEQ:<br>Develop and deploy appropriate mechanisms, report progress to WWTF Workgroup.<br><br>WWTF Workgroup:<br>Collect and share information on the progress made every 5 years.<br><br>Watershed Partnership:<br>Responsible for education. | Encourage appropriate mechanisms to maintain function at lift stations. | Number of systems upgraded every five years.<br>Number of new systems with appropriate mechanisms installed. |
| | EPA/TCEQ:<br>Develop and deploy database, educate SSS owners/operators, report progress to WWTF Workgroup.<br><br>SSS owner/operators:<br>Report SSOs.<br><br>WWTF Workgroup:<br>Collect and share information on the progress made each year. | Improve reporting capabilities for SSOs | Creation of database.<br><br>Number of reports in the database.<br><br>Number of SSS owner /operators reporting SSOs. |

**Table A-3: Animal Sources Measures — Implementation Schedule and Tasks**

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 1** | | | |
| | TSSWCB, local SWCDs, NRCS, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical and financial assistance. | Promote increased participation in existing conservation programs. | Number of eligible landowners identified from workshops.<br>Number of eligible landowners who participated in workshops which are participating in new and expanded programs from workshops. |
| | Watershed Partnership:<br>Responsible for education. | Expand pet owner education efforts. | Number of pet owner contacts and the number of promotional materials distributed. |
| | Watershed Partnership:<br>Responsible for education<br><br>Park organizations:<br>Installation | Install Pet Waste Stations in Parks and Public Areas. | Number of pet waste stations installed. |
| | Watershed Partnership:<br>Responsible for education.<br><br>HOA:<br>Implementation. | Improve HOA bylaws and model ordinances. | Number of HOA who adopted the measures. |
| | Watershed Partnership:<br>Education<br><br>Cities and Counties:<br>Implementation | Increase awareness, development, and enforcement of pet. control ordinances. | Number of ordinances adopted, educational materials created and disseminated, public education conducted. |
| | TSSWCB, local SWCDs, TAHC, TDA, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical assistance. | Promote the reduction of feral hog populations. | The number of workshops offered.<br>The number of attendees at workshops. |
| | DBWP animal sources workgroup:<br>Technical assistance<br><br>Landowners:<br>BMP installation | Promote BMPs for managing lands with large groups of animals not covered by other management measures, such as a wildlife park, petting zoo, or other animal feeding operation | Number of meetings held<br>Number of plans produced<br>Number of BMPs installed |
| **Year 2** | | | |
| | TSSWCB, local SWCDs, NRCS, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical assistance. | Promote increased participation in existing conservation programs. | Number of eligible landowners identified from workshops.<br>Number of eligible landowners who participated in workshops which are participating in new and expanded programs.<br>Number of conservation plans developed. |
| | Watershed Partnership:<br>Responsible for education. | Expand pet owner education efforts. | Number of pet owner contacts and the number of promotional materials distributed. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 2, cont. | Watershed Partnership: Responsible for education.<br><br>Park organizations: Installation | Install Pet Waste Stations in Parks and Public Areas. | Number of pet waste stations installed. |
| | Watershed Partnership: Responsible for education.<br><br>HOA: Implementation | Improve HOA bylaws and model ordinances. | Number of HOA who adopted the measures. |
| | Watershed Partnership: Education<br><br>Cities and Counties: Implementation | Increase awareness, development and enforcement of pet Control ordinances | Number of ordinances adopted, educational materials created and disseminated, public education conducted. |
| | TSSWCB, local SWCDs, TPWD, TAHC, TDA, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical assistance. | Promote the reduction of feral hog populations | The number of workshops offered.<br>The number of attendees at workshops. |
| | DBWP animal sources workgroup:<br>Technical assistance<br><br>Landowners:<br>BMP installation | Promote BMPs for managing lands with large groups of animals not covered by other management measures, such as a wildlife park, petting zoo, or other animal feeding operation. | Number of meetings held.<br>Number of plans produced.<br>Number of BMPs installed. |
| **Year 3** | | | |
| | TSSWCB, local SWCDs, NRCS, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical and financial assistance. | Promote increased participation in existing conservation programs. | Number of eligible landowners identified from workshops.<br>Number of eligible landowners who participated in workshops which are participating in new and expanded programs who participated in workshops.<br>The number of conservation plans developed. |
| | Watershed Partnership: Responsible for education. | Expand pet owner education efforts. | Number of pet owner contacts and the number of promotional materials distributed. |
| | Watershed Partnership: Responsible for education.<br><br>Park organizations: Installation | Install Pet Waste Stations in Parks and Public Areas. | Number of pet waste stations installed. |
| | Watershed Partnership: Responsible for education.<br><br>HOA: Implementation | Improve HOA bylaws and model ordinances. | Number of HOA who adopted the measures. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 3, cont. | Watershed Partnership: Education<br><br>Cities and Counties: Implementation | Increase awareness, development, and enforcement of pet Control ordinances. | Number of ordinances adopted, educational materials created and disseminated, public education conducted. |
| | TSSWCB, local SWCDs, TPWD, TAHC, TDA, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical assistance. | Promote the reduction of feral hog populations. | The number of workshops offered.<br>The number of attendees at workshops. |
| | DBWP animal sources workgroup:<br>Technical assistance<br><br>Landowners:<br>BMP installation | Promote BMPs for managing lands with large groups of animals not covered by other management measures such as a wildlife park, petting zoo, or other animal feeding operation | Number of meetings held.<br>Number of plans produced.<br>Number of BMPs installed. |
| **Year 4** | | | |
| | TSSWCB, local SWCDs, NRCS, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical and financial assistance. | Promote increased participation in existing conservation programs. | Number of eligible landowners identified from workshops.<br>Number of eligible landowners who participated in workshops which are participating in new and expanded programs who participated in workshops.<br>The number of conservation plans developed. |
| | Watershed Partnership: Responsible for education. | Expand pet owner education efforts. | Number of pet owner contacts and the number of promotional materials distributed. |
| | Watershed Partnership: Responsible for education.<br><br>Park organizations: Installation | Install Pet Waste Stations in Parks and Public Areas. | Number of pet waste stations installed. |
| | Watershed Partnership: Responsible for education.<br><br>HOA:<br>Implementation | Improve HOA bylaws and model ordinances. | Number of HOA who adopted the measures. |
| | Watershed Partnership: Education<br><br>Cities and Counties: Implementation | Increase awareness, development, and enforcement of pet Control ordinances. | Number of ordinances adopted, educational materials created and disseminated, public education conducted. |
| | TSSWCB, local SWCDs, TPWD, TAHC, TDA, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical assistance. | Promote the reduction of feral hog populations. | The number of workshops offered.<br>The number of attendees at workshops. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| Year 4, cont. | DBWP animal sources workgroup:<br>Technical assistance<br><br>Landowners:<br>BMP installation | Promote BMPs for managing lands with large groups of animals not covered by other management measures such as a wildlife park, petting zoo, or other animal feeding operation. | Number of meetings held.<br>Number of plans produced.<br>Number of BMPs installed. |
| **Year 5** | | | |
| | TSSWCB, local SWCDs, NRCS, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical and financial assistance. | Promote increased participation in existing conservation programs. | Number of eligible landowners identified from workshops.<br>Number of eligible landowners who participated in workshops which are participating in new and expanded programs who participated in workshops.<br>The number of conservation plans developed. |
| | Watershed Partnership:<br>Responsible for education. | Expand pet owner education efforts. | Number of pet owner contacts and the number of promotional materials distributed. |
| | Watershed Partnership:<br>Responsible for education.<br><br>Park organizations:<br>Installation | Install Pet Waste Stations in Parks and Public Areas. | Number of pet waste stations installed. |
| | Watershed Partnership:<br>Responsible for education.<br><br>HOA:<br>Implementation | Improve HOA bylaws and model ordinances. | Number of HOA who adopted the measures. |
| | Watershed Partnership:<br>Education<br><br>Cities and Counties:<br>Implementation | Increase awareness, development, and enforcement of pet Control ordinances. | Number of ordinances adopted, educational materials created and disseminated, public education conducted. |
| | TSSWCB, local SWCDs, TPWD, TAHC, TDA, and Texas A&M AgriLife Extension Service:<br>Work with landowners and provide information, and technical assistance. | Promote the reduction of feral hog populations | The number of workshops offered.<br>The number of attendees at workshops. |
| | DBWP animal sources workgroup:<br>Technical assistance<br><br>Landowners:<br>BMP installation | Promote BMPs for managing lands with large groups of animals not covered by other management measures such as a wildlife park, petting zoo, or other animal feeding operation | Number of meetings held.<br>Number of plans produced.<br>Number of BMPs installed. |

**Table A-4: Additional Sources Measures — Implementation Schedule and Tasks**

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 1** | | | |
| | Natural Resource Agencies and/or organizations.<br><br>Landowners: Participation | Restore and repair riparian zones. | Number of landowners participating in the workshops<br>Number of landowner workshops completed. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Preserve and restore natural wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands restored/preserved. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Construct treatment wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands created. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Provide demonstrations of and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of BMPs installed. |
| **Year 2** | | | |
| | Natural Resource Agencies and/or organizations.<br><br>Landowners: Participation | Restore and repair riparian zones. | Number of landowners participating in the workshops<br>Number of landowner workshops completed. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Preserve and restore natural wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands restored/preserved. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Construct treatment wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands created. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Provide demonstrations of and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of BMPs installed. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 3** | | | |
| | Natural Resource Agencies and/or organizations.<br><br>Landowners: Participation | Restore and repair riparian zones | Number of landowners participating in the workshops<br>Number of landowner workshops completed. |
| . | Texas Coastal Watershed Program:<br>Education<br><br>Landowners:<br>Participation | Preserve and restore natural wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands restored/ preserved. |
| | Texas Coastal Watershed Program:<br>Education<br><br>Landowners:<br>Participation | Construct treatment wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands created. |
| | Texas Coastal Watershed Program:<br>Education<br><br>Landowners: Participation | Provide demonstrations of and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of BMPs installed. |
| Year 4 | | | |
| | Natural Resource Agencies and/or organizations.<br><br>Landowners:<br>Participation | Restore and repair riparian zones. | Number of landowners participating in the workshops<br>Number of landowner workshops completed. |
| | Texas Coastal Watershed Program:<br>Education<br><br>Landowners:<br>Participation | Preserve and restore natural wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands restored/ preserved. |
| | Texas Coastal Watershed Program:<br>Education<br><br>Landowners:<br>Participation | Construct treatment wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands created. |
| | Texas Coastal Watershed Program:<br>Education<br><br>Landowners:<br>Participation | Provide demonstrations of and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of BMPs installed. |

| Plan Year | Responsible Parties | Implementation Measure | Implementation Milestones |
|---|---|---|---|
| **Year 5** | | | |
| | Natural Resource Agencies and/or organizations.<br><br>Landowners: Participation | Restore and repair riparian zones. | Number of landowners participating in the workshops<br>Number of landowner workshops completed. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Preserve and restore natural wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands restored/preserved. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Construct treatment wetlands. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of wetlands created. |
| | Texas Coastal Watershed Program: Education<br><br>Landowners: Participation | Provide demonstrations of and encourage installation of stormwater best management practices including rain gardens, bioswales, and rain water harvesting. | Number of landowners participating in the workshops<br>Number of landowner workshops completed.<br>Number of BMPs installed. |

# Appendix B.
# Pet Waste Ordinance Examples

# Example 1:
# City of Houston Pooper Scooper Law Section 6-24: Defecation by dogs or cats

"Section 6-24. Defecation by dogs or cats.

(a) It is the duty of each person in control of a dog or cat to promptly remove and dispose of, in a sanitary manner, feces left by such dog or cat.

(b) It shall be the duty of each person in control of a dog or cat to be in possession of materials to remove feces left by such dog or cat.

(c) It is an affirmative defense to prosecution under this section that the person in control of the dog or cat is the owner of the premises, or the owner's agent of the premises, where the dog or cat deposits feces."

(d) Violation of this section is unlawful and any violation shall be punishable upon conviction by a fine of not less than $75.00 or more than $500.00. Each act in contravention of this section is a separate offense."

# Example 2:
# City of Austin Section 3-4-6: DEFECATION BY A DOG OR CAT.

An owner or handler shall promptly remove and sanitarily dispose of feces left on public or private property by a dog or cat being handled by the person, other than property owned by the owner or handler of the dog or cat.

*Source: City of Austin Scoop the Poop Program: <www.ci.austin.tx.us/watershed/downloads/scoop_the_poop_program_background.pdf>*

# Appendix C: Load Reductions

# Management Measures 1.1-1.6 Load Reduction

This section describes the estimates of the potential bacteria load reductions that can be achieved by the effort to repair or replace OSSFs within the Dickinson Bayou watershed. The *E. coli* loading from malfunctioning OSSFs is estimated by using the following equation from the US EPA 2001 document, *Protocol for Developing Pathogen TMDLs.*[17]

$$\text{\# counts} = (\text{\# failing systems}) * \frac{106 \text{ counts} * 0.8\text{x } 0.125\%}{100 \text{ mL}} * \frac{70 \text{ gallons}}{\text{person*day}} * \frac{\text{\# persons}}{\text{household}} * \frac{3785.2 \text{ mL/day}}{\text{gallon}}$$

Inputs and assumptions associated with this equation include:

1) Housing structures not tied into a sanitary sewer system are presumed to have OSSFs.
2) There are 1419 permitted OSSFs within Dickinson Bayou watershed.
3) There are an estimated 3772 unpermitted OSSFs in Dickinson Bayou watershed.
4) A 25% failure rate for permitted OSSF systems and 35% failure rate for unpermitted systems.[18]
5) Fecal coliform concentrations in OSSF effluent were estimated to be $10^6$/100 milliliters of effluent. In general, *E. coli* concentrations are approximately 63% of fecal coliform concentrations. An *E. coli* concentration of 1000 mpn/100 mL is assumed because some treatment level is expected even from malfunctioning OSSFs.
6) Water use of 70 gallons per person per day.
7) 2.75 persons per household, in Texas, according to the 2010 U.S. census.
8) Conversion factor of 35 Enterococcus/126 *E. coli* used for Enterococcus calculations

Given the assumptions and considerations shown above, the *E. coli* loading to Dickinson Bayou from malfunctioning OSSFs comes to 1.21 x $10^{11}$ mpn/day. The Enterococcus loading to Dickinson Bayou is 2.4 x $10^{11}$ mpn/day.

## Load Calculation

If 10 percent of OSSFs are inspected each year and malfunctioning systems are repaired or replaced, an expected daily *E. coli* load reduction of 9.61 x $10^8$ mpn/day and Enterococcus load reduction of 2.67 x $10^8$ mpn is possible each year**.** The ex-

[17] US Environmental Protection Agency. (2001). *Protocol for Developing Pathogen TMDLs* (EPA 841-R-00-002). Washington, D.C.: Environmental Protection Agency.

[18] Texas Commission on Environmental Quality. (2011) *Eight Total Maximum Daily Loads for Bacteria in Dickinson Bayou and Three Tidal Tributaries.*

pected daily bacteria load reduction after the 5 year implementation period is 4.81 x $10^9$ mpn/day for *E. coli* and 1.34 x $10^9$ mpn/day for Enterococcus**.** The location of the system and its proximity to the bayou or tributaries, as well as the severity of the malfunction could result in a greater or lesser bacteria load to the water body than what is assumed in the above calculation.

# Control Action 1.0 Load Reduction

This section describes the calculation of the expected load reduction of indicator bacteria if permitted WWTF effluents concentration limits are decreased by ½, as described in the Dickinson Bayou Bacteria TMDL document. The mass balance calculation used is the following:

# counts/day = (swqs*flow*unit conversion factor) – (1/2*swqs*flow*unit conversion factor)

Inputs and assumptions associated with this equation include:

1) The average self-reported daily flow in million gallons per day (MGD) for each facility is used. For facilities lacking self-reported flow data (i.e., Brazoria Co. MUD #24 and Marlin Atlantis White), the full permitted flow is used in the calculation.
2) The unit conversion factor is 37,854,120 (100mL/MG).
3) The criteria used to assess attainment of the primary contact recreation standard (swqs) in fresh water (126 mpn/100 mL *E. coli*) and saline water (35 mpn/100 mL Enterococcus) is used.

The current permitted WWTF effluents concentration limits for *E. coli* and Enterococcus are 126 mpn/100mL and 35 mpn/100mL, respectively. As a result of the Dickinson Bayou bacteria TMDL, WWTFs in the watershed will reduce these limits to 63 mpn/100mL *E. coli* and 17 mpn/100mL Enterococcus. This measure should be easily implemented within the Dickinson Bayou watershed because most of the WWTFs in the Dickinson Bayou watershed are already discharging below the new limit.

## Load Calculation

# counts/day = (swqs*flow*unit conversion factor) – (1/2*swqs*flow*unit conversion factor)

> *Waste Management of Texas (Discharges above tidal,* E. coli *limit)*
> (126 mpn/100mL * 0.829 MG/day * 37854120 100mL/MG) – (1/2 * 126 mpn /100mL* 0.829 * 37854120 100mL/MG) = **1.98 x $10^9$ mpn /day**

*Meadowland (Discharges above tidal,* E. coli *limit)*
(126 mpn /100mL * 0.009 MG/day * 37854120 100mL/MG) – (1/2 * 126 mpn /100mL * 0.009 MG/day * 37854120 100mL/MG) = **$2.15 \times 10^7$ mpn /day**

*Brazoria Co MUD #24 (Discharges above tidal,* E. coli *limit)*
(126 mpn /100mL * 0.95 MG/day * 37854120 100mL/MG) – (1/2 * 126 mpn /100mL* 0.95 MG/day * 37854120 100mL/MG) = **$2.27 \times 10^9$ mpn /day**

*Pine Colony (Discharges above tidal,* E. coli *limit)*
(126 mpn /100mL*0.026 MG/day * 37854120 100mL/MG) – (1/2 * 126 mpn /100mL * 0.026 MG/day * 37854120 100mL/MG) = **$6.2 \times 10^7$ mpn /day**

*Penreco (Discharges to tidal segment, Enterococcus limit)*
(35 mpn /100mL * 0.57 MG/day * 37854120 100mL/MG) – (1/2* 35 mpn /100mL * 0.026 MG/day * 37854120 100mL/MG) = **$3.78 \times 10^7$ mpn /day**

*Galveston Co WCID #1 (Discharges to tidal segment, Enterococcus limit)*
(35 mpn /100mL * 2.759 MG/day * 37854120 100mL/MG) – (1/2* 35 mpn /100mL * 2.759 MG/day * 37854120 100mL/MG) = **$1.83 \times 10^9$ mpn /day**

*Marlin Atlantis White (Discharges to tidal segment, Enterococcus limit)*
(35 mpn /100mL * 0.5 MG/day * 37854120 100mL/MG) – (1/2* 35 mpn /100mL * 0.5 MG/day * 37854120 100mL/MG) = **$3.31 \times 10^8$ mpn /day**

*Hillman Shrimp and Oyster (Discharges to tidal segment, Enterococcus limit)*
(35 mpn /100mL * 0.005 MG/day * 37854120 100mL/MG) – (1/2* 35 mpn /100mL * 0.005 MG/day * 37854120 100mL/MG) = **$3.31 \times 10^6$ mpn /day**

*Via Bayou (Discharges to tidal segment, Enterococcus limit)*
(35 mpn /100mL * 0.002 MG/day * 37854120 100mL/MG) – (1/2* 35 mpn /100mL * 0.002 MG/day * 37854120 100mL/MG) = **$1.32 \times 10^6$ mpn /day**

### Total *E. coli* Reduction

$1.98 \times 10^9$ mpn /day + $2.15 \times 10^7$ mpn /day + $2.27 \times 10^9$ mpn /day + $6.2 \times 10^7$ mpn /day = $4.33 \times 10^9$ mpn /day = **$4.33 \times 10^9$ mpn /day**

### Total Enterococcus Reduction

$3.78 \times 10^7$ mpn /day + $1.83 \times 10^9$ mpn /day + $3.31 \times 10^8$ mpn /day + $3.31 \times 10^6$ mpn /day + $1.32 \times 10^6$ mpn /day = **$2.20 \times 10^9$ mpn /day**

# Control Action 2.0 Load Reduction

This section describes the calculations made using best available resources to estimate the expected load reductions of indicator bacteria if currently non-compliant WWTFs in the Dickinson Bayou watershed are made compliant, with the current

bacteria effluent limits. This will be achieved through increases in monitoring and enforcement by the TCEQ as well as plant upgrades if necessary. The mass balance calculation used is the following:

Bacteria Load Reduction (mpn/day) = ($Effluent_{ave}$*$flow_{ave}$*unit conversion factor) – (swqs*$flow_{ave}$*unit conversion factor)

Inputs and assumptions associated with this equation include:

1) The average effluent concentration measured at each noncompliant facility during the development of the bacteria TMDL is used ($Effluent_{ave}$).
2) The average annual flow in million gallons per day (MGD) for each facility is used.
3) The unit conversion factor is 37,854,120 (100mL/MG).
4) The criterion used to assess attainment of the primary contact recreation standard (swqs) in fresh water is 126 mpn/100 mL *E. coli* and is used in the load reduction calculation. Both facilities included in this calculation discharge to fresh water.

This calculation determines the bacteria load reductions achieved if the two wastewater treatment facilities identified in the TMDL report as consistently noncompliant (Pine Colony and Meadowland Utilities) begin discharging at their permitted limits. The base line effluent bacteria concentrations used in the calculations were taken from the Dickinson Bayou bacteria TMDL report and are based on samples of effluent collected by UH and the TCEQ. The *E. coli* load reduction estimate derived from this calculation is 1.72 x $10^{11}$mpn/day for the two facilities. The Enterococcus load reduction estimate derived from this calculation is 4.78 x $10^{10}$ mpn/day for the two facilities.

## Load Calculation

*Pine Colony (Discharges above tidal,* E. coli *limit)*
(1.32 x $10^5$ mpn *E. coli*/100mL * 0.026 MG/day * 37,854,120 100mL/MG) – (126 mpn *E. coli*/day * 0.026 MG/day *37,854,120 100mL/MG) = **1.30 x $10^{11}$ mpn /day**

*Meadowland (Discharges above tidal,* E. coli *limit)*
(1.23 x $10^5$ mpn/100mL * 0.009 MG/day * 37,854,120 100mL/MG) – (126 mpn/day * 0.026 MG/day * 37,854,120 100mL/MG) = **4.18 x $10^{10}$ mpn/day**

### Total

*Pine Colony reduction + Meadowland reduction = Total reduction*
1.30 x $10^{11}$ mpn/day + 4.18 x $10^{10}$ mpn/day = **1.72 x $10^{11}$ mpn/day**

# Management Measure 2.3 Load Reduction

This section describes the calculations of expected indicator bacteria load reductions from reducing the number of SSOs occurring within the Dickinson Bayou watershed. Currently only the SSS owned and operated by Galveston County Water Control and Improvement District (GCWCID) No. 1 has reported any SSOs but it can be assumed that other SSSs have SSOs and fail to report them. For this calculation only the data available from GCWCID No. 1 was used, since it is the only SSO data available. The mass balance calculation used is the following:

> SSO indicator bacteria load per day = (Total gallons lost in SSOs during implementation period* unit conversion factor (mL/gal) * indicator bacteria concentration (mpn/mL) / number of implementation days

Over 6 years of SSO data were obtained from May 2002 to September 2008 for the Dickinson Bayou TMDL. 386,900 gallons of untreated sewage were reported as overflows during the study period.

The following assumptions where used for the load reduction calculations:

1) *E. coli* concentration in untreated wastewater is assumed to be $1.5 \times 10^4$ mpn/mL[19]
2) All overflow is expected to reach Dickinson Bayou or its tributaries unimpeded
3) Unreported SSOs are not considered
4) SSOI can reduce SSOs by 25% each year

With reduction in SSOs of 25% per year the average daily reduction in bacteria load to Dickinson Bayou will be $1.45 \times 10^9$ mpn/day for *E. coli* and $4.03 \times 10^8$ mpn/day for Enterococcus.

## Load Calculation

### Current *E. coli* load

> (386,900 gallons * 3785.41178 mL/gal * $1.5 \times 10^4$ mpn/mL) / 2312 days = $9.50 \times 10^9$ mpn/day

### E. coli Load Reduction

> Current *E. coli* load per day * percent reduction = reduction in mpn per day

### Year 1

> {((386,900 gallons * 3785.41178 mL/gal)/2312) *0.25} * $1.5 \times 10^4$ mpn/mL = $2.38 \times 10^9$ mpn/day

[19] Texas Commission on Environmental Quality. (2011) *Eight Total Maximum Daily Loads for Bacteria in Dickinson Bayou and Three Tidal Tributaries*.

**Year 2**

$(1.19 \times 10^5$ mL) * $1.5 \times 10^4$ mpn/mL = $1.78 \times 10^9$ mpn/day

**Year 3**

$(8.91 \times 10^4$ mL) * $1.5 \times 10^4$ mpn/mL = $1.34 \times 10^9$ mpn/day

**Year 4**

$(6.68 \times 10^4$ mL) * $1.5 \times 10^4$ mpn/mL = $1.00 \times 10^9$ mpn/day

**Year 5**

$(5.01 \times 10^4$ mL) * $1.5 \times 10^4$ mpn/mL = $7.52 \times 10^8$ mpn/day

**Total E. coli Load Reduction**

Load reduction mpn/day = (Year 1 + Year 2 + Year 3 + Year 4 + Year 5) / 5

$(2.38 \times 10^9 + 1.78 \times 10^9 + 1.34 \times 10^9 + 1.00 \times 10^9 + 7.52 \times 10^8)$ /5 =

**$1.45 \times 10^9$ mpn/day**

**Current Enterococcus load**

(386,900 gallons * 3785.41178 mL/gal * 4166.67 mpn/mL) / 2312 days = $2.64 \times 10^9$ mpn/day

**Enterococcus Load Reduction**

**Year 1**

{((386,900 gallons * 3785.41178 mL/gal)/2312) *0.25} * $1.5 \times 10^4$ mpn/mL * 4166.67 mpn/mL = $6.60 \times 10^8$ mpn/day

**Year 2**

$(1.19 \times 10^5)$ * $1.5 \times 10^4$ mpn/mL * 4166.67 mpn/mL = $4.95 \times 10^8$ mpn/day

**Year 3**

$(8.91 \times 10^4)$ * $1.5 \times 10^4$ mpn/mL * 4166.67 mpn/mL = $3.71 \times 10^8$ mpn/day

**Year 4**

$(6.68 \times 10^4)$ * $1.5 \times 10^4$ mpn/mL * 4166.67 mpn/mL = $2.78 \times 10^8$ mpn/day

**Year 5**

$(5.01 \times 10^4)$ * $1.5 \times 10^4$ mpn/mL * 4166.67 mpn/mL = $2.09 \times 10^8$ mpn/day

**Total Enterococcus Load Reduction**

Load reduction mpn/day = (Year 1 + Year 2 + Year 3 + Year 4 + Year 5) / 5

$(6.60 \times 10^8 + 4.95 \times 10^8 + 3.71 \times 10^8 + 2.78 \times 10^8 + 2.09 \times 10^8)/5$ = **$4.03 \times 10^8$ mpn/day**

# Management Measure 3.0 Load Reduction

This section describes the calculations made using the best available resources to estimate potential bacteria loading reductions resulting from increasing participation in existing conservation programs for agricultural operations within the Dick-Dickinson Bayou watershed. The mass balance calculation used is the following:

> Reduction in indicator bacteria daily load from conservation plans = Acres of pastureland in the watershed subjected to conservation plan (e.g. 25% of all pastureland not currently under a conservation program) * Export Coefficient (mpn/acre/day) * conversion factor (mpn indicator bacteria/mpn fecal coliform)* overall % effectiveness associated with conservation plans.

The following assumptions were used in calculating bacteria load reductions:

1) Increased participation in conservation programs; 2470 acres within 5 years
2) Export coefficient based on stocking rate of 0.2 cow/acre and a fecal coliform production rate of $7.97 \times 10^5$ mpn/day[20]
3) An overall percent effectiveness of conservation programs of 60%
4) A ratio of 0.63 *E. coli*/fecal coliform; 0.278 Enterococcus per *E. coli* bacteria

The loading reduction calculation is based on landowner participation and agricultural land within programs reaching 25% by the end of a 5 year period. These programs are currently available through NRCS and TSSWCB. The total acreage of pasture land (i.e., Grassland/shrub) in the watershed in 2008 was 10513. Currently 6% of pasture land is involved in conservation programs, leaving 9882 acres of pasture land not under a conservation plan in the watershed. Twenty five percent of this land (the goal for acreage under conservation plans under this I-Plan) amounts to 2470 acres. The estimated load reduction from this amount of pasture land being under a conservation plan totals to $1.49 \times 10^8$ mpn/day for *E. coli* and $4.14 \times 10^7$ mpn/day over the five-year implementation period.

## Load Calculation

### Total *E. coli* Load Reduction

2470 acres * $1.59 \times 10^5$ mpn/acre/day * 0.63 * 0.6 = **$1.49 \times 10^8$ mpn/day**

### Total Enterococcus Load Reduction

2470 acres * $1.59 \times 10^5$ mpn/acre/day * 0.63 * 0.6 *0.278 = **$4.14 \times 10^7$ mpn/day**

[20] Metcalf & Eddy 1991, *Wastewater Engineering: Treatment, Disposal, Reuse*. 3rd Edition. McGraw-Hill, Inc., New York.

# Management Measure 3.1 Load Reduction

This section describes the calculations used to estimate the potential indicator bacteria load reduction from reducing the feral hog population within the Dickinson Bayou watershed. Wild hogs are a huge problem in Texas. With an estimated population of two million animals in the state; if left unchecked the feral hog population will only continue to grow.[21] Loading reductions resulting from feral hog removal were based on the estimate of fecal coliform per hog found in Metcalf and Eddy 1991.[22] Based on best professional judgment and linear reproductive rates of remaining feral hogs, it is assumed that 50 percent of the estimated feral hog population in the Dickinson Bayou watershed can be removed each year. This reduction in feral hog numbers equates on average to a load reduction of $1.57 \times 10^{11}$ cfu/hog/day of *E. coli*. The mass balance calculation used is the following:

> Indicator bacteria daily load reduction from feral hogs management= # of hogs * reproduction rate * removal factor * fecal production rate (cfu/hog/day) * bacteria conversion factor (mpn fecal coliform to mpn alternative indicator bacteria)

The following assumptions were used in calculating bacteria load reductions:

1) On average each feral hog produces $8.9 \times 10^9$ fecal coliforms each day
2) If the feral hog population doubles every 13 years,[23] a linear reproduction rate of 1.077 can be used as an estimate yearly population increases
3) 50% of the feral hog population in the watershed can be eliminated each year
4) Bacteria conversion factor; 0.63 *E. coli* per fecal coliform bacteria; 0.278 Enterococcus per *E. coli* bacteria

## Load Calculation

### *E. coli* Load Reduction

#### Year 1

> 135 hogs x 1.077 x 0.5 * $8.9 \times 10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform = $3.78 \times 10^{11}$ mpn/day

#### Year 2

> 72.7 hogs x 1.077 x 0.5 * $8.9 \times 10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform = $2.04 \times 10^{11}$ mpn/day

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[21] Mapston, M.E. (2004). Feral Hogs in Texas. AgriLife Extension (Publication # B-6149). Retrieved from: <http://icwdm.org/publications/pdf/feral%20pig/txferalhogs.pdf>.
[22] Metcalf and Eddy. 1991. Wastewater Engineering: Treatment, Disposal, Reuse. 3rd Edition. McGraw-Hill, Inc., New York.
[23] Mapston, M.E. (2004). Feral Hogs in Texas. Texas A&M AgriLife Extension (Publication # B-6149). Retrieved from: <http://icwdm.org/publications/pdf/feral%20pig/txferalhogs.pdf>.

### Year 3

39.1 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform = 1.10 x $10^{11}$ mpn/day

### Year 4

21.08 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform = 5.91 x $10^{10}$ mpn/day

### Year 5

11.35 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform = 3.18 x $10^{10}$ mpn/day

### Total E. coli Load Reduction

(Year 1 + Year 2 + Year 3 + Year 4 + Year 5) /5 = total load reduction

(4.08 x $10^{11}$ mpn/day + 2.19 x $10^{11}$ mpn/day + 1.18 x $10^{11}$ mpn/day + 6.36 x $10^{10}$ mpn/day + 1.77 x $10^{10}$ mpn/day) / 5 = 1.57 x $10^{11}$mpn/day

### Enterococcus Load Reduction

### Year 1

135 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform * 0.278 Enterococcus/*E. coli* = 1.05 x $10^{11}$ mpn/day

### Year 2

72.7 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform * 0.278 Enterococcus/*E. coli* = 5.66 x $10^{10}$ mpn/day

### Year 3

39.1 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform * 0.278 Enterococcus/*E. coli* = 3.05 x $10^{10}$ mpn/day

### Year 4

21.08 hogs x 1.077 x 0.5 * 8.9 x $10^9$ fecal coliform mpn/hog/day * 0.63 *E. coli*/fecal coliform * 0.278 Enterococcus/*E. coli* = 1.64 x $10^{10}$ mpn/day

### Year 5

11.35 hogs x 1.077 x 0.5 * 8.9 x 109 fecal coliform mpn/hog/day * 0.63 E. coli/fecal coliform * 0.278 Enterococcus/E. coli = 8.84 x $10^9$ mpn/day

### Total Enterococcus Load Reduction

(Year 1 + Year 2 + Year 3 + Year 4 + Year 5) /5 = total load reduction

(1.13 x $10^{11}$ mpn/day + 6.10 x $10^{10}$ mpn/day + 3.29 x $10^{10}$ mpn/day + 1.77 x $10^{10}$ mpn/day + 9.53 x $10^9$ mpn/day) / 5 = **4.35 x $10^{10}$ mpn/day**

# Management Measures 3.2-3.5 Load Reduction

This section estimates the potential load reduction from increasing the percent of pet owners who properly dispose of pet waste, within the Dickinson Bayou watershed, from 40% to 75% over the five year implementation period. Most domestic cat waste is collected in a litter box and disposed of in the garbage; therefore a load reduction is only calculated for dog waste.

The Dickinson Bayou Bacteria TMDLs estimated the dog population in the Dickinson Bayou watershed to be 14,406 dogs.[24] The National People and Pets Survey found that around 44 percent of dog owners stated that they "always" or "sometimes" picked up their dog's waste in public places.[25] Based on this study it was estimated that 60 percent of dog waste in the Dickinson Bayou watershed is never picked up. The mass balance calculation used is the following:

Daily Indicator bacteria loading from dog waste = No. of dogs * fraction not collected by owners *fecal coliform production rate (CFU/dog/day) * bacteria conversion factor (mpn fecal coliform to mpn alternative indicator bacteria)

The following assumptions were used in calculating bacteria load reductions:

1) On average each dog produces $5 \times 10^9$ fecal coliforms each day[26]
2) Only 40% of dog waste is currently picked up
3) Bacteria conversion factor; 0.63 *E. coli* per fecal coliform bacteria; 0.278 Enterococcus per *E. coli* bacteria

## Load Calculation

### Current Estimated load

***E. coli***

$$14406 * 0.6 * 5 \times 10^9 * 0.63 = 2.72 \times 10^{13} \text{ mpn/day}$$

**Enterococcus**

$$14406 * 0.6 * 5 \times 10^9 * 0.63 * 0.278 = 7.56 \times 10^{12} \text{ mpn/day}$$

### Load estimated if 75 percent of owners picked up their pet's waste

***E. coli***

$$14406 * 0.25 * 5 \times 10^9 * 0.63 = 1.13 \times 10^{13} \text{ mpn/day}$$

[24] Texas Commission on Environmental Quality. (2011) *Eight Total Maximum Daily Loads for Bacteria in Dickinson Bayou and Three Tidal Tributaries.*

[25] McHarg, M., Baldock, C., Headley, B., Robinson, A. (1995) National People and Pets Survey, a report to the Urban Animal Management Coalition.

[26] U.S. Environmental Protection Agency. (2001) *Protocol for Developing Pathogen TMDLs.*

### Enterococcus

$14406 * 0.25 * 5 \times 10^9 * 0.63 * 0.278 = 3.15 \times 10^{12}$ mpn/day

### Load Reduction

Current load – load if 75% picked up = load reduction

### *E. coli*

$2.72 \times 10^{13}$ mpn/day - $1.13 \times 10^{13}$ mpn/day = **$1.59 \times 10^{13}$ mpn/day**

### Enterococcus

$7.56 \times 10^{12}$ mpn/day - $3.15 \times 10^{12}$ mpn/day = **$4.41 \times 10^{12}$ mpn/day**

# Management Measure 3.6 Load Reduction

This section describes the calculations made using the best available resources to estimate potential bacteria loading reductions resulting from implementing BMPs on lands with large groups of animals that are not covered by existing conservation programs. For this calculation, only the Bayou Wildlife Park was used, as it currently represents the only operation of the type this management measure is intended to address in the watershed over the five years.

Daily Indicator bacteria loading = # of Animals * Average Animal Equivalent Unit (AEU) conversion factor * fraction not treated by a BMP *fecal coliform production rate (CFU/AEU/day)* bacteria conversion factor (mpn fecal coliform to mpn alternative indicator bacteria)

The following assumptions were used in calculating bacteria load reductions:

1) An average AEU conversion factor of .7117 is applied to the entire animal population of the park. The value was derived from averaging AEU factors for cows, horses, goats, sheep, deer and an assumed large animal AEU factor of 2.0 (One AES is equal to one cow)[27]
2) On average each AEU produces $5.4 \times 10^9$ fecal coliforms each day[28]
3) Currently 20% of waste produced by park animals is treated by a BMP; Measure 3.6 will increase this to 80% of the bacteria produced being treated.
4) Bacteria conversion factor; 0.63 *E. coli* per fecal coliform bacteria and 0.278 Enterococcus per *E. coli* bacteria

[27] Known animals at the Bayou Wildlife Park are all herbivores and most are ruminates so this is a reasonable substitution. Exact numbers of each animal were unavailable, so best professional judgment was used to determine 400 AEU's represented a reasonable number for the park considering the variety in size of animals present; 400 was the number of Bayou Wildlife Park animals used in the TMDL.

[28] Metcalf & Eddy 1991.

## Load Calculation

### Current Estimated load

***E. coli***

$400 * 0.7117 * 0.8 * 5.4 \times 10^{9} * 0.63 = 7.75 \times 10^{11}$ mpn/day

**Enterococcus**

$400 * 0.7117 * 0.8 * 5.4 \times 10^{9} * 0.63 * 0.278 = 2.15 \times 10^{11}$ mpn/day

### Load if 80% of waste is treated using a BMP

***E. coli***

$400 * 0.7117 * 0.2 * 5.4 \times 10^{9} * 0.63 = 1.94 \times 10^{11}$ mpn/day

**Enterococcus**

$400 * 0.7117 * 0.2 * 5.4 \times 10^{9} * 0.63 * 0.278 = 5.38 \times 10^{10}$ mpn/day

### Total Load Reduction

Current Load (only 20% treated) – Load with 80% treatment = load reduction

***E. coli***

$7.75 \times 10^{11}$ mpn/day - $1.94 \times 10^{11}$ mpn/day = **$5.81 \times 10^{11}$ mpn/day**

**Enterococcus**

$2.15 \times 10^{11}$ mpn/day - $5.38 \times 10^{10}$ mpn/day = **$1.61 \times 10^{11}$ mpn/day**

# Management Measure 4.0 Load Reduction

This section describes the calculations used to estimate the expected bacteria load reduction resulting from restoring and repairing riparian zones along Dickinson Bayou and its tributaries. This measure sets out to implement a 50 foot vegetated buffer along the banks of ditches, creeks and major tributaries that are part of the Dickinson Bayou hydrologic system, as well as the banks of Dickinson Bayou itself, by the end of the initial 5 year I-Plan period. The goal for this measure is to have 20% of all the runoff contributed to Dickinson Bayou flowing through riparian buffers before reaching the bayou.

Assumptions used for calculations:

1) Riparian areas remove 49% of bacteria in runoff.[29]
2) 20% of Dickinson Bayou water ways will be treated by riparian buffers.

[29] Texas Sea Grant.

## Load calculation

Percent bacteria load removed by riparian buffers * percent of runoff that runs through buffers = load reduction in percent

0.49 * 0.2 = **0.098 or a 9.8% load reduction**

Observed daily in-stream median load* 0.098 reduction

### Segment 1104 (above tidal)

***E. coli***

$3.90 \times 10^{10}$ mpn/day[32] * 0.098 = $3.82 \times 10^{9}$ mpn/day

**Enterococcus**

$3.90 \times 10^{10}$ mpn/day[33] * 0.098 * 0.278 Enterococcus/*E. coli* = $1.06 \times 10^{9}$ mpn/day

### Segment 1103 (tidal)

***E. coli***

$1.11 \times 10^{11}$ mpn/day[34] * 0.098 = $1.09 \times 10^{10}$ mpn/day

**Enterococcus**

$1.11 \times 10^{11}$ mpn/day[35] * 0.098 * 0.278 Enterococcus/*E. coli* = $3.02 \times 10^{9}$ mpn/day

### Total Bacteria Reduction for Dickinson Bayou over 5 years

***E. coli***

$3.82 \times 10^{9}$ mpn/day + $1.09 \times 10^{10}$ mpn/day = **$1.47 \times 10^{10}$ mpn/day**

**Enterococcus**

$1.06 \times 10^{9}$ mpn/day + $3.02 \times 10^{9}$ mpn/day = **$4.08 \times 10^{9}$ mpn/day**

# Management Measure 6.0 Load Reduction

This section describes the expected load reduction from constructing stormwater treatment wetlands.

Reduction in indicator bacteria daily load from stormwater treatment wetlands = Area of watershed treated * Average rainfall * runoff coefficient * Event Mean Concentration for specific Land Use type (E.coli/$cm^3$) * overall % effectiveness of stormwater wetlands

The following assumptions where used during the load reduction calculation:

1) 1,000 acres of low intensity development are treated by stormwater wetlands in 5 years (approximately 200 acres each year)
2) 48 inches of rainfall per year in the watershed

3) Export coefficient of 6,538 *E. coli*/cubic inch[30]
4) Runoff coefficient of 0.65
5) 78% effectiveness of stormwater wetlands in removing bacteria from stormwater[31]
6) 0.278 Enterococcus per *E. coli* bacteria

The loading reduction calculation is based on the expected reduction for 200 acres of land per year where stormwater runoff is treated by a stormwater wetland.

## Load Calculation

### *E. coli*

200 acres * 6.27 x $10^6$ sq inches/acre *48 in/year * 0.65 * 6538 MPN/cubic inch * 0.6 * 5 yrs * 2.74 x $10^{-3}$ years/day = **2.10 x $10^{12}$ *E.coli*/day**

### Enterococcus

200 acres * 6.27 x $10^6$ sq inches/acre *48 in/year * 0.65 * 6538 MPN/cubic inch * 0.6 * 5 yrs * 2.74 x $10^{-3}$ years/day * 0.278 = **5.85 x $10^{11}$ enterococcus/day**

# Management Measure 7.0 Load Reduction

This section describes the expected load reduction from providing demonstrations and encouraging installation of stormwater BMPs including rain gardens, bioswales, and rain water harvesting.

Reduction in indicator bacteria daily load from stormwater BMPs = Area of watershed treated * Average rainfall * runoff coefficient * Event Mean Concentration for specific Land Use type (E.coli/$cm^3$) * overall % effectiveness of stormwater BMPs

The following assumptions where used during the load reduction calculation:

1) 500 acres of low intensity development are treated by stormwater BMPs in 5 years (approximately 100 acres each year)
2) Average rainfall of 48 inches per year in the watershed
3) Event Mean Concentration of 6,538 *E. coli*/cubic inch[32]
4) Runoff coefficient of 0.65

[30] Texas Commission on Environmental Quality. (2011) *Eight Total Maximum Daily Loads for Bacteria in Dickinson Bayou and Three Tidal Tributaries*.
[31] From Center for Watershed Protection Pollutant Removal Database.
[32] Newell et al 1992.

5) 60% effectiveness of stormwater BMPs in removing bacteria from stormwater[33]
6) 0.278 Enterococcus per *E. coli* bacteria

The loading reduction calculation is based on the expected reduction for 100 acres land where stormwater runoff is treated by a BMP.

## Load Calculation

### *E. coli*

100 acres * 6.27 x $10^6$ sq inches/acre *48 in/year * 0.65 * 6538 MPN/cubic inch * 0.6 * 5 yrs * 2.74 x $10^{-3}$ years/day = **1.05 x $10^{12}$ *E.coli*/day**

### Enterococcus

100 acres * 6.27 x $10^6$ sq inches/acre *48 in/year * 0.65 * 6538 MPN/cubic inch * 0.6 * 5 yrs * 2.74 x $10^{-3}$ years/day * 0.278 = **2.92 x $10^{11}$ Enterococcus/day**

[33] From Center for Watershed Protection Pollutant Removal Database.

# Appendix D. Responsible Parties

**Center for Texas Beaches and Shores** (CTBS/ Texas A&M Galveston) was established in 1993 by the Texas Legislature to address beach erosion and wetlands loss throughout the state. CTBS is dedicated to the conservation and protection of the Texas shoreline, bays, and waterways through innovative research in cooperation with government and private sector agencies. They are focused on developing a comprehensive, holistic approach to Texas coastal research and restoration solutions incorporating natural, economic, and political processes.

**Dickinson Bayou Watershed Partnership** is a collaborative of stakeholders from state agencies, nonprofit organizations, civic groups, academic institutions, local governments, business and industry groups, and utilities. The DBWP is developing and implementing a watershed plan for the purposes of protecting, preserving, and restoring the quality of the Dickinson Bayou watershed and its communities. <www.dickinsonbayou.org>.

**Brazoria County Environmental Health Services** is a county agency concerned with the protection and enforcement of county, State, and Federal regulations. The environmental health programs focuses on preventing communicable disease and environmental conditions that could be harmful to your health. They are also the responsible party for on-site sewage facilities in Brazoria County.

**Galveston County Health District** is a county agency that provides credible and responsible public services. The district is responsible for public and environmental health programs, EMS, and free or reduced cost public health clinics. Included in the District is the Water Pollution Services Division who is responsible for investigating and answering citizen complaints regarding water pollution issues such as sewage overflows and wastewater sewage treatment plant inspections for compliance with state and federal regulations. They are the responsible party for on-site sewage facilities in Galveston County.

**Texas A&M AgriLife Extension Service** is a part of the Texas A&M University System, the state legislature, and the communities it serves. The mission of Texas A&M AgriLife Extension Service is to improve the lives of people, businesses, and communities across Texas and beyond through high-quality, relevant education.

**Houston-Galveston Area Council** is an association of counties, cities, and school districts in the Gulf Coast Planning Region. It is involved with community and environmental planning, land use planning, air and water quality, and quality of life issues throughout the Houston-Galveston area. <www.h-gac.com>.

**Texas Commission on Environmental Quality** is responsible for regulating the discharge of contaminants to surface water, groundwater, soil, and air through a wide variety of programs, and conducts public outreach and education in support of these programs. The TCEQ also conducts monitoring and assessment of surface waters to determine compliance with water quality standards. TCEQ conducts Section 401 certification reviews of U.S. Army Corps of Engineers (USACE) Section

404 permit applications for the discharge of dredged or fill material into waters of the U.S., including wetlands. These certification reviews determine whether a proposed discharge will comply with state water quality standards. TCEQ also admin-administers the SEPP, an innovative approach to resolving enforcement actions and improving environmental quality. SEPs are comprised of a wide variety of activities including wetland protection and restoration. TCEQ hosts the Galveston Bay Estuary Program and also provides extensive outreach materials. <www.tceq.texas.gov/index.html>.

**Keep Dickinson Beautiful** works to create partnerships to make Dickinson a cleaner, more beautiful place to live, work and play, and to preserve our heritage of tall Pines, natural beauty and rich culture.
<www.ci.dickinson.tx.us/dbweb/intro.html>.

**Municipal Utility District** is a special-purpose district or other governmental jurisdiction that provides public utilities (such as electricity, natural gas, sewage treatment, waste collection/management, wholesale telecommunications, and water) to the residents of that district. MUDs are formed by a vote of the area, and represented by board of directors who are voted on by the local people. As governmental bodies, they are usually nonprofit.

**Texas State Soil and Water Conservation Board** administers Texas' soil and water conservation law and coordinates conservation and pollution abatement programs throughout the state. Its WQMP program is a voluntary mechanism by which site-specific plans are developed and implemented on agricultural and silvicultural lands to prevent or reduce nonpoint source pollution from these operations. Plans include appropriate treatment practices, production practices, management measures, technologies, or combinations thereof. Plans are developed in cooperation with local SWCDs, cover an entire operating unit, and allow financial incentives to augment participation. <www.tsswcb.texas.gov>.

**U.S. Department of Agriculture** (USDA) is active in natural resource management, particularly through the **Natural Resources Conservation Service** and the U.S. Forest Service. Both organizations provide resources for natural resource conservation, public land management for conservation purposes, and educational programs. <www.usda.gov>.

**Texas Parks and Wildlife Department** provides outdoor recreational opportunities by managing and protecting fish and wildlife and their habitat and acquiring and managing parklands and historic areas. Responsibilities include hunting and fishing, wildlife management areas, law enforcement, state parks and historic areas, conservation and resource protection, and hunter and boater education. In the Galveston Bay watershed, TPWD operates several state parks, historic sites, and wildlife management areas, and has coordinated several large habitat restoration projects. Locally, TPWD leases the Armand Bayou Coastal Preserve from the Texas General Land Office (GLO). Also of local interest is TPWD's Rec-

reation Grants Program, which offers matching funds for communities wishing to construct recreational facilities. The Private Lands Initiative and the Wildscapes Program are available to assist landowners in managing their property in an ecologically friendly manner. <www.tpwd.state.tx.us>.

**Texas Animal Health Commission** was founded in 1893 with a mission to address the Texas fever tick problem. TAHC regulations are made and adopted by 13 governor-appointed commissioners who represent the general public and various livestock industries and professions. The Commissioners meet as needed to study the regulatory needs of the agency, review public comments on proposed regulation changes, and adopt new rules when necessary. TAHC also works to keep pests from reoccurring as major livestock health hazards. TAHC has legislative authority to make and enforce regulations to prevent, control, and eradicate specific infectious animal diseases which endanger livestock.

**Texas Department of Agriculture** is a state agency established by the Texas Legislature in 1907. TDA is responsible for ensuring consumer protection**,** supporting production agriculture, and promoting healthy living and economic development. Their mission statement is: *To partner with all Texans to make Texas the nation's leader in agriculture, fortify our economy, empower rural communities, promote healthy lifestyles, and cultivate winning strategies for rural, suburban, and urban Texas through exceptional service and the common threads of agriculture in our daily lives.*

**Texas Coastal Watershed Program** (Texas Sea Grant Program /Texas A&M AgriLife Extension Service). County and marine agents associated with the program for both Texas Sea Grant (TSG) and Texas A&M AgriLife Extension Service are active in the Dickinson Bayou area and available to assist with a variety of water quality education programs and demonstrations in the watershed. The Texas Coastal Watershed Program is a regional program of TSG and Texas A&M AgriLife Extension Service and has an active watershed education program in the area. <www.urban-nature.org>.

**The Water Environment Association of Texas** is a group of about 1,600 Texas professionals who have dedicated their careers to protecting and enhancing our state's water resources. They are a not-for-profit technical and educational organization with members from a variety of disciplines.