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Implementation Plan for One Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal

Segment 1501

Assessment Unit 1501_01

Tres Palacios Creek Watershed Stakeholder Group and
Texas Water Resources Institute

With support from:
Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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<www.tceq.texas.gov/waterquality/tmdl/>

This plan is based on technical reports prepared for the TCEQ by the Texas Institute for Applied Environmental Research, and on the recommendations of the Tres Palacios stakeholder group organized by the Texas Water Resources Institute.

Agencies that participated in the development of this document include:
Texas A&M AgriLife Extension Service
Texas A&M AgriLife Research
Texas Commission on Environmental Quality
Texas Parks and Wildlife Department
U.S. Department of Agriculture Natural Resources Conservation Service
Texas State Soil and Water Conservation Board
Texas Water Resources Institute

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Abbreviations

§	section
ac	acres
An.U	animal unit
AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
CCN	Certificate of Convenience and Necessity
cfs	cubic feet per second
cfu	colony-forming units
CHAMP	County Hog Abatement Matching Program
CIG	Conservation Innovation Grant
CRP	Clean Rivers Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
CZM	Coastal Zone Management Program
CZMA	Coastal Zone Management Administration
E. coli	*Escherichia coli*
ECHO	Enforcement and Compliance History Online database
EDAP	Economically Distressed Areas Program
EE	Environmental Education
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
FG	future growth
FOTG	Field Office Technical Guide
GIS	geographic information system
ha	hectare
I-Plan	implementation plan
I/I	inflow and infiltration
LA	load allocation
LIP	Landowner Incentive Program
LULC	land use/land cover
mL	milliliter
MGD	million gallons per day
MOS	margin of safety
MPN	most probable number
MS4	municipal separate storm sewer system
MUD	municipal utility district
NIWQP	National Integrated Water Quality Program
NLCD	National Land Cover Database
NPS	nonpoint source
NRCS	Natural Resources Conservation Service

O&M	operation and maintenance
OSSF	on-site sewage facility
RCPP	Regional Conservation Partnership Program
RUS	Rural Utilities Service
SARE	Sustainable Agriculture Research and Education
SEP	Supplemental Environmental Projects
SSO	sanitary sewer overflow
SWCD	soil and water conservation districts
SWMP	stormwater management plan
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TEEX	Texas A&M Engineering Extension Service
TGLO	Texas General Land Office
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TRWA	Texas Rural Water Association
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
TWS	Texas Wildlife Services
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	wasteload allocation
WWD	Water and Waste Disposal
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

Implementation Plan for One TMDL for Indicator Bacteria in Tres Palacios Creek Tidal

Executive Summary

In 2018, the Texas Commission on Environmental Quality (TCEQ) will consider adoption of One Total Maximum Daily Load (TMDL) for Indicator Bacteria in the Tidal Segment of Tres Palacios Creek (Segment 1501).

This implementation plan, or I-Plan:

- describes the steps that watershed stakeholders and the TCEQ will take toward achieving the pollutant reductions identified in the TMDL report, and
- outlines the schedule for implementation activities.

The ultimate goal of this I-Plan is to restore the primary contact recreation use in Segment 1501 by reducing concentrations of bacteria to levels established in the TMDL. *Escherichia coli* (*E. coli*) are widely used as an indicator bacteria to assess attainment of the contact recreation use in freshwater bodies, while Enterococci are used as the indicator bacteria in salt waters. Enterococci are the relevant indicator for the Tres Palacios Creek Tidal segment. The criteria for assessing attainment of the contact recreation use are expressed as the number (or "counts") of Enterococci bacteria, typically given as the most probable number (MPN). The primary contact recreation use is not supported when the geometric mean of all Enterococci samples exceeds 35 MPN per 100 milliliters (mL).

The TMDL identified regulated and unregulated sources of bacteria in the watershed that could contribute to water quality impairment. Regulated sources identified include domestic and industrial wastewater treatment facilities (WWTFs), regulated stormwater, sanitary sewer overflows (SSOs), dry weather discharges, and illicit discharges.

Unregulated sources that could contribute to the bacteria load in the watershed include various agricultural activities, agricultural animals, domestic animals (e.g., cattle, dogs, and horses), neglected and failing on-site sewage facilities (OSSFs), and wildlife and other unmanaged animals (e.g., deer, feral hogs).

This I-Plan includes nine management measures that will be used to reduce bacteria in the Tres Palacios Creek watershed. Management measures refer to strategies for reducing unregulated pollutants, generally through voluntary

practices. Control actions refer to strategies for reducing regulated sources, generally through permits. No control actions related to regulated discharges are included in this plan.

Management Measures

1. *Development and Implementation of Conservation Plans in Priority Areas of the Watershed*
2. *Removal and Management of Feral Hogs*
3. *Identification, Prioritization, and Remediation of OSSFs*
4. *Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses*
5. *Planning and Management for Urban Stormwater*
6. *Installation of Urban Best Management Practices (BMPs)*
7. *Development and Implementation of Pet Waste Programs*
8. *Planning and Implementation of Wastewater Reuse*
9. *Infrastructure Maintenance and Replacement*

For each of the measures, this plan identifies an education component, the responsible parties, technical and financial needs, measurable milestones assessed through monitoring and outreach efforts, estimated load reductions, and a schedule of activities. Implementation of the management measures will largely be dependent upon the availability of funding.

The stakeholders and the TCEQ will review progress under the TCEQ's adaptive management process. The plan may be adjusted periodically as a result of progress reviews.

Introduction

Texas is committed to restoring and maintaining water quality in impaired rivers, lakes, and bays, and 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 the Tres Palacios Creek watershed as defined in the TMDL report. It is a flexible tool that governmental and nongovernmental organizations involved in implementation use to guide their activities to improve water quality. The participating partners may accomplish the activities described in the plan through rule, order, guidance, or other appropriate formal or informal action.

This I-Plan contains the following components:

- a description of management measures that will be implemented to achieve the water quality target;

- a schedule for implementing activities (Appendix A);
- a follow-up tracking and monitoring plan to determine the effectiveness of the management measures undertaken;
- 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 if the plan needs to be modified;
- identification of the communication strategies the TCEQ will use to disseminate information to stakeholders; and
- a review strategy that stakeholders will use to periodically assess and revise the plan to ensure there is continued progress in improving water quality.

This plan encompasses the nine key elements of watershed-based plans. These elements are outlined in the Nonpoint Source Program Grants Guidelines for States and Territories (EPA, 2013) and include: possible causes and sources of the impairment, management measure descriptions, estimated potential load reductions, technical and financial assistance needed, educational components for each measure, schedules of implementation, measurable milestones, indicators to measure progress, monitoring components, and responsible entities. Consequently, projects that incorporate the nonpoint source (NPS) nine key elements of a watershed plan may be eligible for funding under the Environmental Protection Agency's (EPA's) Section 319(h) grant program.

Watershed Overview

Tres Palacios Creek, located along the Texas Gulf Coast midway between the cities of Victoria and Houston, is comprised of two segments—the upstream segment is designated as "Above Tidal" (Segment 1502) and the downstream segment is designated as "Tidal" (Segment 1501) (Figure 1). The above tidal portion of the creek is a perennial freshwater stream, while the lower tidal portion is influenced by seawater from Tres Palacios Bay. The tidal segment is the impaired portion.

Tres Palacios Creek Above Tidal (Segment 1502) flows from the crossing of US 59 in Wharton County to a location 1.0 km (0.6 miles) upstream of the confluence of Wilson Creek in Matagorda County, where Tres Palacios Creek Tidal (Segment 1501) begins and flows to the outlet into Tres Palacios Bay (TCEQ, 2012a). At its mouth, Tres Palacios Creek drains 268.5 square miles (171,816 acres) in Wharton (36 percent of the watershed) and Matagorda (64 percent of the watershed) counties.

Land Use/Land Cover

The land use/land cover (LULC) data for the Tres Palacios Creek watershed were obtained from the U.S. Geological Survey (USGS) 2011 National Land Cover Database (NLCD) and are displayed in Figure 2. The NLCD determined that Cultivated Crops (52.5 percent) is the dominant land use in both segments of the watershed. The watershed is predominantly rural in land use; around 6 percent of the area is classified as Developed (open space, low intensity, medium intensity, and high intensity). Table 1 lists the types of land uses within the watershed, as well as the corresponding percentage of land for each use.

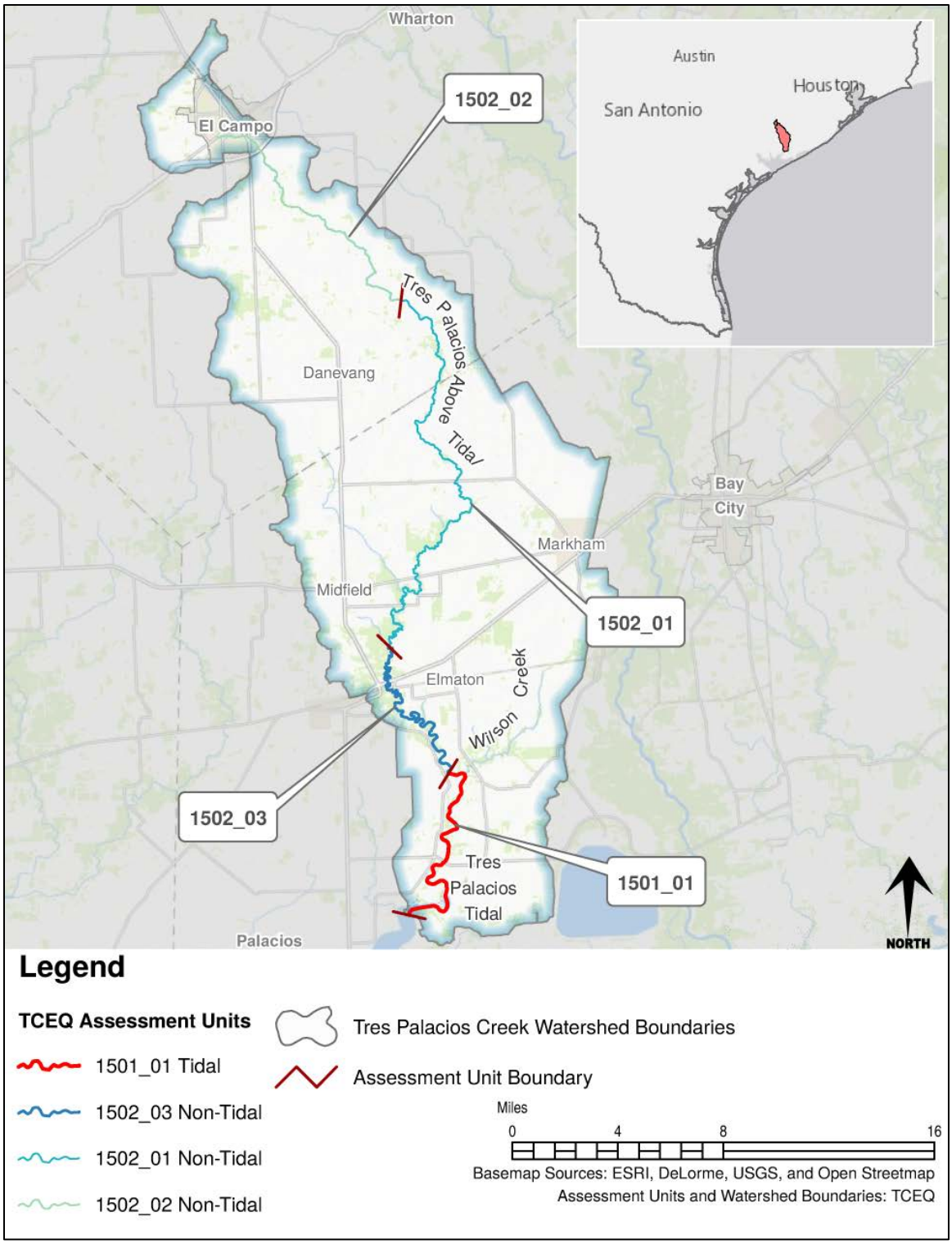

Figure 1: Tres Palacios Creek watershed overview map with TCEQ assessment units within Tres Palacios Creek

Impaired segment is shown in red. Source: Assessment units (TCEQ, 2016)

Table 1: Land Use/Land Cover within the Tres Palacios Creek watershed

Source: NLCD (USGS, 2014)

Classification	Square Miles	Percent of Total
Open Water	1.5	0.6%
Developed, Open Space	11.8	4.4%
Developed, Low Intensity	3.0	1.1%
Developed, Medium Intensity	1.1	0.4%
Developed, High Intensity	0.4	0.1%
Barren Land	0.2	0.1%
Deciduous Forest	2.8	1.0%
Evergreen Forest	5.8	2.2%
Mixed Forest	2.3	0.8%
Shrub/Scrub	10.1	3.8%
Herbaceous	3.0	1.1%
Hay/Pasture	78.6	29.3%
Cultivated Crops	140.9	52.5%
Woody Wetlands	4.6	1.7%
Emergent Herbaceous Wetlands	2.4	0.9%
Total	**268.5**	**100%**

Tres Palacios Creek Population and Future Growth

According to 2010 Census data, there are approximately 14,663 people in the Tres Palacios Creek watershed, with a population density of approximately 55 people per square mile. Of those, 9,544 people (65 percent) live within the City of El Campo, which accounts for only two percent of the watershed area.

Calculations based on population projections developed by the Office of the State Demographer and the Texas Water Development Board (TWDB, 2014) indicate that, between 2010 and 2050, the populations of Matagorda and Wharton counties are expected to increase 18.7 and 23.1 percent respectively. Estimates for the Tres Palacios Creek watershed range from 17.3 to 22.5 percent as refined by water user group (Table 2).

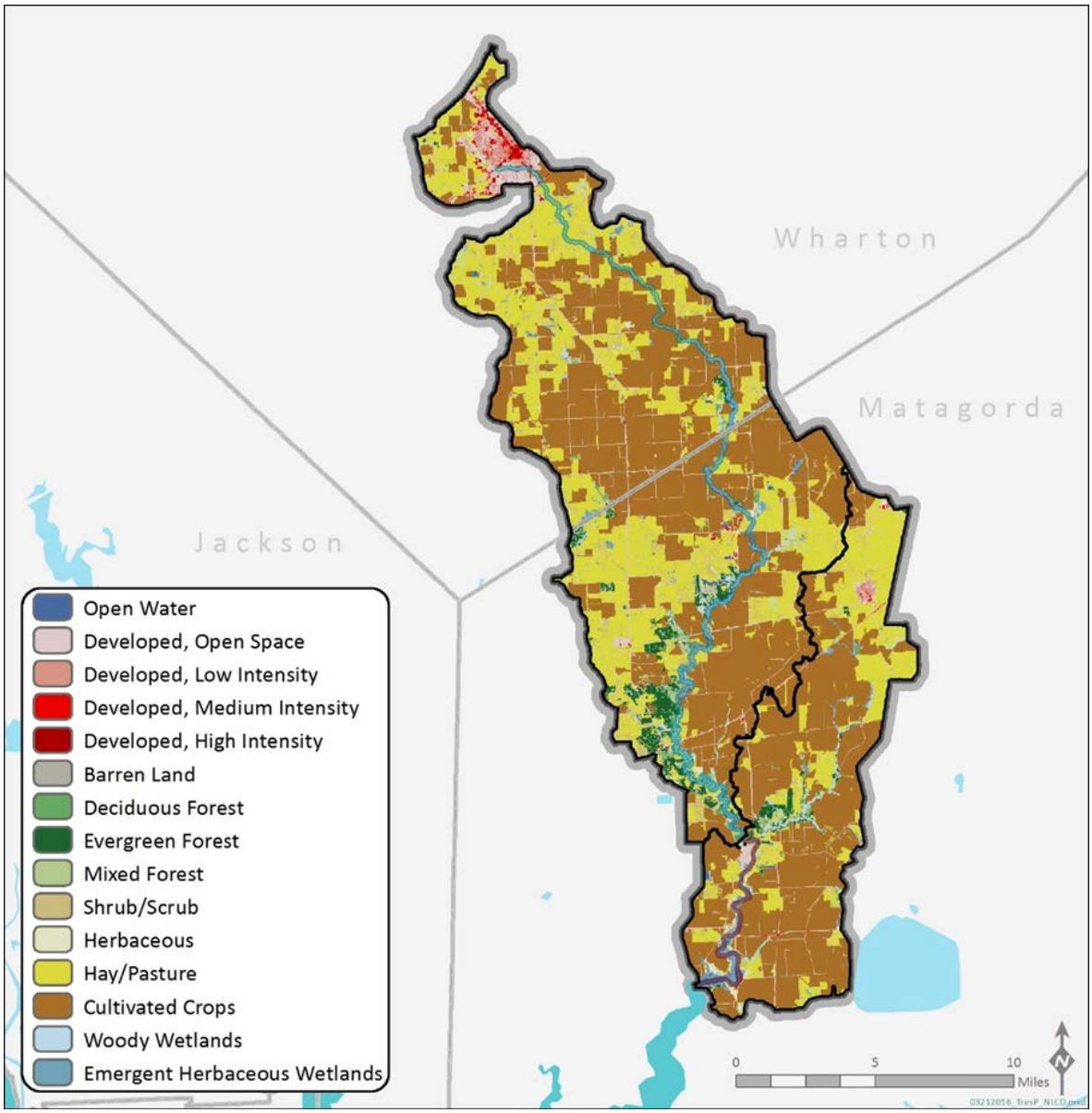

Figure 2: LULC within the Tres Palacios Creek watershed

Source: NLCD (USGS, 2014)

Table 2. 2010 population and 2010-2050 population projections

Source: Calculated from 2016 Regional and 2017 State Water Plan Projections Data (TWDB, 2014)

Water User Group	2010 U.S. Census	2020 Population Projection	2030 Population Projection	2040 Population Projection	2050 Population Projection	Percent Increase (2010 – 2050)
El Campo (in Wharton County)	9,544	10,470	10,959	11,350	11,688	22.5%
Wharton County (Other)	2,189	2,250	2,418	2,552	2,669	21.9%
Matagorda County	2,930	3,090	3,252	3,357	3,437	17.3%
Total	14,663	15,810	16,629	17,259	17,794	21.4%

Wastewater Treatment Facilities

Four permitted WWTFs operate within the Tres Palacios Creek watershed (Figure 3). The City of El Campo WWTF, Midfield WWTF, and the Markham municipal utility district (MUD) WWTF treat domestic wastewater. These facilities and permitted requirements for flow and *E. coli* are outlined in Table 3. The Apex Matagorda LLC facility does not have a bacteria monitoring requirement and is not included in the table. No WWTFs discharge directly into the impaired assessment unit (AU) (1501_01). However, Markham MUD discharges into Wilson Creek, which is a tributary that drains into the impaired AU (1501_01), Tres Palacios Creek Tidal. According to EPA's Enforcement and Compliance History Online database (ECHO), one violation for elevated bacteria and two violations for exceeding daily average discharge have been reported for watershed WWTFs since 2013 (EPA, 2016). However, no formal enforcement actions were taken. Generally, levels of bacteria are well below state standards and daily average flows are well below permitted limits.

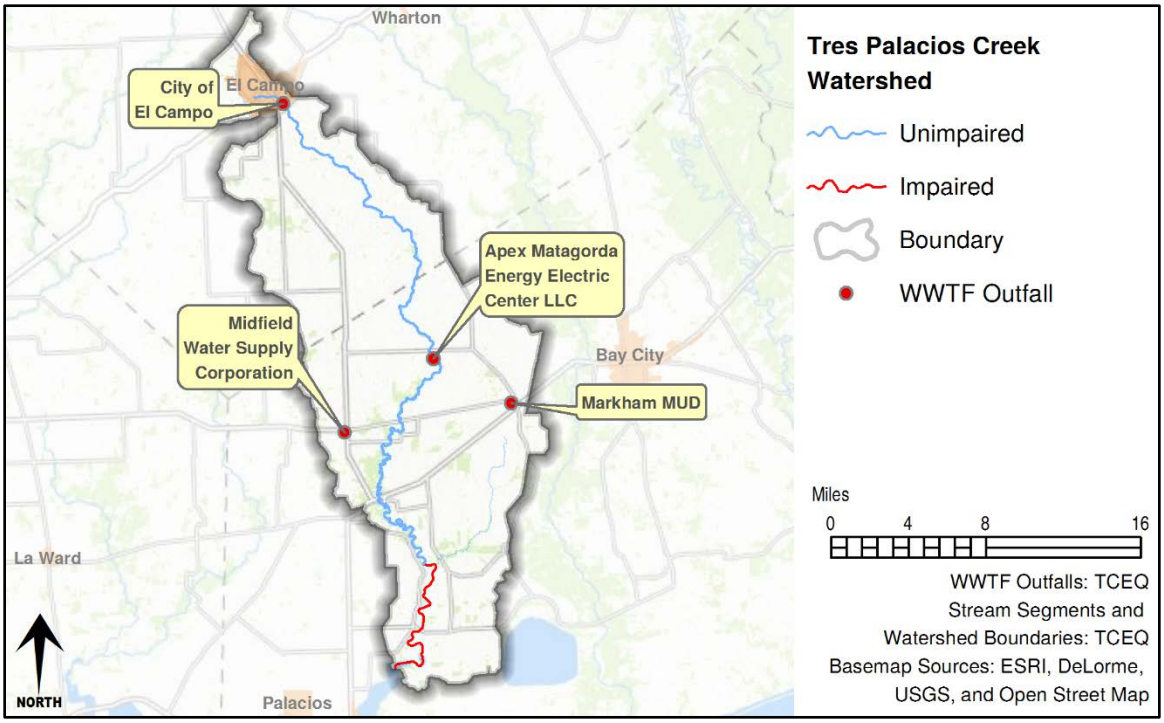

Figure 3: WWTF locations within the Tres Palacios Creek watershed

Source: Permitted outfalls (TCEQ, 2012)

Table 3. Permitted WWTFs with bacteria requirements in the Tres Palacios Creek watershed according to the EPA ECHO database

Reporting period January 2013 - December 2015

Facility Name	Permitted Flow (MGD)*	Reported Flow (3-yr mean MGD)	*E. coli* Limit (cfu/100mL)✧	Reported Daily Average *E. coli* (cfu/100mL)†
City of El Campo WWTF	2.628 (annual avg)	1.03	126 Daily Avg 399 Single Grab	3.81
Midfield WWTF	0.03 (daily avg)	0.01	126 Daily Avg 399 Single Grab	NA
Markham MUD WWTF	0.3 (daily avg)	0.08	126 Daily Avg 399 Single Grab	1.13

*MGD: million gallons per day
✧These facilities report in *E. coli* because they discharge into the non-tidal AUs
†Mean of reported daily averages from January 2013 through December 2015

The TCEQ first identified impairment to the tidal section of Tres Palacios Creek, referred to as AU 1501_01 in the 2014 Texas Integrated Report (TCEQ, 2015a). In that report, the TCEQ indicated that AU 1501_01 did not meet the water quality standard for primary contact recreation due to elevated levels of Enterococci bacteria. The impaired AU comprises the entire length of the tidal segment of Tres Palacios Creek (Segment 1501).

Primary contact recreation use is not supported when (1) the geometric mean of all Enterococci samples exceed 35 MPN per 100 milliliters (mL) and/or (2) individual samples exceed 89 MPN per 100 mL more than 25 percent of the time.

Enterococci monitoring in AU 1501_01 has occurred at two TCEQ monitoring stations within the watershed — 12515 and 20636 (Table 4). Enterococci data collected at these stations over the seven-year monitoring period of December 1, 2005 through November 30, 2012 were used in assessing attainment of the primary contact recreation use in the 2014 Texas Integrated Report. Table 4 contains the water quality monitoring results from the 2014 Texas Integrated Report.

Table 4. Summary of Enterococci in Tres Palacios Creek Tidal

Source: TCEQ, 2015b

Water Body	AU Number	Parameter	Data Date Range	Station	Number of Samples	Station geomean (MPN/100 mL)
Tres Palacios Creek Tidal	1501_01	Enterococci	12/2005-11/2012	12515	46	49
				20636	18	149

Summary of TMDL

This section summarizes the information developed for the TMDL titled "*One Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal.*" 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 document. Unless otherwise noted, all information in this section was derived from the above-titled TMDL document and/or the document titled *"Technical Support Document for Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal"* (TIAER 2015b).

Pollutant Sources and Loads

Wasteload Allocation

The wasteload allocation (WLA) for regulated source contributions in the watershed includes WWTFs (WLA_{WWTF}) and regulated stormwater (WLA_{SW}).

Wastewater Treatment Facilities

WWTFs regulated under the Texas Pollutant Discharge Elimination System (TPDES) are allocated a daily waste load (WLA_{WWTF}), calculated as their full permitted discharge flow rate multiplied by the instream geometric criterion after

reductions for a margin of safety (MOS). WLA_{WWTF} for the three WWTFs with bacteria limits within the Tres Palacios Creek watershed are listed in Table 5. WLA_{WWTF} is expressed in the following equation:

$$WLA_{WWTF} = \text{Criterion} * \text{Flow (MGD)} * \text{Conversion Factor} * (1 - F_{MOS})$$

Where:

Criterion = 35 MPN/100 mL for Enterococci; 126 MPN/100 mL for *E. coli*

Flow = full permitted flow [million gallons per day (MGD)]

Conversion factor (to MPN/day) = 1.54723 cubic feet per second (cfs)/MGD *283.168 100 mL/ft^3 * 86,400 seconds/day

F_{MOS} = fraction of loading assigned to MOS (5 percent or 0.05)

Table 5. Wasteload allocations for TPDES permitted facilities in Tres Palacios Creek watershed

AU	TPDES Permit No.	NPDES Permit No.	Facility	Full Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (Billion MPN/ day)	Enterococci WLA_{WWTF} (Billion MPN/ day)
1502_02	WQ0010844001	TX0021474	City of El Campo WWTF	2.628	11.908	3.307
1502_03	WQ0013091001	TX0098205	Midfield WWTF	0.03	0.136	0.038
1501_01	WQ0015075001	TX0134309	Markham MUD WWTF	0.3	1.359	0.378
Tres Palacios Creek Watershed Total					13.403	3.723

* Load includes a reduction for MOS of 5%

Regulated Stormwater

Stormwater discharges from municipal separate storm sewer systems (MS4), industrial, and construction areas are regulated point sources. Regulated stormwater discharges (WLA_{SW}) must be included in the WLA. Further detail on how the WLA_{SW} was calculated can be found in *One Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal.* The calculation for allowable loads from regulated stormwater is expressed by the following equation:

$$\Sigma WLA_{SW} = (TMDL - \Sigma WLA_{WWTF} - FG - MOS) * FDA_{SWP}$$

Where:

ΣWLA_{SW} = sum of all regulated stormwater loads

TMDL = total maximum daily load

ΣWLA_{WWTF} = sum of all WWTF loads

FG = future growth loads from potential permitted facilities

MOS = margin of safety

FDA_{SWP} = fractional proportion of drainage area under jurisdiction of stormwater permits

Load Allocation

The load allocation (LA) is the sum of loads from unregulated sources. The LA is calculated as:

$$LA = TMDL - WLA_{WWTF} - WLA_{SW} - FG - MOS$$

Where:

LA = allowable loads from unregulated sources within the AU

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

WLA_{SW} = sum of all regulated stormwater loads

FG = future growth loads from potential permitted facilities

MOS = margin of safety

Allowance for Future Growth

The future growth (FG) component addresses the requirement of TMDLs to account for future loadings that may occur as a result of population growth, changes in community infrastructure, and development. The assimilative capacity of streams increases as the amount of flow increases. Increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the contact recreation standard.

Currently, three facilities that treat domestic wastewater are located within the Tres Palacios Creek watershed and have been assigned a WLA (Table 5). To account for the FG component of impaired AU 1501_01, the loading from the WWTFs with bacteria limits are included in the FG computation, which is based on the WLA_{WWTF} formula. The FG equation contains an additional term to account for projected population growth between 2010 and 2050 in El Campo for the El Campo WWTF and Matagorda County for Midfield WWTF and the Markham MUD WWTF (Table 6).

$$FG = Criterion * [\%POP_{2010\text{-}2050} * WWTF_{FP}] * Conversion\ Factor * (1\text{-}F_{MOS})$$

Where:

Criterion = 35 MPN/100 mL Enterococci or 126 MPN/100 mL for *E. coli*

$\%POP_{2010\text{-}2050}$ = estimated percent increase in population between 2010 and 2050

$WWTF_{FP}$ = full permitted flow (MGD)

Conversion Factor = 1.547 cfs/MGD *283.168 100 mL/ft^3 * 86,400 s/d

F_{MOS} = fraction of loading assigned to margin of safety (5 percent or 0.05)

The calculation results for the impaired AU watershed are shown in Table 6.

Table 6. Future growth calculations for the Tres Palacios Creek watershed

TPDES Permit Number	Facility	Full Permitted Flow (MGD)	Type/ Location of Outfall	Percent Increase (2010-2050)	2050 Permitted Flow (FG) (MGD) [a]	Enterococci FG (Billion MPN/day) [b]
WQ0010 844001	City of El Campo WWTF	2.628	Municipal/ El Campo	22.46%	0.590	0.7425
WQ0013 091001	Midfield WWTF	0.03	Municipal/ Matagorda County	17.30%	0.005	0.0063
WQ0015 075001	Markham MUD WWTF	0.3	Municipal/ Matagorda County	17.30%	0.05	0.063
Tres Palacios Creek Total					**0.645**	**0.812**

[a] Significant digits based on full permitted flow

[b] FG = Criterion * [$\%POP_{2010\text{-}2050}$*$WWTF_{FP}$] * Conversion Factor *(1-F_{MOS})

Total Maximum Daily Load

Table 7 summarizes the TMDL calculations for Tres Palacios Creek Tidal (AU 1501_01). The TMDL was calculated based on the median flow in the 0–10 percentile range (5 percent exceedance, high flow regime) for flow exceedance from the load duration curve developed for the downstream surface water quality monitoring station in the watershed (12515) and is detailed in the *One Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal*. Allocations are based on the current geometric mean criterion for Enterococci of 35 MPN/100 mL for each component of the TMDL.

The TMDL equation can be expanded to show the components of WLA and LA:

$$TMDL = WLA_{WWTF} + WLA_{SW} + LA + FG + MOS$$

Table 7. TMDL allocation summary for the Tres Palacios Creek watershed

AU	Stream Name	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA	Future Growth
1501_01	Tres Palacios Creek Tidal	725.905	36.295	3.723	5.679	679.396	0.812

* Load units expressed as billion MPN/day

Implementation Strategy

This plan documents nine management measures to reduce bacteria loads. Management measures were selected based on feasibility, costs, support, and timing. Activities can be implemented in phases based on the needs of the stakeholders, availability of funding, and the progress made in improving water quality.

Adaptive Implementation

All 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, the stakeholders will periodically assess progress using the schedule of implementation, interim measurable milestones, water quality data, and the communication plan included in this document. If periodic assessments find that insufficient progress has been made or that implementation activities have improved water quality, the implementation strategy will be adjusted.

Activities and Milestones

To facilitate the development of the Tres Palacios Creek TMDL I-Plan, the Texas Water Resources Institute (TWRI), under contract with the TCEQ, held a series of public meetings in the watershed from April 2015 through August 2016. Collectively, the Tres Palacios Creek watershed stakeholder group and an agricultural work group held eight meetings to develop this I-Plan. The stakeholder group developed detailed, consensus-based action plans that later became sections of this I-Plan. The nine stakeholder-developed implementation activities are described in the following section.

Management Measures

The implementation plan for *One Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal* includes the following nine management measures.

1. *Development and Implementation of Conservation Plans in Priority Areas of the Watershed*
2. *Removal and Management of Feral Hogs*
3. *Identification, Prioritization, and Remediation of OSSFs*
4. *Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses*
5. *Planning and Management for Urban Stormwater*
6. *Installation of Urban Best Management Practices*
7. *Development and Implementation of Pet Waste Programs*
8. *Planning and Implementation of Wastewater Reuse*
9. *Infrastructure Maintenance and Replacement*

Sources of Technical Assistance

Technical assistance needs in the watershed vary substantially depending on the sources of pollution being addressed and the specific management recommendation being used. Many watershed stakeholders have various expertise, but in some instances, additional technical knowledge is needed.

Table 8 lists sources of technical assistance that contributed to guidance on planning and implementing management practices associated with the Tres Palacios Creek management measures.

Table 8. Sources of technical assistance for Tres Palacios Creek management measures

Management Measure	Technical Assistance
MM 1: Development and Implementation of Conservation Plans in Priority Areas of the Watershed	Texas State Soil and Water Conservation Board Texas A&M AgriLife Extension Service and County Extension Agents Natural Resources Conservation Service Soil and Water Conservation Districts Texas Parks and Wildlife Department
MM 2: Removal and Management of Feral Hogs	Texas A&M AgriLife Extension Service Texas Wildlife Services
MM 3: Identification, Prioritization, and Remediation of OSSFs	TCEQ Region 12 TCEQ Small Business and Local Government Assistance Program
MM 4: Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses	TCEQ Region 12 TCEQ Small Business and Local Government Assistance Program
MM 5: Planning and Management for Urban Stormwater	TCEQ Region 12

Management Measure	Technical Assistance
MM 6: Installation of Urban Best Management Practices	TCEQ Region 12, TCEQ NPS Program
MM 7: Development and Implementation of Pet Waste Programs	TCEQ Region 12, TCEQ NPS Program
MM 8: Planning and Implementation of Wastewater Reuse	TCEQ Region 12, Texas A&M Engineering Extension Service
MM 9: Infrastructure Maintenance and Replacement	Texas A&M Engineering Extension Service – WWTF operation and maintenance Texas Rural Water Association TCEQ Sanitary Sewer Overflow Initiative Private Engineering firms – general civil engineering services

*MM = Management Measure

Sources of Financial Assistance

Successful implementation of the Tres Palacios Creek management measures will require substantial fiscal resources. Due to the extremely rural nature of the watershed, substantial local sources of funding do not exist in the watershed. As a result, grant and other external sources of funding will be needed to support implementation efforts. Many landowners are already engaged in implementing management measures, which correspond to actions established in a watershed protection plan for the area. These measures include the development and implementation of Water Quality Management Plans (WQMPs) through the Texas State Soil and Water Conservation Board (TSSWCB) and installation of other conservation practices through Farm Bill-funded programs such as U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP). The continued funding support from federal and state governments for these two programs will provide a large portion of the funds needed to implement the management measures.

There are few local sources of funding. Monetary support from local watershed residents is limited to landowners willing to invest money to support management needs on their respective properties.

Procurement of grant funds will be relied upon for implementation of management measures, as they are the only other source of money identified, thus far, that can contribute to this effort. Some specific sources of funding that are applicable and available for use in implementing these management measures and their respective descriptions are exhibited in Table 9.

Table 9. Sources of financial assistance for Tres Palacios Creek management measures

Management Measure	Financial Assistance Program
MM 1: Development and Implementation of Conservation Plans in Priority Areas of the Watershed	Coastal Zone Management Administration Awards Conservation Innovation Grants Conservation Stewardship Program Environmental Education Grants Environmental Quality Incentives Program Farm Business Management and Benchmarking Program Federal and State CWA §319(h) Grants (EPA/TCEQ/TSSWCB) Regional Conservation Partnership Program Sustainable Agriculture Research and Education Targeted Watershed Grants Program TSSWCB Water Quality Management Plan Program
MM 2: Removal and Management of Feral Hogs	State CWA §319(h) Grants (TSSWCB) or other available opportunities Texas Department of Agriculture County Hog Abatement Matching Program Texas Wildlife Services
MM 3: Identification, Prioritization, and Remediation of OSSFs	Coastal Impact Assistance Program Coastal Management Program and National Coastal Zone Management Program State CWA §319(h) grants (TCEQ) Texas Supplemental Environmental Projects Fund
MM 4: Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses	State CWA §319(h) Grants (TCEQ/TSSWCB) USDA Rural Utilities Service Water and Waste Disposal Loans and Grants
MM 5: Planning and Management for Urban Stormwater	State CWA §319(h) Grants (TCEQ) Clean Water State Revolving Fund
MM 6: Installation of Urban Best Management Practices	Clean Water State Revolving Fund Environmental Education Grants State CWA §319(h) Grants (TCEQ) Urban Water Small Grants
MM 7: Development and Implementation of Pet Waste Programs	State CWA §319(h) Grants (TCEQ)
MM 8: Planning and Implementation of Wastewater Reuse	Clean Water State Revolving Fund Water and Waste Disposal Loans and Grants
MM 9: Infrastructure Maintenance and Replacement	Clean Water State Revolving Fund Economically Distressed Areas Program Water and Waste Disposal Loans and Grants

Management Measure 1

Development and Implementation of Conservation Plans

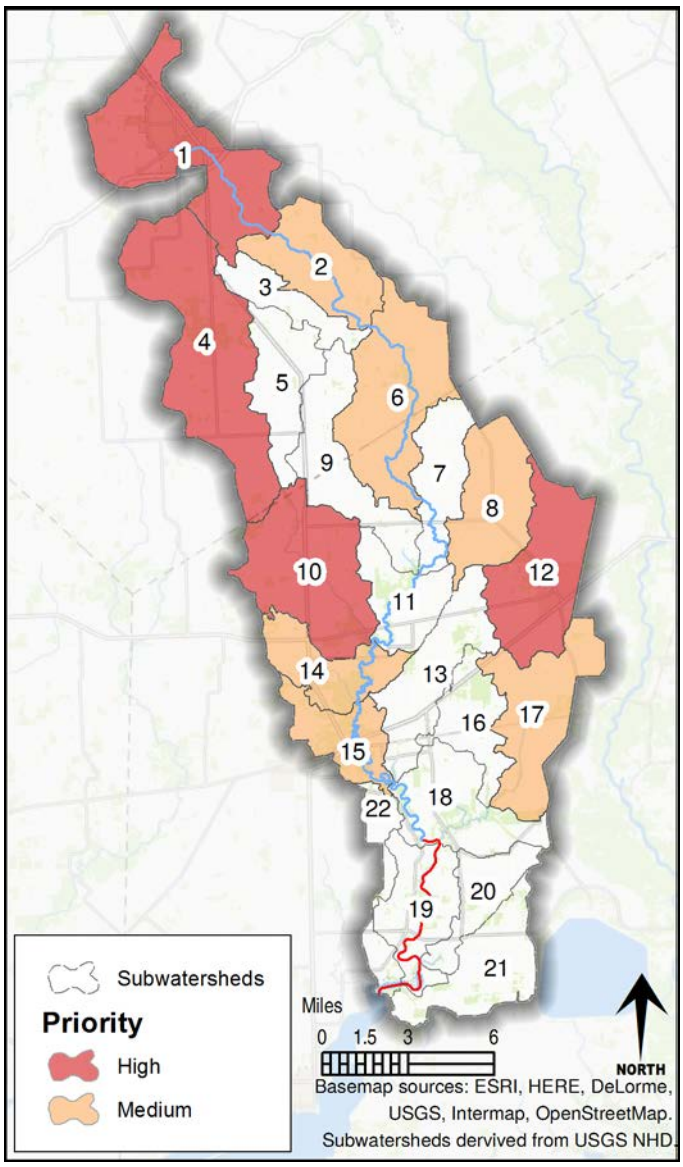

Figure 4: Priority areas for livestock management measures

Description

The purpose of this management measure is to develop and implement conservation plans in priority areas of the Tres Palacios Creek watershed. Bacteria loadings in the Tres Palacios Creek watershed from cattle and other livestock were estimated to be relatively high compared to other evaluated sources. These sources are also considered manageable as the behavior of cattle and the areas where they spend their time can be modified through changes to food, shelter, and water availability and access. Cattle grazing is highly dependent upon proximity to these resources, especially water. Their fecal loading is also strongly

tied to resource utilization as it is directly related to the amount of time an animal spends in an area. Therefore, reducing the amount of time livestock spend in riparian pastures through rotational grazing, adding alternative watering facilities, or moving supplemental feeding locations can directly reduce the potential for bacteria from livestock to enter the creek. Actual practices needed or appropriate will vary by operation and will be determined through technical assistance from the NRCS, TSSWCB, or local soil and water conservation districts (SWCDs), as appropriate.

The implementation of proven BMPs within priority subwatersheds can lead to instream water quality improvements by reducing degradation and minimizing fecal deposition in the riparian area. Currently, 38 conservation plans (30 in Wharton County and 8 in Matagorda County) have been developed and implemented across the watershed. Establishing additional acreage under management practices and conservation plans in this watershed is the primary goal of this management measure. The high priority subwatersheds for this management measure were determined by cattle stocking information and include 1, 4, 10, and 12 (Figure 4).

Education Component

Education is one of the most important components of this management measure. An intensive education and outreach program is needed to broadly promote the adoption of management practices through the appropriate programs. Awareness of the programs, management practices, and their benefits is often one of the largest factors affecting adoption of BMPs and should also be assessed so that adjustments can be made to encourage adoption. Educational programs specific to some of the landowner interests currently exist and will also be used as a part of the education and outreach campaign. Existing programs, such as the Lone Star Healthy Steams Program and the Statewide Riparian and Stream Ecosystem Management Education Program are resources that will promote the adoption of BMPs. Additionally, management practice field days will be held in order for the public to gain knowledge about how to implement particular BMPs throughout the watershed.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Watershed Coordinator

TWRI will serve as the watershed coordinator for the watershed. Duties will include: assisting stakeholders in the development of conservation plans, implementing BMPs, and organizing the educational programs related to this management measure.

Local Stakeholders

Local stakeholders, specifically landowners and livestock owners, will evaluate the option of adopting conservation plans through specific programs of their choice, including, but not limited to, the agencies described in the following paragraphs. If found feasible, the individual stakeholders will approach the appropriate agency and work with that agency to develop conservation plans to mitigate impacts to water quality. Stakeholders who adopt conservation plans should adhere to the requirements written into their specific conservation plans. The agencies described below are responsible for helping stakeholders adopt and implement their conservation plans.

Texas A&M AgriLife Extension Service

The Texas A&M AgriLife Extension Service (AgriLife Extension) provides quality, relevant outreach and continuing education programs and services to Texans. AgriLife Extension will work with the watershed coordinator in the continued development and delivery of education programs related to this management measure (outlined below).

Funded with TSSWCB Clean Water Act (CWA) Section 319(h) NPS grants, AgriLife Extension and the TWRI have developed the Lone Star Healthy Streams – Grazing Cattle curriculum. This educational program is delivered statewide and serves as the foundation for landowners' understanding of the effects of grazing cattle on bacteria loading to streams and the BMPs designed to reduce bacteria from grazing cattle. The curriculum promotes the adoption of BMPs and participation in federal and state cost-share programs. Upon request, TSSWCB and AgriLife Extension will deliver the program to landowners in the Tres Palacios Creek watershed.

Funded with TSSWCB CWA Section 319(h) NPS grants, AgriLife Extension and the TWRI have also developed the Lone Star Healthy Streams – Horse curriculum. This educational program is being delivered statewide and serves as the foundation for landowners' understanding of the effects on bacteria loading to streams and the BMPs designed to reduce bacteria from horses. The project manual is available at <http://lshs.tamu.edu/media/340453/horse_manual.pdf>. Upon request, TSSWCB and AgriLife Extension will deliver the program to horse owners in the Tres Palacios Creek watershed.

In concert with curriculum development, AgriLife Extension is evaluating the effectiveness of selected BMPs in reducing bacteria loading from grazing cattle to streams. BMPs evaluated include grazing management, shade, fencing, alternative water source development, riparian buffers, and combinations of these BMPs. The results, to date, show significant impacts to animal behavior and subsequent fecal bacteria loading, thus substantiating the use of these practices to mitigate TMDL pollutant loading. The project manual for dairy cattle is available at < http://lshs.tamu.edu/media/340447/dairy_manual.pdf> and the manual for beef cattle is found at < http://lshs.tamu.edu/media/340444/beef_cattle.pdf>.

Funded with TSSWCB CWA Section 319(h) NPS grants, AgriLife Extension and TWRI have also developed the Texas Stream and Riparian Ecosystem Training curriculum. This educational program is delivered statewide to introduce riparian principles, watershed processes, basic hydrology, erosion/deposition principles, and riparian vegetation. Potential causes of degradation and possible resulting impairments, as well as available local resources and technical assistance to prevent and resolve degradation are also discussed.

Texas State Soil and Water Conservation Board

The TSSWCB is the lead agency in Texas responsible for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural (forestry-related) NPS pollution (Texas Agriculture Code 2007). In accordance with this responsibility, the TSSWCB administers a certified WQMP Program that provides, through SWCDs, cost-share assistance for management practices on agricultural and silvicultural lands; however, not all WQMPs receive financial assistance.

Each WQMP is developed, maintained, and implemented under rules and criteria adopted by the TSSWCB. A WQMP achieves a level of pollution prevention or abatement consistent with the state's water quality standards and is a site-specific plan designed to assist landowners in managing NPS pollution from agricultural and silvicultural activities. WQMPs are traditional conservation plans based on the criteria outlined in the USDA NRCS Field Office Technical Guide (FOTG). The FOTG is the best available technology and is tailored to meet local needs.

A WQMP includes appropriate land treatment practices, production practices, management measures, technologies, or combinations thereof. WQMPs are developed in cooperation with the landowner, with assistance from the NRCS, are approved by the local SWCD, and are certified by the TSSWCB. This way of preventing and abating NPS pollution uses a voluntary approach while affording the landowner a mechanism for compliance with the state's water quality standards.

The TSSWCB regularly performs status reviews on WQMPs to ensure that the producers are implementing the measures described in the WQMP. The TSSWCB administers technical and financial assistance programs to assist producers in implementing their WQMPs. The TSSWCB utilizes both state funds and federal grants to implement the WQMP program. Several essential practices from the NRCS FOTG included in a WQMP have specific applicability to the bacteria reduction goals of this TMDL and I-Plan.

A grazing management system is a vital component of a WQMP for livestock operations. The TSSWCB, in collaboration with the NRCS and SWCD, will continue to provide technical assistance to landowners in developing and implementing WQMPs that include grazing management systems. The TSSWCB will develop WQMPs on 100 percent of the livestock operations in the Tres Palacios Creek watershed for those that request planning assistance through the SWCD. The

TSSWCB will annually perform status reviews on at least 5 percent of all WQMPs in the Tres Palacios Creek watershed.

Soil and Water Conservation Districts

An SWCD, like a county or school district, is a subdivision of state government. SWCDs are administered by a board of five directors who are elected by their fellow landowners. There are 216 individual SWCDs organized in Texas. It is through this conservation partnership that local SWCDs are able to furnish technical assistance to farmers and ranchers in the preparation of a complete soil and water conservation plan to meet each land unit's specific capabilities and needs. SWCDs #316 and #342 serve the Tres Palacios Creek watershed. More information on the program is available at <https://www.tsswcb.texas.gov/en/swcds>.

U.S. Department of Agriculture Natural Resources Conservation Service

The NRCS is a federal agency that works hand-in-hand with Texans to improve and protect their soil, water, and other natural resources. For decades, private landowners have voluntarily worked with NRCS specialists to prevent erosion, improve water quality, and promote sustainable agriculture. The NRCS provides conservation planning and technical assistance to landowners, groups, and units of government to develop and implement conservation plans that protect, conserve, and enhance their natural resources. When providing assistance, NRCS focuses on the sound use and management of soil, water, air, plant, and animal resources. NRCS ensures sustainability, allows for productivity, and respects the customers' needs. Conservation planning can make improvements to livestock operations, crop production, soil quality, water quality, pastureland, forestland, and wildlife habitats. The NRCS also integrates ecological and economic considerations in order to address private and public concerns. The NRCS with assistance from local SWCDs and the watershed coordinator will work with local landowners in the development of conservation programs through the programs listed below.

The NRCS administers numerous Farm Bill Programs authorized by the U.S. Congress that provide financial assistance for many conservation activities, including:

- Conservation Innovation Grants (CIG)
- Conservation Stewardship Program (CSP)
- EQIP
- Regional Conservation Partnership Program (RCPP)
- Agricultural Conservation Easement Program
- USDA Conservation Reserve Program administered by USDA Farm Service Agency

EQIP and other programs were reauthorized in the federal Agricultural Act of 2014 (Farm Bill) to provide a voluntary conservation program for farmers and

ranchers that promotes agricultural production and environmental quality as compatible national goals. People who are engaged in livestock or agricultural production on eligible land may participate in EQIP. EQIP offers financial and technical assistance to eligible participants for installation or implementation of structural and management practices on eligible agricultural land.

EQIP also provides incentive and cost-share payments to implement conservation practices. EQIP activities are carried out according to a plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice(s) to address resource concerns. All practices are subject to NRCS technical standards described in the FOTG and adapted for local conditions. The local SWCD approves the plan.

Local Work Groups provide recommendations to NRCS on allocating EQIP county base funds and on resource concerns for other USDA Farm Bill programs. The Tres Palacios Creek watershed stakeholders are encouraged to participate in Local Work Groups in order to promote the goals of this I-Plan, as compatible with the resource concerns and conservation priorities for EQIP.

Technical Assistance

The entities mentioned in this section provide resources of technical and financial assistance for Management Measure 1, but funding sources for this management measure need not be limited to these entities.

The intent of the previously mentioned programs is for the agencies listed under Management Measure 1 to work with landowners to voluntarily implement management and conservation plans. Technical assistance to agricultural producers for developing management and conservation plans is provided through the TSSWCB's WQMP Program, which is funded through state general revenue.

Financial Assistance

TSSWCB, SWCDs, and NRCS will continue to provide appropriate levels of cost-share assistance to agricultural producers that will facilitate the implementation of BMPs and conservation programs in the Tres Palacios Creek watershed, as described in Management Measure 1. Historically, according to TSSWCB data, conservation plan development and implementation in this watershed has been moderately low; as such, it is anticipated that additional levels of funding will be needed to meet implementation needs.

Coastal Zone Management Administration Awards

This program assists states in implementing and enhancing Coastal Zone Management Administration programs that have been approved by the U.S. Commerce Department. Funds are available for projects in areas such as coastal wetlands management and protection, natural hazards management, public access improvements, reduction of marine debris, assessment of impacts of coastal growth and development, special area management planning, regional

management issues, and demonstration projects with potential to improve coastal zone management.

Conservation Innovation Grants

The CIG is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, EQIP funds are used to award competitive grants to non-federal governmental or nongovernmental organizations, tribes, or individuals.

Conservation Stewardship Program

The CSP helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.

Environmental Education Grants

Under the Environmental Education (EE) Grant Program, the EPA seeks grant proposals from eligible applicants to support environmental education projects that promote environmental stewardship and help develop knowledgeable and responsible students, teachers, and citizens. This grant program provides financial support for projects that design, demonstrate, and/or disseminate environmental education practices, methods, or techniques as described in requests for proposals. Under this program, EPA has distributed between $2 and $3.5 million in grant funding per year since 1992.

Environmental Quality Incentives Program

The EQIP is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and non-industrial private forestland. An additional purpose of EQIP is to help producers meet federal, state, tribal, and local environmental regulations.

Farm Business Management and Benchmarking Program

The Farm Business Management and Benchmarking Competitive Grants Program provides funds to (1) improve the farm management knowledge and skills of agricultural producers; and (2) establish and maintain a national, publicly available, farm financial management database to support improved farm management.

Federal and State CWA §319(h) Grants (EPA/TCEQ/TSSWCB)

The EPA provides grant funding to Texas to implement the state's approved Nonpoint Source Management Program. The EPA-approved Texas program provides the framework for determining which activities are eligible for funding under CWA Section 319(h). In general, these activities include non-regulatory programs and are related to controlling NPS pollution. EPA-approved NPS programs cover costs associated with technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific NPS projects. This program requires a 40% match through local funding or in-kind services.

National Integrated Water Quality Program

The National Integrated Water Quality Program (NIWQP) provides funding for research, education, and extension projects aimed at improving water quality in agricultural and rural watersheds. The NIWQP has identified eight "themes" that are being promoted in research, education, and extension. The eight themes are (1) animal manure and waste management, (2) drinking water and human health, (3) environmental restoration, (4) nutrient and pesticide management (5) pollution assessment and prevention (6) watershed management, (7) water conservation and agricultural water management and (8) water policy and economics. Awards are made in four program areas: National Projects; Regional Coordination Projects; Extension Education Projects; and Integrated Research, Education, and Extension Projects. It is important to note that funding from this program is only available to universities.

Regional Conservation Partnership Program

The RCPP is a new, comprehensive, and flexible program that uses partnerships to stretch and multiply conservation investments and reach conservation goals on a regional or watershed scale. Through RCPP, the NRCS and state, local, and regional partners coordinate resources to help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved.

Sustainable Agriculture Research and Education

The Sustainable Agriculture Research and Education Program funds efforts that enhance the capabilities of Texas agricultural professionals in the area of sustainable agriculture. Grants and education are available to advance innovations in sustainable agriculture. The grants are aimed at advancing sustainable innovations and have contributed to an impressive portfolio of sustainable agriculture efforts across the nation.

Targeted Watershed Grants Program

The Targeted Watersheds Grant Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's watersheds. It is a competitive grant program based on the

fundamental principles of environmental improvement: collaboration, new technologies, market incentives, and results-oriented strategies. The Targeted Watersheds Grant Program focuses on multi-faceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders.

TSSWCB Water Quality Management Plan Program

WQMPs are property-specific plans that prescribe management practices that, when implemented, will improve the quality of land and water on the property. Once the plans are developed, TSSWCB may be able to provide financial assistance for implementing a portion of the practices. It should be noted that TSSWCB's WQMP Program is dependent on continued appropriations from the Texas Legislature.

This I-Plan targets the adoption and implementation of a total of 45 conservation plans and eight education programs over a five-year period. Adoption and implementation of the conservation plans is estimated to cost an average of $15,000 per plan (Table 10). Funding for implementation, either in the form of grants or through cost sharing incentives, is available through the entities listed under the descriptions provided previously in this section. The funding needed for education programs was estimated using an average cost of $50,000 per program.

Table 10. Estimated costs for Management Measure 1

Entity	Activity Needed	Estimated Cost
Entities Administering Incentive Programs for Stakeholders	Implementation of 45 Conservation Plans at $15,000 each	$675,000
Entities Administering Education/Outreach Programs	Eight Education and Outreach Programs at $50,000 each	$400,000

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the number of conservation plans developed, and
- the number of education/outreach programs delivered and materials developed.

Progress Indicators

Progress indicators for this management measure will consist of the following:

- Year 1 – develop nine conservation plans, provide one Lone Star Healthy Streams Workshop, provide one Management Practice Field Day
- Year 2 – develop nine additional conservation plans, provide one Riparian and Stream Ecosystem Training Workshop

- Year 3 – develop nine additional conservation plans, provide one Lone Star Healthy Streams Workshop, provide one Management Practice Field Day
- Year 4 – develop nine additional conservation plans, provide one Riparian and Stream Ecosystem Training Workshop
- Year 5 – develop nine additional conservation plans, provide one Lone Star Healthy Streams Workshop, provide one Management Practice Field Day

Monitoring Component

Monitoring of this management measure will consist of using the TCEQ's Clean Rivers Program (CRP) to monitor surface water quality and measure bacteria loadings (especially in priority areas). The CRP partner for the Tres Palacios Creek watershed is the Lower Colorado River Authority. Monitoring data collected by the CRP partner will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Develop and implement nine conservation plans: SWCDs, NRCS responsible.
- Lone Star Healthy Streams education program: Watershed coordinator and AgriLife Extension responsible.
- Management Practice Field Days: AgriLife Extension, SWCDs responsible.

Year 2:

- Develop and implement nine additional conservation plans: SWCDs, NRCS responsible.
- Riparian and Stream Ecosystem Management education program: Watershed coordinator and AgriLife Extension responsible.

Year 3:

- Develop and implement nine conservation plans: SWCDs, NRCS responsible.
- Lone Star Healthy Streams education program: Watershed coordinator and AgriLife Extension responsible.
- Management Practice Field Days: Watershed coordinator, AgriLife Extension, SWCDs responsible.

Year 4:

- Develop and implement nine conservation plans: SWCDs, NRCS responsible.
- Riparian and Stream Ecosystem Management education program: Watershed coordinator and AgriLife Extension responsible.

Year 5:

- Develop and implement nine conservation plans: SWCDs, NRCS responsible.
- Lone Star Healthy Streams education program: Watershed coordinator and AgriLife Extension responsible.
- Management Practice Field Days: Watershed coordinator, AgriLife Extension, SWCDs responsible.

Estimated Loading Reductions

Prescribed management will most effectively reduce direct deposition but will also reduce bacteria loads from the landscape as well. By implementing prescribed grazing, cross fencing, watering facilities, and other BMPs identified by local SWCDs, potential annual Enterococci loading reductions are calculated to be 2.61×10^{14} colony-forming units (cfu)/year. See Appendix B for details.

Table 11. Management Measure 1:

Conservation plans will be developed in areas where they will most appropriately address direct and indirect fecal deposition from cattle and other livestock, and prescribe BMPs that will reduce time livestock spend in the creek or riparian corridor, likely focusing on prescribed grazing, cross-fencing, and watering facilities.

Potential Load Reduction (in cfu/year Enterococci)	**Technical and Financial Assistance Needed**	**Education Component**	**Schedule of Implementation**	**Interim, Measurable Milestones**	**Indicators of Progress**	**Monitoring Component**	**Responsible Entity**
2.61×10^{14} cfu/year	**Technical Assistance** TSSWCB, AgriLife Extension and County Extension Agents, NRCS, SWCDs **Financial Assistance** Coastal Zone Management Administration Awards Conservation Innovation Grants Conservation Stewardship Program Environmental Education Grants Environmental Quality Incentives Program Farm Business Management and Benchmarking Program Federal and State CWA §319(h) Grants (EPA/TCEQ/TSSWCB) National Integrated Water Quality Program Regional Conservation Partnership Program Sustainable Agriculture Research and Education Targeted Watershed Grants Program TSSWCB Water Quality Management Plan Program	An intensive education and outreach program is needed to broadly promote the adoption of BMPs through the appropriate education programs such as Lone Star Healthy Streams, Riparian and Stream Ecosystem Management, and Management Practice Field Days.	**Years 1, 3, and 5** Develop and implement nine conservation plans each year in the Tres Palacios Creek watershed, hold Lone Star Healthy Streams education program and Management Practice Field Days **Years 2 and 4** Develop and implement nine conservation plans each year in the Tres Palacios Creek watershed and hold Riparian and Stream Ecosystem Management education program	Number of conservation plans developed and implemented Number of education programs delivered	**Years 1-5**: Development and implementation of nine conservation plans each year in the Tres Palacios Creek watershed, delivery of various education programs each year	TCEQ CRP and watershed coordinator	Watershed Coordinator Local Stakeholders AgriLife Extension NRCS SWCDs TPWD TSSWCB

Management Measure 2

Removal and Management of Feral Hogs

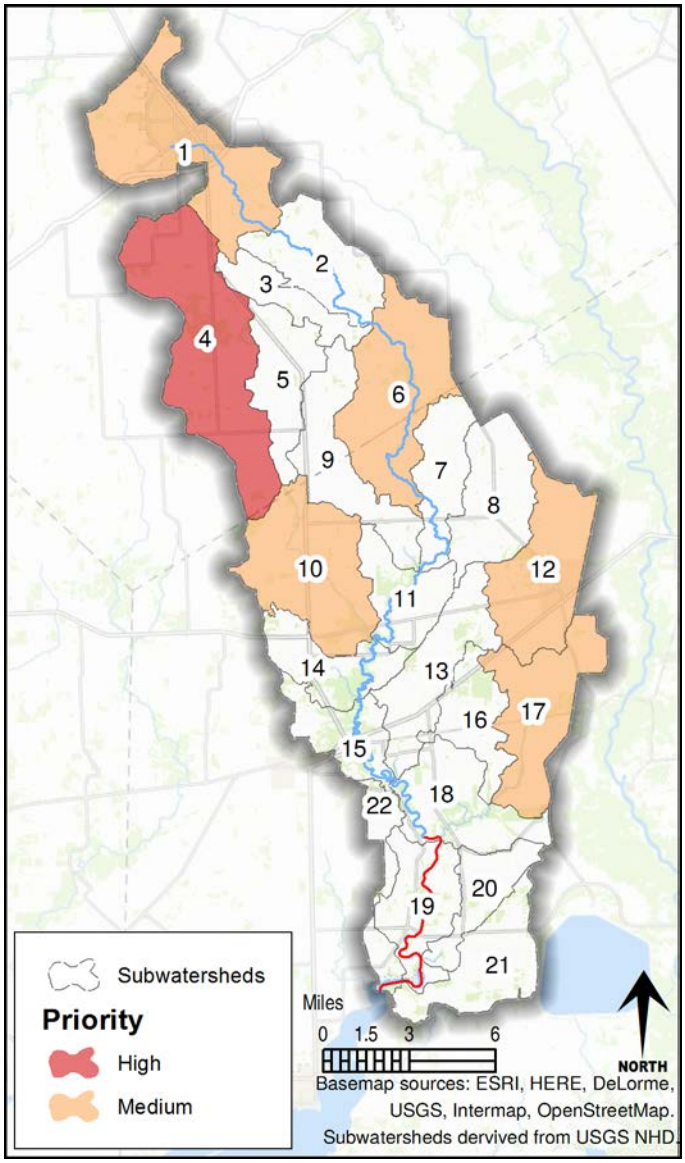

Figure 5: Priority areas for feral hog management measures

Description

Feral hogs have been identified as significant contributors of pollutants to water bodies. As feral hogs congregate around water resources to drink and wallow, their concentration in high numbers in riparian areas poses a threat to water quality. Fecal matter deposited directly in streams by feral hogs contributes to bacteria and nutrients, polluting the state's water bodies. In addition, the extensive rooting activities of feral hogs can cause extreme erosion and soil loss. The destructive habits of feral hogs cause an estimated $52 million worth of agricultural crop and property damage each year in Texas. Also, it has been estimated

that 60 percent would need to be removed annually to hold the population stable with no increase (Timmons et al., 2012). Stakeholders in watersheds across the state, including the Tres Palacios Creek watershed, have recommended that efforts to control feral hogs be undertaken to reduce the population, limit the spread of these animals, and minimize their effects on water quality and the surrounding environment.

The purpose of this management measure is to manage the feral hog population such that the current population does not increase, especially to a level that is unmanageable. Without a significant number of hogs removed from the watershed on an annual basis and sustained efforts to keep the population at a manageable level, water quality improvements may not be realized. Various control efforts are currently employed, such as live trapping, shooting, hunting with dogs, aerial hunting, exclusion, and habitat management. The continuation and increased intensity of these practices, especially in priority areas, along with technical and financial assistance, is needed to reach the overall goal of this plan. Activities will be targeted towards priority areas where landowners should be contacted to discuss the economic savings of removing feral hogs, specific methods to do so, and available programs that assist in feral hog removal.

In an effort to track progress of this management measure, the AgriLife Extension Feral Hog Reporting tool will be used in addition to other tracking techniques. Sightings of feral hogs should be a notable indicator of a significant reduction in the feral hog population. The reporting tool can be found at <http://feralhogreports.tamu.edu/>.

Implementation for much of this management measure is dependent on available funding. Funding assistance will be needed for personnel, materials, supplies for feral hog management, and education. The priority subwatersheds for this management measure include 1, 4, 6, 10, 12, and 17, as well as riparian areas along water bodies (Figure 5).

Education Component

Education and outreach for this management measure is needed to ensure that stakeholders understand the importance of feral hog removal and the economic savings that result from such removal. Some educational programs exist through AgriLife Extension and are discussed in the following description of this management measure, but services offered by AgriLife Extension are statewide programs and funding for personnel is limited. Stakeholders would benefit greatly by receiving educational materials; therefore, a targeted campaign should be implemented consisting of multiple educational opportunities for stakeholders, including the development and tailoring of educational materials, and the dissemination of these materials.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Watershed Coordinator

TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with AgriLife Extension and other local entities to deliver feral hog educational workshops, as well as make online resources available. The watershed coordinator will also work with the local county officials to maintain a feral hog tracking database.

Local Stakeholders

Local stakeholders, specifically landowners, land managers, and lessees will evaluate the option of adopting a conservation plan related to feral hog control through a specific program of their choice, including but not limited to, the list below. If found feasible, the individual stakeholders will approach the appropriate agency and work with that agency to develop feral hog management plans to mitigate impacts to water quality. Stakeholders who adopt feral hog management plans should adhere to the requirements written into their specific plan. The agencies listed below are responsible for helping stakeholders adopt and implement these plans.

Texas Parks and Wildlife Department (TPWD)

The TPWD's Private Lands Services is a program for private landowners to provide practical information on ways to manage wildlife resources consistent with other land use goals, to ensure plant and animal diversity, to provide aesthetic and economic benefits, and to conserve soil, water, and related natural resources. To participate, landowners may request assistance by contacting the TPWD district serving their county. TPWD biologists serving specific geographical areas can be found at the following TPWD website: <http://tpwd.state.tx.us/landwater/land/technical_guidance/biologists/>.

TPWD's only cost share program is the Landowner Incentive Program (LIP). To learn more about TPWD's LIP or request financial assistance from a TPWD biologist in the LIP program, visit the website at: <http://tpwd.texas.gov/landwater/land/private/lip/>. The website explains the types of projects funded by LIP. Once a property's potential has been determined, a biologist will provide recommendations and, if requested, help the landowner develop a written wildlife management plan. Other funding opportunities may also be available through various TPWD programs.

Texas A&M AgriLife Extension Service

Funded with TSSWCB CWA Section 319(h) NPS grants, AgriLife Extension and the TWRI developed the Lone Star Healthy Streams – Feral Hog curriculum. This education program is delivered statewide and serves as the foundation for educating landowners about the effects of feral hogs on bacteria loading into streams and also about control techniques designed to abate feral hogs and reduce their bacteria contributions. Techniques discussed include trapping, hunting, and snaring of feral hogs, as well as what to do to dispose of captured feral hogs.

Concurrent with curriculum development, and with TSSWCB funding, AgriLife Extension has developed:

- a series of publications addressing management strategies and techniques for feral hog control, and
- an on-line feral hog activity reporting system to support identification of target areas for implementation of feral hog control activities, as mentioned above.

Both the publication series and the on-line reporting tool were piloted in the Plum Creek watershed, but they are now being applied to watersheds statewide that are impacted by feral hogs. The project work plan and more information can be found at the following websites: <www.tsswcb.texas.gov/managementprogram/lonestar2> and <http://plumcreek.tamu.edu/FeralHogs>.

With continuous efforts, feral hogs can be managed. Texas Wildlife Services (TWS), through cooperative agreements between AgriLife Extension and the USDA's Animal and Plant Health Inspection Service, provides statewide leadership in the science, education, and practice of wildlife and invasive species management, including feral hogs, to protect the state's agricultural, industrial, and natural resources, as well as the public's health, safety, and property (Texas Health and Safety Code Chapter 825).

Technical Assistance

Technical assistance for Management Measure 2 will be provided as needed by the AgriLife Extension, TPWD, and TWS.

Financial Assistance

State CWA §319(h) Grants (TSSWCB)

The EPA provides grant funding to Texas to implement the state's approved Nonpoint Source Management Program. The EPA-approved Texas program provides the framework for determining which activities are eligible for funding under CWA Section 319(h). In general, these activities include non-regulatory programs and are related to controlling NPS pollution; EPA-approved NPS programs cover costs associated with technical assistance, financial assistance,

education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific NPS projects.

Texas Department of Agriculture **(TDA)**

Since 2008, the TDA has awarded grants to TWS for a feral hog abatement program. The grants are used to carry out a number of specifically identified direct control projects where control efforts can be measured. Certain areas of the state have been targeted due to the contributions from feral hogs to impaired water quality and bacteria loading.

County Hog Abatement Matching Program **(CHAMP)**

The TDA administers CHAMP, which is designed to encourage counties across Texas to create partnerships with other counties, local governments, businesses, landowners, and associations to reduce feral hog populations and the damage caused by these animals in Texas.

To be eligible to receive an award from CHAMP, a Texas county must partner with at least one other Texas county, and may partner with other local entities.

Texas Wildlife Services

TWS is available to provide assistance in addressing feral hog issues and will remain available to all citizens of the state. While direct control will be limited to availability of personnel in cooperative association areas (i.e., areas designated by groups of landowners to improve wildlife habitats and other associated wildlife programs), technical assistance can be provided to individuals on how to best resolve feral hog problems.

This I-Plan targets annual maintenance of feral hog populations through their reduction by 20 percent (or approximately 1,000 feral hogs). The estimated costs of implementation through hog removal and education programs are detailed in Table 12.

Table 12. Estimated costs of Management Measure 2

Entity	Activities Needed	Estimated Costs
Landowners, land managers, lessees	Voluntary construction of deer feeder exclusions at $200 each	Unknown
Watershed coordinator, AgriLife Extension	Deliver three Feral Hog Management Workshops at $7,500 each	$22,500
Watershed coordinator, AgriLife Extension, TPWD	Deliver three Wildlife Management Workshops at $7,500 each	$22,500

Measurable Milestones

Measureable milestones for this management measure will consist of:

- the number of educational programs delivered per year

- the number of educational materials developed and disseminated
- the number of individuals reached
- the number of feral hogs removed per year

Progress Indicators

Progress indicators will consist of the following:

- Year 1 – development and submittal of funding proposals to fund education programs and implementation of feral hog management measures
- Years 2-5 – number of materials developed and disseminated, number of persons reached through education, number of feral hogs removed from the watershed

Monitoring Component

Monitoring for this management measure will consist of continuing TCEQ CRP monitoring at existing sites. The CRP partner for the Tres Palacios Creek watershed is the Lower Colorado River Authority. Monitoring data collected by the CRP partner will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Voluntarily construct fencing around deer feeders to prevent feral hog utilization: landowners, land managers, lessees responsible.
- Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers: landowners, land managers, lessees responsible.
- Voluntarily shoot hogs; ensure lessees shoot hogs on site: landowners, land managers, lessees responsible.
- Feral Hog Management education program: watershed coordinator and AgriLife Extension responsible.
- Wildlife Management education program: watershed coordinator, AgriLife Extension, TPWD responsible.
- Promote use of AgriLife Extension's online tracking tool to report hog harvest data: watershed coordinator and AgriLife Extension responsible.

Year 2:

- Voluntarily construct fencing around deer feeders to prevent feral hog utilization: landowners, land managers, lessees responsible.
- Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers: landowners, land managers, lessees responsible.
- Voluntarily shoot hogs; ensure lessees shoot hogs on site: landowners, land managers, lessees responsible.
- Promote use of Extension's online tracking tool to report hog harvest data: watershed coordinator and AgriLife Extension Service responsible.

Year 3:

- Voluntarily construct fencing around deer feeders to prevent feral hog utilization: landowners, land managers, lessees responsible.
- Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers: landowners, land managers, lessees responsible.
- Voluntarily shoot hogs; ensure lessees shoot hogs on site: landowners, land managers, lessees responsible.
- Feral Hog Management education program: watershed coordinator and AgriLife Extension responsible.
- Wildlife Management education program: watershed coordinator and AgriLife Extension Service, TPWD.
- Promote use of AgriLife Extension's online tracking tool to report hog harvest data: watershed coordinator and AgriLife Extension responsible.

Year 4:

- Voluntarily construct fencing around deer feeders to prevent feral hog utilization: landowners, land managers, lessees responsible.
- Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers: landowners, land managers, lessees responsible.
- Voluntarily shoot hogs; ensure lessees shoot hogs on site: landowners, land managers, lessees responsible.
- Promote use of AgriLife Extension's online tracking tool to report hog harvest data: watershed coordinator and AgriLife Extension responsible.

Year 5:

- Voluntarily construct fencing around deer feeders to prevent feral hog utilization: landowners, land managers, lessees responsible.
- Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers: landowners, land managers, lessees responsible.
- Voluntarily shoot hogs; ensure lessees shoot hogs on site: landowners, land managers, lessees responsible.

- Feral Hog Management education program: watershed coordinator and AgriLife Extension responsible.
- Wildlife Management education program: watershed coordinator, AgriLife Extension, TPWD responsible.
- Promote use of AgriLife Extension's online tracking tool to report hog harvest data: watershed coordinator and AgriLife Extension responsible.

Estimated Loading Reductions

Reducing the feral hog population will reduce bacteria loading to the landscape and direct deposition to the creek. This effort will primarily reduce direct deposition as these animals spend the majority of their time in the riparian corridors. Expected Enterococci load reductions from reduced feral hog populations are 9.66×10^{12} cfu/year. See Appendix B for details.

Table 13. Management Measure 2:

Stakeholders will voluntarily implement efforts to reduce feral hog populations throughout the watershed by reducing food supplies, removing hogs as practical, and educating landowners on BMPs for hog removal.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
9.66×10^{12} cfu/year	**Technical Assistance** AgriLife Extension, TWS **Financial Assistance** State CWA 319(h) Grants (TSSWCB) TDA County Hog Abatement Matching Program TWS	An education and outreach program is needed to broadly promote the adoption of BMPs such as the Feral Hog Management and the Wildlife Management education programs.	**Years 1-5** Voluntarily construct fencing, identify travel corridors for trapping and hunting, shoot hogs, promote use of Extension's online tracking tool for reporting harvest data **Years 1, 3, and 5** Feral Hog Management and Wildlife Management education programs	The number of educational programs delivered per year The number of educational materials developed and disseminated The number of individuals reached The number of feral hogs removed per year	**Year 1**: Development and submittal of funding proposals to fund education programs and implementation of feral hog management measures **Years 2-5**: Number of materials developed and disseminated, number of persons reached through education, number of feral hogs removed from the watershed	TCEQ CRP and watershed coordinator	Stakeholders Watershed Coordinator AgriLife Extension TPWD

Management Measure 3

Identification, Prioritization, and Remediation of OSSFs

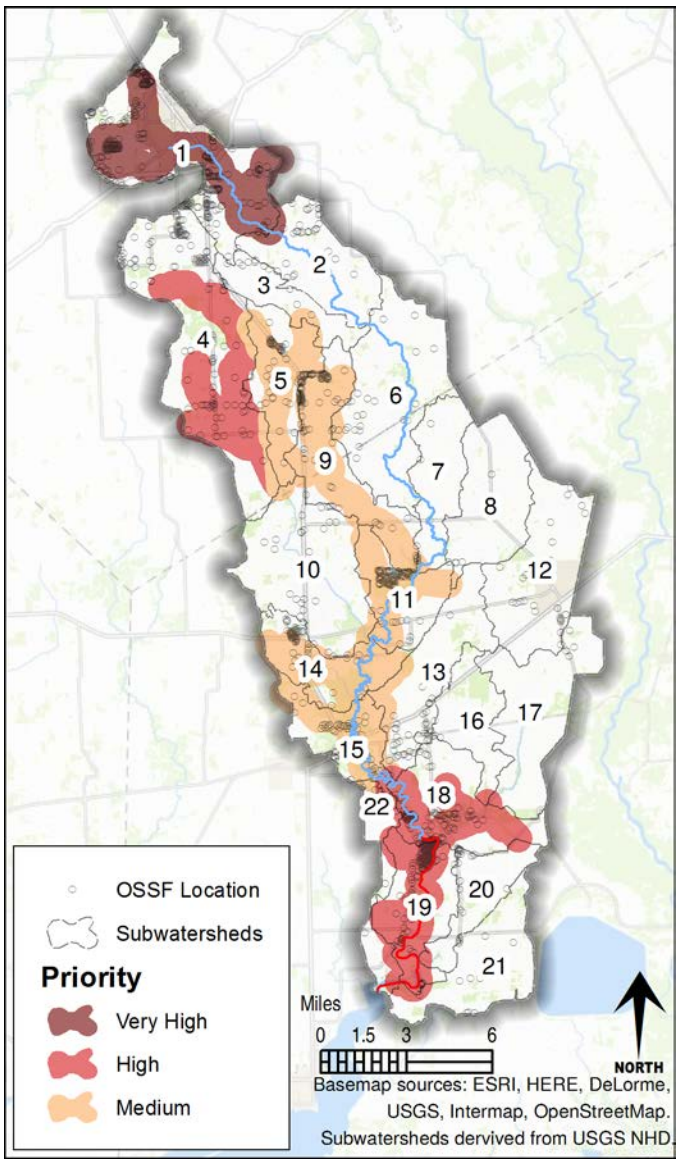

Figure 6: Priority areas for OSSF management measures

Description

The purpose of this management measure is to manage OSSFs throughout the Tres Palacios Creek watershed through identification, prioritization, and remediation of the systems. Failing OSSFs have been known to contribute to bacteria impairments all over the state. Within the Tres Palacios Creek watershed, soils are not conducive for conventional septic systems, so aerobic systems are most commonly used. Within Matagorda County, aerobic systems make up approximately 98 percent of all systems due to soil type. In Wharton County, both

aerobic and conventional systems can be found. For aerobic systems in both counties, the Authorized Agents require that a maintenance contract be in place with a licensed maintenance provider. As a result, it is assumed that the vast majority of aerobic systems can be considered as properly treating sewage.

It is the purpose of this management measure to identify OSSFs that are failing and not properly treating sewage. The watershed coordinator will work with Matagorda and Wharton county staff to facilitate inspections of potentially failing OSSFs by county staff or other authorized personnel. Failing OSSFs will be identified through inspections and looking at existing databases. Currently, Matagorda County maintains a database of OSSFs and their maintenance contracts and this database can be used to identify systems that are not meeting their maintenance requirements. Systems that have been identified as failing will be documented in a new database and should be upgraded or replaced as resources are made available. Further, education on system operation and maintenance as well as proper installation, inspection, and repair procedures should be delivered. Education and outreach events should also discuss financial assistance options available to OSSF owners. The high priority subwatersheds for this management measure include subwatersheds 1, 4, 18, and 19, as well as systems within close proximity to the water body (Figure 6).

Education Component

The level of general knowledge and understanding of operation and maintenance requirements for OSSFs is thought to be low throughout the TMDL watershed. Education and outreach for OSSFs is important in this TMDL watershed and will be targeted to homeowners as well as local officials, as these officials have the ability to establish mechanisms that will mitigate pollution problems from OSSFs at community, county, watershed, and regional scales. Efforts must also be made to deliver educational materials on proper OSSF operation and maintenance to homeowners.

AgriLife Extension currently hosts education programs for homeowners about proper operation and maintenance requirements, and provides an overview of general OSSF requirements, collection and storage, pretreatment (and advanced pretreatment) components, disinfection, final treatment and dispersal, selection, and permitting. Information about this program can be found at <http://ossf.tamu.edu/>. As funding allows, this program will be delivered in the TMDL watersheds to assist in meeting the educational requirements of this plan.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Watershed Coordinator

TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with AgriLife Extension, OSSF owners, and Matagorda and Wharton counties to secure resources needed for the repair and replacement of OSSFs and to deliver needed educational programs. TWRI will work with local stakeholders, AgriLife Extension, and county governments to coordinate database development for failing or potentially failing OSSFs. The development of such a database will follow guidance and recommendations of stakeholders and local entities (including who will maintain the database and what information will be stored). Such a database can provide guidance for future prioritization and progress tracking as OSSF repair and replacement proceeds.

Local Stakeholders

As resources are made available, OSSF owners will be responsible for making sure needed repairs or replacements are made on malfunctioning OSSFs.

Texas A&M AgriLife Extension Service

As resources are made available, AgriLife Extension will work with TWRI and county staff to identify and assist in the repair or replacement of failing OSSFs and deliver education programs. AgriLife Extension will work with county staff to facilitate the inspection of OSSFs by county staff or other authorized agents, including AgriLife Extension staff as appropriate.

Matagorda and Wharton Counties

As resources are made available, Matagorda and Wharton counties will be responsible for ongoing activities associated with this management measure within their respective jurisdictions and working with TWRI and AgriLife Extension in the identification of failing OSSFs. Matagorda and Wharton counties will work with the watershed coordinator, AgriLife Extension, and authorized entities to inspect OSSFs as appropriate and as resources permit.

Technical Assistance

Technical assistance for Management Measure 3 may be provided as needed by TCEQ Region 12 and the TCEQ Small Business and Local Government Assistance Program. This may include providing confidential environmental consultation to both Matagorda and Wharton counties without threat of enforcement actions. In particular, compliance assistance and resources are available to local governments regarding OSSF permitting programs. AgriLife Extension will provide educational opportunities through the Texas Well Owner Network, Installer and Maintenance Provider Workshops, and OSSF Operation and Maintenance (O&M) Workshops.

Financial Assistance

Texas General Land Office Coastal Impact Assistance Program

The Coastal Impact Assistance Program provides federal grant funds (derived from federal offshore lease revenues in oil producing states) for conservation, protection, and/or restoration of coastal areas, including wetlands. The program also provides funding for mitigation of damage to fish, wildlife, or natural resources; for planning assistance and the administrative costs of complying with planning objectives; for implementation of a federally-approved marine, coastal, or comprehensive conservation management plan; and for mitigation of the impact of outer Continental Shelf activities through funding of onshore infrastructure projects and public services.

Coastal Zone Management Program and Coastal Management Program

The Coastal Zone Management (CZM) Program, administered by the National Oceanic and Atmospheric Administration and the Texas General Land Office (TGLO), is a voluntary partnership between the federal government and U.S. coastal and Great Lake states and territories. It is authorized by the Coastal Zone Management Act of 1972 to address national coastal issues. The Act provides funding for protecting, restoring, and responsibly developing our nation's diverse coastal communities and resources. To meet the goals of the Act, the National CZM Program takes a comprehensive approach to coastal resource management—balancing the often competing, and occasionally conflicting, demands of coastal resource use, economic development, and resource conservation. Some of the key elements of the National CZM Program include:

- protecting natural resources
- managing development in high hazard areas
- giving development priority to coastal-dependent uses
- providing public access for recreation
- coordinating state and federal actions

The CZM Program provides pass-through funding to TGLO, which, in turn, uses the funding to finance coastal restoration, conservation, and protection projects under the TGLO's Coastal Management Program.

State CWA §319(h) Grants (TCEQ)

The EPA provides grant funding to Texas to implement the state's approved Nonpoint Source Management Program. The EPA-approved Texas program provides the framework for determining which activities are eligible for funding under CWA Section 319(h). In general, these activities include non-regulatory programs and are related to controlling NPS pollution. EPA-approved NPS programs cover costs associated with technical assistance, financial assistance,

education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific NPS projects.

Texas Supplemental Environmental Projects Fund

The Supplemental Environmental Projects (SEP) program, administered by the TCEQ, directs fines, fees, and pentalties for environmental violations toward environmentally benefical uses. Through this program, a respondent in an enforcement matter can choose to invest penalty dollars into improving the environment, rather than paying into the Texas General Revenue Fund. Program dollars may be directed to OSSF repair, trash dump clean up, and wildlife habitat restoration or improvement, among other things. Program dollars may be directed to entities for single, one-time projects that require special approval from the TCEQ or directed to entities (such as Resource Conservation and Development Councils) with pre-approved "umbrella" projects.

This management measure aims to fund one position to identify and maintain a database of OSSFs in need of replacement, replace a total of 30 OSSF systems over a 5-year period, and deliver three OSSF O&M workshops. Table 14 outlines the estimated costs of implementing the management measure.

Table 14. Estimated costs of Management Measure 3

Entity	Activities Needed	Estimated Costs
Watershed Coordinator, AgriLife Extension, OSSF Owners	Repair or replacement of 30 systems at $7,500 each	$225,000
Watershed Coordinator, AgriLife Extension, Matagorda and Wharton counties	Personnel to identify failing OSSFs at $40,000 annually	$200,000
Watershed Coordinator, Matagorda and Wharton counties	Maintain OSSF database	$50,000
Watershed Coordinator	Program administration at $15,000 annually	$75,000
Watershed coordinator, AgriLife Extension	Deliver three OSSF O&M workshops at $7,500 each	$25,000

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the number of OSSF owners contacted for inspections and/or outreach
- the number of OSSF inspections made

- development of an OSSF database
- the number of OSSFs repaired or replaced
- the number of educational materials developed and distributed

Progress Indicators

Progress indicators for this management measure will consist of the following:

- Year 1 – Develop and submit proposals to fund personnel to identify, inspect, and track OSSFs; repair or replace six failing OSSFs; deliver one OSSF O&M workshop
- Years 2-5 – Address the repair and replacement of an additional six systems per year; provide two additional OSSF O&M workshops

Monitoring Component

Monitoring will consist of using TCEQ CRP monitoring and measuring bacteria loading, especially in priority areas. The CRP partner for the Tres Palacios Creek watershed is the Lower Colorado River Authority. Monitoring data collected by the CRP partner will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Develop and submit a proposal to fund OSSF replacement and repair program: watershed coordinator and counties responsible.
- Identify and inspect OSSFs in close proximity to waterways: watershed coordinator, AgriLife Extension, and counties responsible.
- Develop a single OSSF database that documents OSSF information: watershed coordinator, AgriLife Extension, and counties responsible.
- Administer OSSF repair or replacement program to address deficient systems identified during inspections: watershed coordinator responsible.
- Repair or replace six OSSF systems per year (contingent upon funding): watershed coordinator, OSSF owners, and contractor responsible.
- OSSF O&M Workshops: watershed coordinator and AgriLife Extension responsible.
- OSSF Installer and Maintenance Provider Workshop: watershed coordinator and AgriLife Extension responsible.

Year 2:

- Identify and inspect OSSFs in close proximity to waterways: watershed coordinator, AgriLife Extension, and counties responsible.
- Maintain single OSSF database that documents OSSF information: watershed coordinator, AgriLife Extension, and counties responsible.
- Administer OSSF repair or replacement program to address deficient systems identified during inspections: watershed coordinator responsible.
- Repair or replace six OSSF systems per year (contingent upon funding): watershed coordinator, OSSF owners, and contractor responsible.
- Implement Texas Well Owner Network: watershed coordinator and AgriLife Extension responsible.

Year 3:

- Identify and inspect OSSFs in close proximity to waterways: watershed coordinator, AgriLife Extension, and counties responsible.
- Maintain single OSSF database that documents OSSF information: watershed coordinator, AgriLife Extension, and counties responsible.
- Administer OSSF repair or replacement program to address deficient systems identified during inspections: watershed coordinator responsible.
- Repair or replace six OSSF systems per year (contingent upon funding): watershed coordinator, OSSF owners, and contractor responsible.
- OSSF O&M Workshops: watershed coordinator and AgriLife Extension responsible.
- OSSF Installer and Maintenance Provider Workshop: watershed coordinator and AgriLife Extension responsible.

Year 4:

- Identify and inspect OSSFs in close proximity to waterways: watershed coordinator, AgriLife Extension, and counties responsible.
- Maintain single OSSF database that documents OSSF information: watershed coordinator, AgriLife Extension, and counties responsible.
- Administer OSSF repair or replacement program to address deficient systems identified during inspections: watershed coordinator responsible.
- Repair or replace six OSSF systems per year (contingent upon funding): watershed coordinator, OSSF owners, and contractor responsible.
- Implement Texas Well Owner Network: watershed coordinator and AgriLife Extension responsible.

Year 5:

- Identify and inspect OSSFs in close proximity to waterways: watershed coordinator, AgriLife Extension, and counties responsible.
- Maintain single OSSF database that documents OSSF information: watershed coordinator, AgriLife Extension, and counties responsible.
- Administer OSSF repair or replacement program to address deficient systems identified during inspections: watershed coordinator responsible.

- Repair or replace six OSSF systems per year (contingent upon funding): watershed coordinator, OSSF owners, and contractor responsible.
- OSSF O&M Workshops: watershed coordinator and AgriLife Extension responsible.
- OSSF Installer and Maintenance Provider workshop: watershed coordinator and AgriLife Extension responsible.

Estimated Loading Reductions

As planned, 30 systems will be repaired or replaced throughout the watershed. The identification and replacement of OSSFs should prioritize areas within priority areas and within close proximity to water bodies. If all 30 systems are replaced as outlined, potential load reductions are 1.22×10^{13} cfu/year.

Table 15. Management Measure 3:

Potential OSSF failures will be addressed by working with homeowners to identify and inspect all OSSFs within priority areas. Deficient systems will be repaired or replaced as appropriate to bring them into compliance with local requirements.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
1.22×10^{13} cfu/year	**Technical Assistance** TCEQ Region 12, TCEQ Small Business and Local Government Assistance Program **Financial Assistance** Coastal Impact Assistance Program Coastal Management Program and National Coastal Zone Management Program State CWA §319(h) Grants (TCEQ) Texas SEP Fund	An education and outreach program is needed to broadly promote the adoption of BMPs such as OSSF O&M Workshops, OSSF Installer and Maintenance Provider Workshops, and the Texas Well Owner Network	**Years 1, 3, and 5** Identify and inspect OSSFs, develop and then consistently maintain single OSSF database, administer replacement program annually, repair or replace six systems each year as funding allows, implement OSSF O&M Workshops and OSSF Installer and Maintenance Provider Workshops **Years 2 and 4** Identify and inspect OSSFs, maintain single OSSF database, administer replacement program annually, repair or replace six systems each year as funding allows, implement Texas Well Owner Network	The number of OSSF owners contacted for inspections or outreach The number of OSSF inspections made The number of OSSFs repaired or replaced The number of educational materials developed and distributed	**Year 1**: Development and submittal of proposals to fund personnel to identify, inspect, and track OSSFs, repair or replace six failing OSSFs, deliver OSSF O&M workshop **Years 2-5:** Address the repair or replacement of an additional six systems per year, provide two additional OSSF O&M workshops	TCEQ CRP and watershed coordinator	Watershed Coordinator AgriLife Extension OSSF Owners Matagorda and Wharton counties

Management Measure 4

Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses

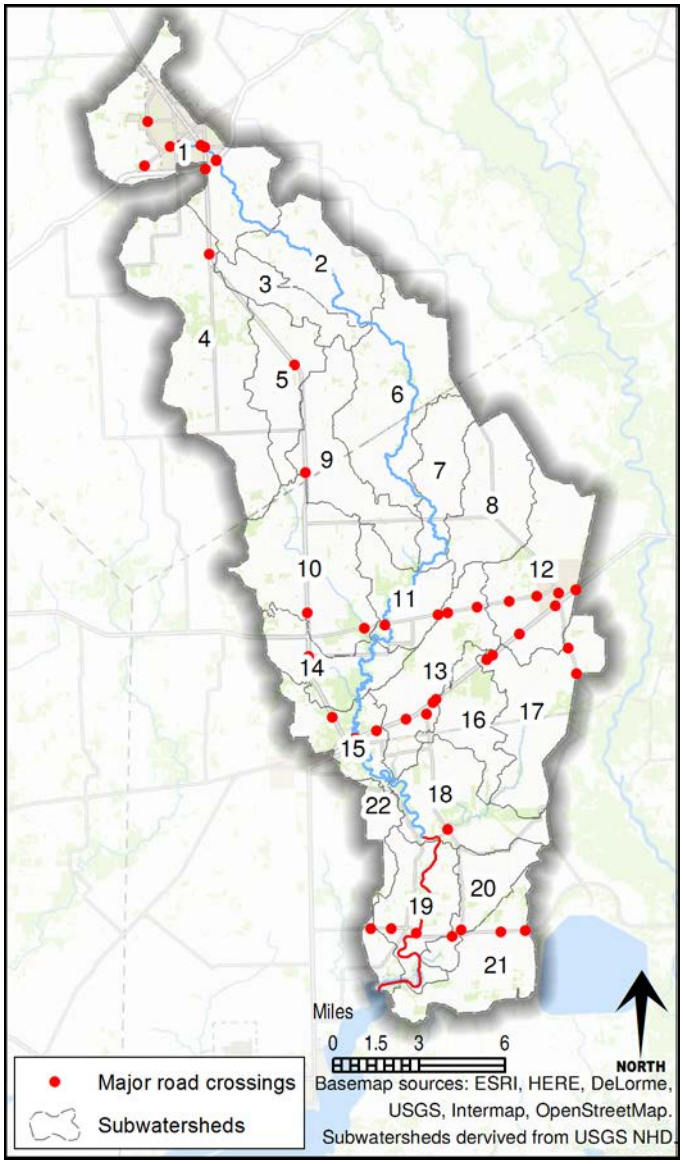

Figure 7: Map indicating locations of major road and stream crossings

Description

The purpose of this management measure is to reduce illicit dumping and promote proper disposal of animal carcasses. Illicit dumping has been identified as a concern of stakeholders. Trash, household items, waste, and animal carcasses have been known to be dumped into some local creeks and then washed downstream during rain events.

Challenges in enforcing illicit dumping can include the lack of available personnel for education and enforcement, lack of equipment necessary to reduce the

ease of dumping, lack of equipment available to monitor sites for enforcement, and other challenges unique to the area. It is the purpose of this management measure to reduce the amount of dumping in and near the local water bodies. Through various types of efforts, including education (for both local officials and residents), signage at water bodies, enforcement, and other measures, illicit dumping in water bodies can be reduced. Responsible parties will develop a strategy about how to reduce illicit dumping and then implement their respective strategies. The priority areas for this management measure include major road and stream crossings throughout the watershed (Figure 7).

Education Component

Education for both residents and local officials is important. Local officials need to understand the implications of illicit dumping and the strategies to reduce this local source of water pollution. A source of potential educational opportunities for local officials is the Texas Illegal Dumping Resource Center <http://www.tidrc.com/index.html>, which also provides continuing education units to individuals who are interested in receiving educational credits. Residents must also be educated, so that the public understands the harmful effects of illicit dumping on local water bodies. Some possible methods of education could include, but are not limited to, signage at bridge crossings, educational inserts in water bills, and other methods designed to reach the population of interest.

Additionally, there is a need for an educational campaign that consists of educating recreational hunters and local landowners about the proper disposal of animal carcasses. Other targeted educational efforts should be conducted on the proper disposal of recreational vehicle waste. For this campaign, educational materials can be developed and disseminated through a variety of avenues including, but not limited to, feed stores, direct mailing, newspaper articles, magazine articles, and billboards.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Watershed Coordinator

TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with Matagorda and Wharton counties to identify strategies, secure resources, and implement strategies that reduce illicit dumping. The watershed coordinator will work with the appropriate entities to develop educational programs and materials as needed.

Matagorda and Wharton Counties and Certificate of Convenience or Necessity (CCN) Holders

As resources are made available, Matagorda and Wharton counties will be responsible for working with the watershed coordinator to develop strategies, secure resources, and implement strategies intended to reduce illicit dumping. Counties retain responsibility for associated enforcement actions within their respective jurisdictions that fall within the TMDL watershed.

Technical Assistance

Technical assistance for Management Measure 4 is available, as needed, from TCEQ Region 12 and TCEQ Small Business and Local Government Assistance Program. Through this program, TCEQ can provide confidential assistance to local governments without the threat of enforcement actions. In particular, the program can connect local government entities with technical resources on municipal solid waste programs. AgriLife County Extension agents will assist in educational activities related to mitigation of illicit dumping. County staff will be needed to secure and install signage.

Financial Assistance

State CWA §319(h) Grants (TCEQ/TSSWCB)

The EPA provides grant funding to Texas to implement the state's approved Nonpoint Source Management Program. The EPA-approved Texas program provides the framework for determining which activities are eligible for funding under CWA Section 319(h). In general, these activities include non-regulatory programs and are related to controlling NPS pollution. EPA-approved NPS programs cover costs associated with technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific NPS projects.

USDA Rural Utilities Service Water and Waste Disposal (WWD) Loans and Grants

The USDA Rural Utilities Service (RUS) provides funding for water and waste facility construction in rural communitites (populations of 10,000 or less). The program also provides funding to organizations to provide technical assitance and training to communities in relation to water and waste activities. The intent of the program is to ensure that the neediest areas receive funding.

Table 16 shows the estimated costs of developing and implementing educational activities and programs designed to reduce illicit dumping.

Table 16. Estimated costs of Management Measure 4

Entity	Activities Needed	Estimated Costs
Watershed coordinator and Counties	Acquire equipment needed to reduce illicit dumping (signage at 25 crossings, est. $960 per crossing)	$24,000
Watershed coordinator and TBD Educational Entities	Education and Outreach	$115,000

Measurable Milestones

Measureable milestones for this management measure will consist of:

- Five signs per year and related illegal dumping deterrent measures
- the number of illegal and illicit dumping education programs developed and delivered

Progress Indicators

Progress indicators for this management measure will consist of the following:

- Year 1 – development and submittal of grant proposal for additional personnel, equipment, and educational programs
- Years 2-5 – number of educational materials delivered, equipment installed, number of illegal dumping complaints received

Monitoring Component

Monitoring for this management measure will consist of the watershed coordinator utilizing TCEQ CRP monitoring and measuring bacteria loadings. Additional monitoring may be developed as needed, as funding allows.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Submit proposal to acquire personnel, equipment, and develop educational material: watershed coordinator and counties responsible.
- Install and maintain five signs throughout watershed: watershed coordinator and counties responsible.
- Work with appropriate entities to develop illegal dumping and animal carcass disposal education programs: watershed coordinator responsible.

Years 2-5:

- Continue to acquire equipment needed to reduce illicit dumping; install and maintain five additional signs throughout watershed annually: watershed coordinator and Counties responsible.
- Continued development of illegal dumping and animal carcass disposal education programs: watershed coordinator responsible.

Estimated Loading Reductions

Potential load reductions from reducing illicit dumping and properly disposing of animal carcasses cannot be quantified at this time. It is uncertain how much pollution will be removed and what effects the proposed activities will have on bacteria loading to water bodies in the watershed.

Table 17. Summary of Management Measure 4:

Stakeholders will work with responsible parties to lessen the impact of illicit dumping and improper animal carcass disposal.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
Not applicable	**Technical Assistance** TCEQ Region 12, TCEQ Small Business and Local Government Assistance Program **Financial Assistance** State CWA §319(h) Grants (TCEQ/TSSWCB) USDA RUS Water and Waste Disposal Loans and Grants	An education and outreach program is needed to broadly promote the adoption of BMPs such as programs focusing on illegal dumping and proper disposal of animal carcasses. These programs could greatly benefit the area both immediately and in the foreseeable future.	**Years 1–5** Implement and maintain five signs per year, develop illegal dumping and animal carcass disposal education programs over the course of the five-year span	The number of additional signs and related illegal dumping deterrent measures The number of illegal and illicit dumping education programs developed and delivered	**Year 1**: Development and submittal of grant proposal for additional personnel, equipment, and educational programs **Years 2–5:** Number of educational materials delivered, equipment installed, number of illegal dumping complaints received	TCEQ CRP and watershed coordinator	Watershed coordinator Matagorda and Wharton counties

Management Measure 5

Planning and Management for Urban Stormwater

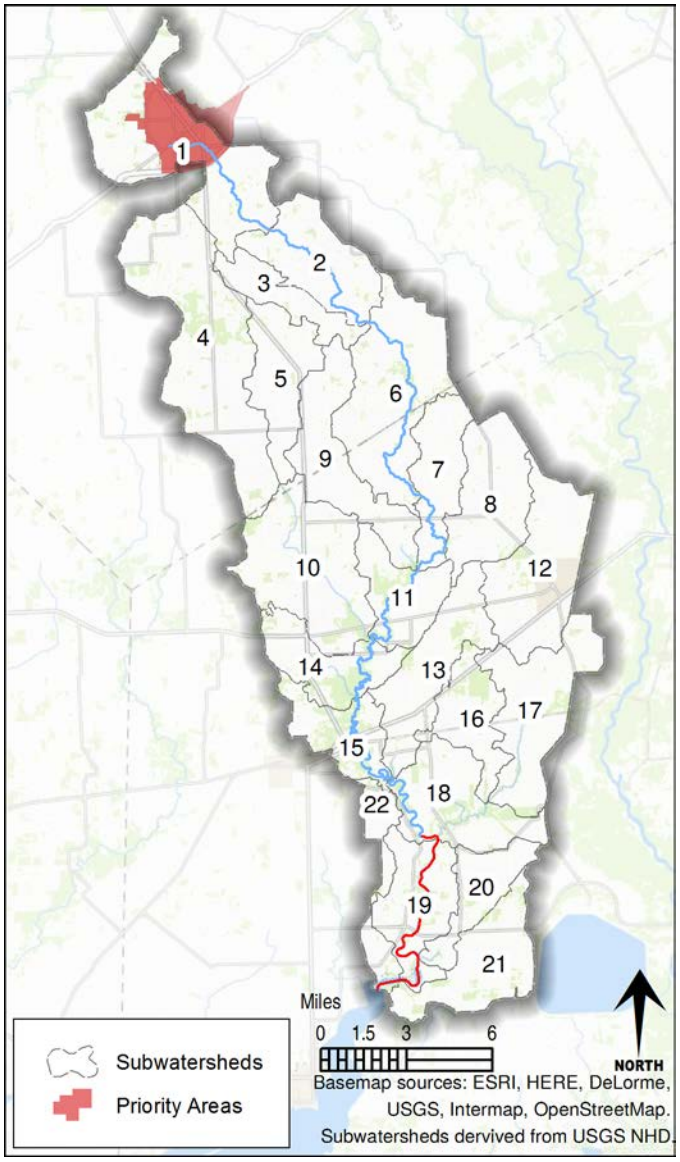

Figure 8: Priority area for stormwater management measure

Description

The purpose of this management measure is to plan and manage urban stormwater. The City of El Campo is the prominent urbanized area within the watershed. Stormwater from El Campo is currently unregulated. However, based on recent census figures, there is potential for El Campo to be regulated by the Phase II MS4 stormwater permit program by 2020. This permit is required for small urbanized areas with a population density of at least 1,000 people per square mile. Under this permit, the city would be required to develop a stormwater management plan (SWMP) that includes at least the following measures:

- public education and outreach,
- public involvement or participation,
- detection and elimination of illicit discharges,
- control of stormwater runoff from construction sites,
- post-construction stormwater management in new development and redevelopment zones, and
- pollution prevention and "good housekeeping" measures for municipal operation.

The city has expressed a desire to prepare for Phase II permit requirements. By working with the City of El Campo to assist with Phase II preparation and securing funding where possible to facilitate the transition, responsible parties can assist the city in prioritizing management practices and measures that most effectively reduce bacteria loading. Comprehensive stormwater assessments within the city would assist with the identification of illicit discharge detection and elimination, development of pollution prevention, and "good housekeeping" strategies for municipal operation. They would also help with the identification of new development and redevelopment zones that require stormwater BMPs, as well as increase public awareness and involvement in urban stormwater issues. The City of El Campo is the only priority area for this management measure (Figure 8).

Education Component

Targeting both homeowners and elected officials, educational and outreach programs will be delivered that highlight various practices designed to reduce the impact of stormwater on water quality. The programs will also be designed to help local governments develop strategies for reducing potential bacteria loadings to local water bodies from urban stormwater. Some local entities may use this information and the technical and financial assistance provided by state and federal agencies to develop comprehensive urban stormwater assessments.

These programs will be implemented through a variety of methods including, but not limited to, public service announcements, utility bill inserts, other direct mailing, educational kiosks, and pet waste stations in parks and at public environmental events (e.g., Earth Day celebrations). These educational events will include seminars on low impact development and retrofitting strategies that can be implemented on existing stormwater structures or incorporated into the designs of new structures. These programs can lead to the selection of appropriate BMPs tailored to the specific needs of each municipality or CCN holder.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Texas Water Resources Institute

TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with the City of El Campo to identify and secure resources needed to assist in the initiation, planning, and preparation of an appropriate SWMP.

City of El Campo

As resources are identified and secured, the City of El Campo is responsible for Phase II preparation and securing funding where possible to facilitate the transition.

Technical Assistance

Technical assistance for Management Measure 5 is available as needed from TCEQ Region 12. City of El Campo staff will be needed throughout the planning process.

Financial Assistance

Clean Water State Revolving Fund

Through the TWDB, the Clean Water State Revolving Fund (CWSRF) program provides low-interest loans to local governments and service providers for infrastructure projects that include stormwater BMPs. The loans can spread project costs over a repayment period of up to twenty years. Repayments are cycled back into the fund and used to pay for additional projects.

Table 18 shows the estimated costs of implementing Management Measure 5 based on anticipated planning needs in preparation for MS4 requirements. Needed capital investments to meet permit requirements are unknown and not estimated.

Table 18. Estimated costs of Management Measure 5

Entity	Activities Needed	Estimated Costs
Watershed coordinator and City of El Campo	Initiate SWMP and other strategies anticipated to be required as part of MS4 requirements.	$25,000

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the number of comprehensive stormwater assessments

Progress Indicators

- Year 1 – Development and submittal of a proposal to fund urban stormwater education and the development of comprehensive stormwater assessments
- Years 2-5 – Initiation of comprehensive stormwater assessments and SWMP preparation in El Campo

Monitoring Component

Monitoring for this management measure is the responsibility of the MS4 permittee. The City of El Campo will be responsible for monitoring if or when they receive an MS4 permit.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Develop and submit a proposal to fund urban stormwater education programs: watershed coordinator and City of El Campo responsible.
- Develop and submit a proposal to fund comprehensive stormwater assessments: watershed coordinator and City of El Campo responsible.
- As funding allows, initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements: watershed coordinator and City of El Campo responsible.
- Deliver one stormwater education program per year: watershed coordinator and City of El Campo responsible.

Year 2:

- As funding allows, initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements: watershed coordinator and City of El Campo responsible.
- Deliver one stormwater education program per year: watershed coordinator and City of El Campo responsible.

Year 3:

- As funding allows, initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements: watershed coordinator and City of El Campo responsible.
- Deliver one stormwater education program per year: watershed coordinator and City of El Campo responsible.

Year 4:

- As funding allows, initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements: watershed coordinator and City of El Campo responsible.

- Deliver one stormwater education program per year: watershed coordinator and City of El Campo responsible.

Year 5:

- As funding allows, initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements: watershed coordinator and City of El Campo responsible.
- Deliver one stormwater education program per year: watershed coordinator and City of El Campo responsible.

Estimated Loading Reductions

Pollution control requirements included in potential SWMPs are unknown prior to plan development. Therefore, quantifying load reductions resulting from plan development and implementation is not possible. However, working with the City of El Campo on SWMP development helps ensure that issues of concern included in the I-Plan are addressed.

Table 19. Management Measure 5:

The City of El Campo anticipates MS4 Phase II permit requirements in the future. This measure involves planning for the development of stormwater management strategies, prioritization of management practices, and recommendation of measures to most effectively reduce bacteria loadings in the Tres Palacios Creek from urban stormwater runoff.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
Not applicable	**Technical Assistance** TCEQ Region 12 City of El Campo **Financial Assistance** State CWA §319(h) Grants (TCEQ) Clean Water State Revolving Fund	An education and outreach program is needed to broadly promote the adoption of BMPs such as stormwater education programs put on by the City of El Campo.	**Years 1-5** Initiation of stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements, delivery of one stormwater education program each year	The number of comprehensive stormwater assessments	**Year 1**: Development and submittal of a proposal to fund urban stormwater education and the development of comprehensive stormwater assessments **Years 2-5:** Initiation of comprehensive stormwater assessments and SWMP preparation in El Campo	City of El Campo	Watershed coordinator City of El Campo

Management Measure 6

Installation of Urban Best Management Practices

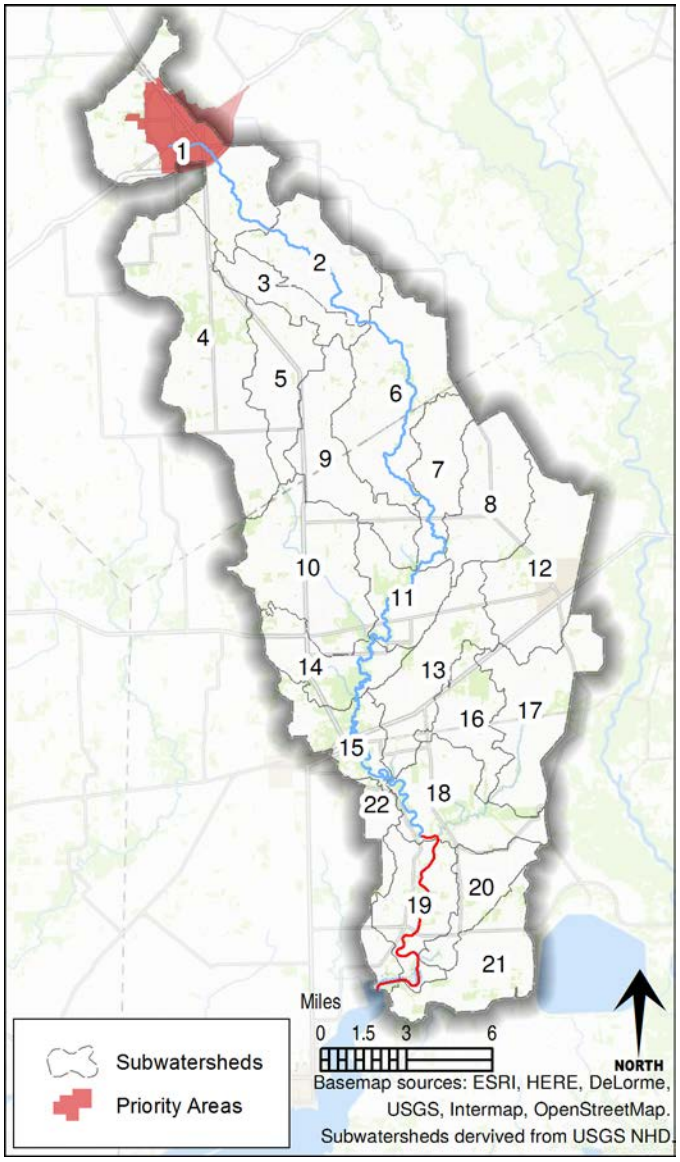

Figure 9: Priority area for urban BMP management measure

Description

The purpose of this management measure is to install the best urban management practices possible throughout the watershed. Management of potential urban sources of bacteria can be addressed with a number of different BMPs. Urban stormwater BMPs reduce or delay runoff generated by impervious or highly compacted surfaces such as roofs, roads, and parking lots. A wide variety of urban stormwater BMPs are available and performance in reducing flow volumes and bacteria pollution varies based on specific design and location. Examples of

BMPs that can be used in urbanized areas include: grass swales, rain gardens, retention ponds, detention basins, wetland basins, and porous pavement. Well placed and designed stormwater BMPs can substantially decrease and delay runoff as well as bacteria loading. This management measure will be focused on the largest developed urban area in the watershed — the City of El Campo (Figure 9). The potential exists for this management measure to overlap with Management Measure 5. However, these are two distinct efforts.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Watershed Coordinator

TWRI will serve as the watershed coordinator this watershed. The watershed coordinator will work with the City of El Campo to identify and secure resources needed to identify suitable locations and to install stormwater BMPs. The watershed coordinator will also work with the City of El Campo and AgriLife Extension to pursue funding and secure the delivery of stormwater related educational activities and materials throughout the watershed.

City of El Campo

The City of El Campo will work with the watershed coordinator to pursue resources needed to identify suitable locations and installation of stormwater BMPs in addition to needed education resources. Once funds have been secured, the city will work with the watershed coordinator to conduct educational activities that raise awareness of the impacts of stormwater on local water quality. The city will also work with the watershed coordinator to identify locations for potential implementation of stormwater BMPs and, if found feasible and resources available, implement these practices.

Texas A&M AgriLife Extension Service

As resources are made available, AgriLife Extension in both Matagorda and Wharton counties will assist in the advertising and delivery of educational activities throughout the watershed.

Technical Assistance

Technical assistance for Management Measure 6 is available as needed from TCEQ Region 12 and the EnviroMentors program. In particular, TCEQ Region 12 is available to connect municipalities to resources on stormwater permitting, funding resources, record keeping, and reporting. The EnvironMentors program can connect the city with qualified professionals to provide technical peer-to-peer assistance on stormwater projects or with permitting and compliance rules. City staff will be needed for assistance with planning and prioritization of activities. Outside contractors may be needed for planning and implementation.

Financial Assistance

Clean Water State Revolving Fund

Through the TWDB, the CWSRF program provides low-interest loans to local governments and service providers for infrastructure projects that include stormwater BMPs. The loans can spread project costs over a repayment period of up to twenty years. Repayments are cycled back into the fund and used to pay for additional projects.

Environmental Education (EE) Grants

Under the EE Grant Program, EPA seeks grant proposals from eligible applicants to support environmental education projects that promote environmental stewardship and help develop knowledgeable and responsible students, teachers, and citizens. This grant program provides financial support for projects that design, demonstrate, and/or disseminate environmental education practices, methods, or techniques as described in the EE Grant Program solicitation notices.

State CWA §319(h) Grants (TCEQ)

The EPA provides grant funding to Texas to implement the state's approved Nonpoint Source Management Program. The EPA-approved Texas program provides the framework for determining which activities are eligible for funding under CWA Section 319(h). In general, these activities include non-regulatory programs and are related to controlling NPS pollution. EPA-approved NPS programs cover costs associated with technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific NPS projects.

Urban Water Small Grants

The objective of the Urban Waters Small Grants, administered by the EPA, is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. In particular, the Urban Waters Small Grants Program seeks to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of, local urban waterways.

Table 20 shows the estimated costs of implementing Management Measure 6. The estimates are based on the implementation of stormwater detention basins to capture and treat stormwater runoff and the delivery of education and outreach programs to watershed residents.

Table 20. Estimated costs of Management Measure 6

Entity	Activities Needed	Estimated Costs
Watershed coordinator and City of El Campo	Identify, plan, and prioritize areas for urban BMP stormwater projects	Not known
Watershed coordinator and City of El Campo	Plan and construct stormwater BMP projects as funding allows	TBD
Watershed coordinator, AgriLife Extension, and City of El Campo	Deliver annual stormwater education programs at $2,500 each	$37,500

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the number of urban stormwater BMPs adopted
- the number of educational programs delivered
- the number of individuals reached through educational activities

Progress Indicators

Progress indicators for this management measure will consist of:

- Year 1 – Development and submittal of a proposal to fund urban stormwater education components and planning activities
- Year 2 – Funding secured for education and planning activities
- Years 3-5 – Number of stormwater BMPs installed and acres treated if BMP installation is determined feasible; number of educational materials delivered

Monitoring Component

Monitoring for this management measure will consist of continuing TCEQ CRP monitoring at existing sites. The City of El Campo will also be responsible for continued monitoring of BMPs.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Initiate, plan, and prioritize areas for urban BMP stormwater demonstration projects; capture 50 acres of urban area total during five-year span: watershed coordinator and City of El Campo responsible.

- Submit proposal for both educational programs and BMP implementation: watershed coordinator and City of El Campo responsible.

Years 2-5:

- Plan and construct urban BMP stormwater demonstration projects treating 50 urbanized acres as funding allows: watershed coordinator and City of El Campo, and contractors responsible.
- Deliver education and outreach programs to area residents and property owners: watershed coordinator, City of El Campo, and AgriLife Extension responsible.

Estimated Loading Reductions

As planned, implementation of stormwater BMPs treating at least 50 developed acres will reduce Enterococci loadings in the watershed by 1.74×10^{10} cfu/year.

Table 21. Management Measure 6:

Potential locations for urban stormwater BMPs will be identified by working with local community representatives. Education and outreach will be used to teach residents about BMPs that can be used on their own properties and how they reduce bacteria pollution in the Tres Palacios Creek watershed.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
1.74×10^{10} cfu/year	**Technical Assistance** TCEQ Region 12 City of El Campo **Financial Assistance** Clean Water State Revolving Fund Environmental Education Grants State CWA §319(h) Grants (TCEQ) Urban Small Water Grants	An education and outreach program is needed to broadly promote the adoption of BMPs by area residents and property owners.	**Years 1-5** Identify, plan, and prioritize areas for urban BMP stormwater demonstration projects (capture 50 acres over the course of the five years); plan and construct urban BMP stormwater projects to capture 50 acres as funding allows; deliver education and outreach programs to area residents and property owners	The number of urban stormwater BMPs adopted The number of educational programs delivered The number of individuals reached through educational activities	**Year 1**: Development and submittal of proposal to fund urban stormwater education components and planning activities **Year 2:** Funding secured for education and planning activities **Years 3-5:** Number of stormwater BMPs installed and acres treated if BMP installation is determined feasible; number of educational materials delivered	TCEQ CRP City of El Campo	Watershed coordinator City of El Campo AgriLife Extension

Management Measure 7

Development and Implementation of Pet Waste Programs

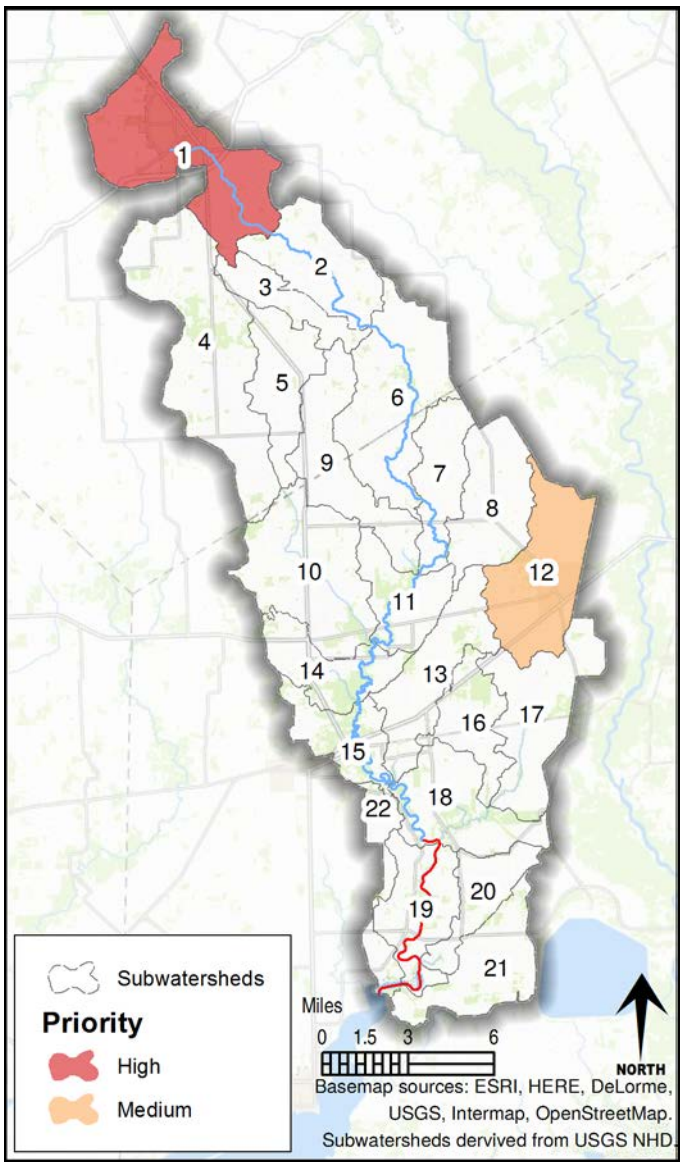

Figure 10: Priority areas for domestic pet management measures

Description

The purpose of this management measure is to develop and implement pet waste programs throughout the watershed. Bacteria loading from domestic pets was determined to be among the higher potential bacteria contributors in the watershed. Management strategies emphasize reducing the amount of pet waste that can be transferred to streams via overland transport. Providing waste bag dispensers and collection stations in areas of higher pet density (parks, neighborhoods) encourages pet owners to pick up pet waste before it can be transported to streams. Limiting the number of pets and the number of off-

leash pets can also reduce the likelihood of pet waste reaching water bodies. Matagorda County and the City of El Campo already implement leash laws. El Campo also limits households to no more than five dogs and/or cats and requires registration of all pets. Finally, providing education and outreach materials to pet owners about bacteria pollution and pet waste can increase the number of residents that pick up and dispose of pet wastes. Recognizing that domestic pets in rural portions of the watershed likely have large areas to roam and that picking up pet waste is likely not feasible for all owners, management actions should target areas of the watershed with high housing and pet densities. Priority areas in the watershed for this management measure are shown in Figure 10.

Education Component

Besides the aforementioned management strategies, providing education and outreach materials to pet owners about bacteria pollution and pet waste can increase the number of residents that pick up and dispose of pet wastes.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

Watershed Coordinator

TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with the City of El Campo, landowners, utilities, and county governments as appropriate to identify suitable locations for pet waste stations and to secure resources for the installation and maintenance of stations.

City of El Campo, Matagorda and Wharton counties, CCN holders

The City of El Campo, Matagorda County, Wharton County, and utilities with a CCN (CCN provides the holder exclusive rights to provide retail water and/or sewer services in the covered area) will be responsible for working with the watershed coordinator to identify suitable pet waste station locations. These entities will also work with the watershed coordinator to secure resources as needed for the installation and maintenance of stations. As resources are made available, these entities will install and maintain pet waste stations. These entities will also work with the watershed coordinator and AgriLife Extension to deliver education programs or material in order to educate individuals on the impact bacteria pollution and pet waste can have on nearby water resources.

Texas A&M AgriLife Extension Service

As resources are made available, AgriLife Extension will work with above entities to deliver education programs or material in order to educate individuals on the impact bacteria pollution and pet waste can have on nearby water resources.

Technical Assistance

City and county staff will be needed as appropriate for installation and maintenance activities.

Financial Assistance

CWA Section 319(h) NPS Grant Program

Local stakeholders should pursue funding for urban stormwater education and outreach and for urban BMP installation through the TCEQ's CWA Section 319(h) Grant Program.

Environmental Education Grants

Under the EE Grant Program, EPA seeks grant proposals from eligible applicants to support environmental education projects that promote environmental stewardship and help develop knowledgeable and responsible students, teachers, and citizens. This grant program provides financial support for projects that design, demonstrate, or disseminate environmental education practices, methods, or techniques as described in the EE Grant Program solicitation notices.

Urban Water Small Grants

The objective of the Urban Waters Small Grants from the EPA is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. In particular, the Urban Waters Small Grants Program seeks to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of, local urban waterways.

The estimated costs for implementing Management Measure 7 are based on the installation of one pet waste station per CCN (there are three in the watershed) at $3,500 each, and providing outreach and education materials to watershed residents on pet waste and water quality for the duration of this plan (Table 22).

Table 22. Estimated costs of Management Measure 7

Entity	Activities Needed	Estimated Costs
Watershed coordinator, City of El Campo, CCN Holders, Matagorda and Wharton counties	One pet waste station and supplies per CCN ($3,500 each)	$10,500
Watershed coordinator, City of El Campo, Matagorda and Wharton counties, CCN holders, AgriLife Extension	Urban pollution workshop ($2,500 per workshop at one per CCN annually, for five years)	$37,500

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the number of pet waste stations installed
- the number of educational materials developed and delivered

Progress Indicators

Progress indicators for this management measure will consist of:

- Year 1 – Development and submittal of a proposal to fund pet waste station installation and educational material delivery
- Year 2 – Funding secured for pet waste management measures, number of pet waste stations installed, number of educational materials developed and delivered, number of residents reached with educational material
- Years 3-5 – Number of pet waste stations installed, number of educational materials developed and delivered, number of residents reached with educational material

Monitoring Component

Monitoring for this management measure will consist of continuing TCEQ CRP monitoring at existing sites. Monitoring data collected by the CRP partner will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Submit proposals for funding of pet waste stations and educational material delivery: watershed Coordinator, City of El Campo, Matagorda and Wharton counties responsible.
- Install and maintain one pet waste collection station: watershed coordinator, City of El Campo responsible.
- Develop and deliver education and outreach materials to pet owners: watershed coordinator, City of El Campo, CCN holders, AgriLife Extension responsible.

Years 2-5:

- Install and maintain one pet waste collection station per CCN (three total): watershed coordinator, City of El Campo, CCN holders.

- Develop and deliver education and outreach materials to at least 2,500 residents: watershed Coordinator, City of El Campo, CCN holders, AgriLife Extension responsible.

Estimated Loading Reductions

Estimating an expected load reduction from education and outreach materials is inherently difficult because the reach and effectiveness of programs can be uncertain. Targeted education and outreach efforts reaching at least 2,500 pet owners have an expected annual reduction of 9.58×10^{13} cfu/year.

Table 23. Management Measure 7:

Stakeholders will conduct voluntary implementation efforts to reduce the amount of pet waste throughout the watershed by providing pet waste stations and educating pet owners about bacteria pollution caused by pet waste.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
9.58×10^{13} cfu/year	**Technical Assistance** City and County staff as appropriate **Financial Assistance** State CWA §319(h) Grants (TCEQ)	An education and outreach program is needed to broadly promote the adoption of BMPs for the City of El Campo.	**Years 1-5** Install one pet waste station per CCN (three CCNs total), provide and deliver education and outreach materials to pet owners	The number of pet waste stations installed The number of educational materials developed and delivered	**Year 1**: Development and submittal of proposal to fund pet waste station installation and educational material delivery **Year 2:** Funding secured for pet waste management measures, number of pet waste stations installed, number of educational materials developed and delivered, number of residents reached with educational material **Years 3-5:** Number of pet waste stations installed, number of educational materials developed and delivered, number of residents reached with educational material	TCEQ CRP partner and watershed coordinator	Watershed coordinator City of El Campo Matagorda and Wharton counties CCN holders Watershed stakeholders AgriLife Extension

Management Measure 8

Planning and Implementation of Wastewater Reuse

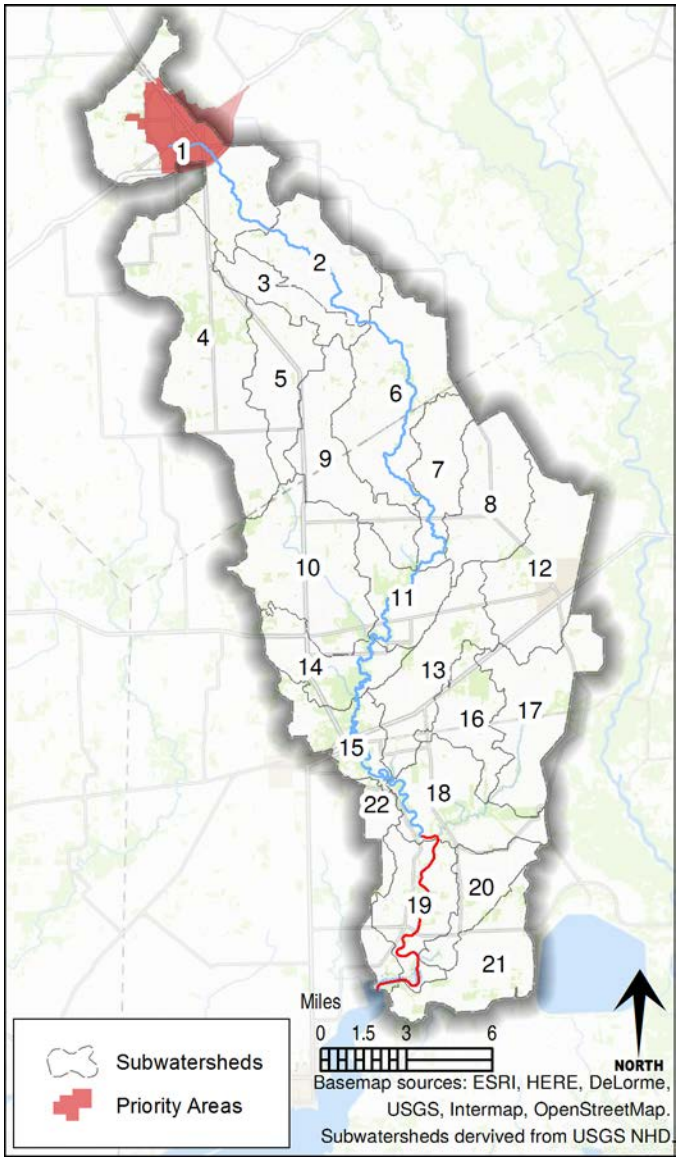

Figure 11: Priority area for wastewater reuse management measures

Description

The purpose of this management measure is to plan and implement wastewater reuse. The City of El Campo has expressed interest in pursuing wastewater reuse to reduce bacteria loadings in Tres Palacios Creek. Wastewater reuse decreases potential bacteria loadings in the watershed by diverting WWTF effluent to non-potable uses such as irrigation, or into constructed wetlands for enhanced wastewater treatment. The reuse of wastewater offers an attractive option for irrigation, especially in times of drought. However, viable options for wastewater reuse in El Campo have not been identified. Working with city staff

and officials to identify and secure needed financial and technical resources is required to implement this measure. The City of El Campo will be the priority area for this management measure as shown in Figure 11.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

City of El Campo

As resources permit, the City of El Campo will be responsible for planning for reuse of wastewater in addition to the implementation of these reuse methods in the City of El Campo.

Watershed Coordinator

TWRI will serve as the watershed coordinator this watershed. The watershed coordinator will work with the City of El Campo as needed to facilitate the identification and acquisition of resources to plan and implement wastewater reuse projects.

Technical Assistance

Technical assistance and compliance assistance for Management Measure 8 is available as needed from TCEQ's Small Business and Local Government Assistance Section, which may provide advice and assistance to the City of El Campo to help maintain regulatory standards. The Small Business and Local Government Assistance program can connect the city with technical resources in regards to permitting, and provide confidential help with compliance if needed. The Texas A&M Engineering Extension Service (TEEX) provides training and resources for operators and staff.

Financial Assistance

Clean Water State Revolving Fund

Through the TWDB, the CWSRF program provides low-interest loans to local governments and service providers for infrastructure projects that include stormwater BMPs. The loans can spread project costs over a repayment period of up to twenty years. Repayments are cycled back into the fund and used to pay for additional projects.

The estimated costs for the planning and implementation associated with wastewater treatment reuse at the City of El Campo's WWTF are outlined in Table 24. The estimated infrastructure costs for WWTF upgrades, storage capacity, and diversion to suitable sites is approximately $3,600,000.

Table 24. Estimated costs of Management Measure 8

Entity	Activities Needed	Estimated Costs
City of El Campo and watershed coordinator	Planning and identifying suitable sites	Not Known
City of El Campo and watershed coordinator	Planning and implementing wastewater reuse infra-structure	$3,600,000

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the amount of funding applied for and secured to initiate planning and implementation of wastewater reuse
- the amount of wastewater diverted from discharge directly into the Tres Palacios Creek

Progress Indicators

Progress indicators for this management measure consist of:

- Years 1-5 – Development and submittal of a proposal to fund wastewater reuse projects, implementation of wastewater reuse if or when feasible

Monitoring Component

Monitoring of this management measure will consist of using the TCEQ's CRP to monitor surface water quality and measure bacteria loadings. Monitoring data collected by the CRP partner will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Year 1:

- Submit a proposal to fund the planning and implementation of wastewater reuse projects: City of El Campo and watershed coordinator responsible.
- Inventory, identify, and prioritize sites within El Campo that could utilize wastewater reuse as funding allows: City of El Campo and watershed coordinator responsible.
- Plan and implement wastewater reuse projects as funding allows: City of El Campo and watershed coordinator responsible.

Years 2-5:

- Inventory, identify, and prioritize sites within El Campo that could utilize wastewater reuse as funding allows: City of El Campo and watershed co-ordinator responsible.
- Plan and implement wastewater reuse projects as funding allows: City of El Campo and watershed coordinator responsible.

Estimated Loading Reductions

If 100 percent of the effluent is diverted, the total potential load reduction is 1.28×10^{12} cfu/year.

Table 25. Management Measure 8:

The City of El Campo has indicated interest in pursuing wastewater reuse to irrigate city properties. However, viable land options have not been identified. Identification of sites with high potential to use wastewater effluent as irrigation is needed. Securing funding for project planning and implementation will also be required.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
1.28×10^{12} cfu/year	**Technical Assistance** TCEQ, TEEX **Financial Assistance** Clean Water State Revolving Fund Water and Waste Disposal Loans and Grants	Not applicable	**Years 1-5** Inventory, identify, and prioritize sites that could utilize wastewater reuse; plan and implement reuse projects as funding allows	The amount of funding applied for and secured to initiate planning and implementation of wastewater reuse The amount of wastewater diverted from discharge directly into the Tres Palacios Creek	**Years 1-5**: Development and submittal of proposal to fund wastewater reuse projects; implementation of wastewater reuse if or when feasible	TCEQ CRP partner and watershed coordinator	City of El Campo Watershed coordinator

Management Measure 9

Infrastructure Maintenance and Replacement

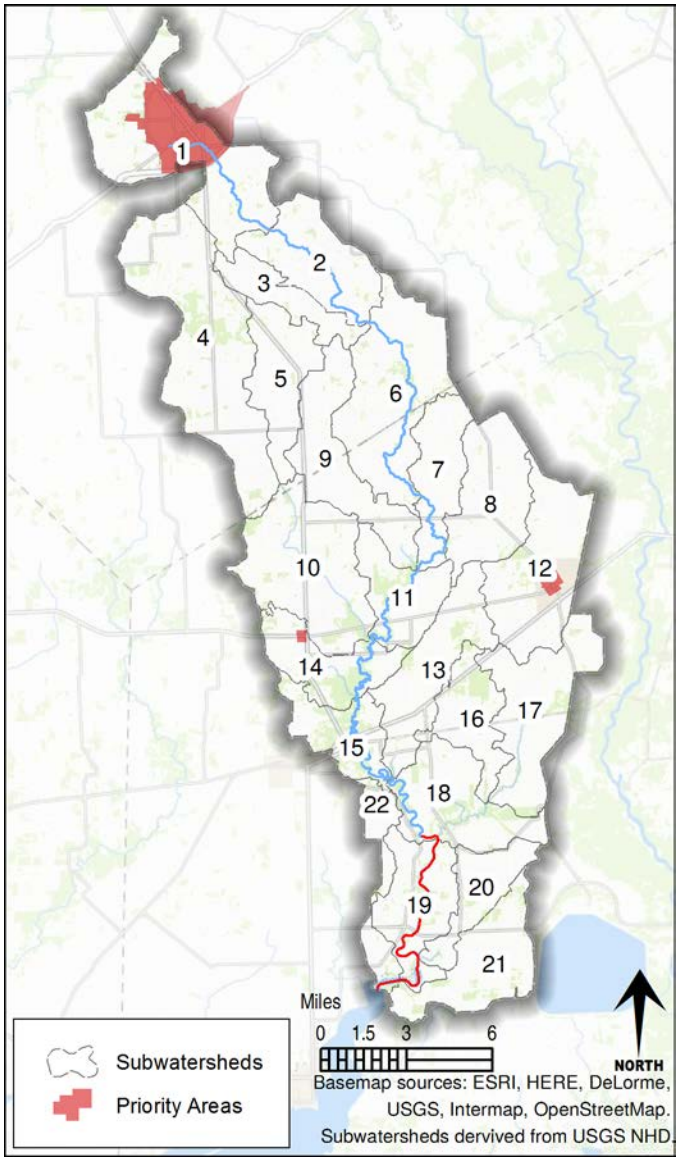

Figure 12: Priority area for infrastructure management measures

Description

The purpose of this management measure is to maintain and replace watershed infrastructure over time. SSOs are a minor contributor to bacteria loads in the Tres Palacios Creek watershed. The City of El Campo has reported a single SSO due to equipment malfunction over the previous 10 years. However, as the collection system infrastructure ages, the maintenance and replacement of equipment will be necessary to maintain proper operation and the prevention of any episodic releases of untreated waste.

Inflow and infiltration (I/I) was voiced as a possible concern by city representatives. Inflow is surface runoff that enters collection systems through manhole covers, sewer cleanouts, illicit connections, or damaged infrastructure. Infiltration is groundwater that enters the collection system through compromised infrastructure. I/I have the potential to overload a system during storm events, causing the discharge of untreated waste. Furthermore, I/I have a diluting effect that may decrease treatment efficiency and can increase pumping and treatment costs.

Management measures for SSO and I/I include identifying and repairing the oldest or most problematic sections of the collection system infrastructure to prevent episodic releases to Tres Palacios Creek. The priority area for this management measure is shown in Figure 12.

Responsible Parties and Sources of Assistance

Each organization listed below will be responsible only for expenses associated with its own efforts.

Responsible Parties

The City of El Campo, Markham MUD, and Midfield WWTF will conduct routine inspections of wastewater infrastructure to identify repairs that are needed and reduce unauthorized discharges. Responsible parties will also coordinate and provide staff workshops and or trainings as needed to ensure staff are prepared to inspect and identify needed infrastructure maintenance and repairs.

Technical Assistance

Technical assistance for Management Measure 9 is available as needed from the TCEQ Region 12 and the Small Business and Local Government Assistance Program to the City of El Campo, Markham MUD, and Midfield WWTF by providing expertise on environmental compliance issues; TCEQ compliance assistance specialists are available through TCEQ Region 12. The Small Business and Local Government Assistance Program is available to provide confidential help to the City and small operators working towards permit compliance. Both TCEQ Region 12 and the TCEQ Small Business and Local Government Assistance Program may be able to assist the City of El Campo and other local wastewater operators in the identification of other available technical resources. Additional technical assistance is available from TEEX for WWTF operation and maintenance through Infrastructure and Safety Trainings, and by online and in-person training materials offered by the Texas Rural Water Association (TRWA).

Financial Assistance

Clean Water State Revolving Fund

Through the TWDB, the CWSRF program provides low-interest loans to local governments and service providers for infrastructure projects that include

stormwater BMPs. The loans can spread project costs over a repayment period of up to twenty years. Repayments are cycled back into the fund and used to pay for additional projects.

WWD Loans and Grants

The USDA RUS provides funding for water and waste facility construction in rural communitites (populations of 10,000 or less). The program also provides funding to organizations to provide technical assistance and training to communities in relation to water and waste activities. The intent of the program is to ensure that the neediest areas receive funding.

The estimated costs for upgrading infrastructures and providing staff training is provided in Table 26. Although each responsible party will incur costs, the City of El Campo was the only entity able to provide firm cost estimates.

Table 26. Estimated costs of Management Measure 9

Entity	Activities Needed	Estimated Costs
City of El Campo	Coordinate workshops and trainings	$30,000
Other Responsible Parties	Coordinate workshops and trainings	Unknown
City of El Campo	Upgrade and repair infrastructure as needed	$400,000
Other Responsible Parties	Upgrade and repair infrastructure as needed	Unknown

Measurable Milestones

Measurable milestones for this management measure will consist of:

- the number of documented replacements and repairs of wastewater conveyance infrastructure
- the number of wastewater infrastructure failures reported to appropriate authorities
- the number of educational programs or materials delivered

Progress Indicators

- Years 1-5 – Number of unauthorized discharges, the amount of infrastructure repaired or replaced, number of educational hours or trainings delivered to staff

Monitoring Component

Monitoring of this management measure will consist of using the TCEQ's CRP to monitor surface water quality and measure bacteria loadings. Monitoring data collected by the CRP partner will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Implementation Schedule

Contingent upon the receipt of proposed project funding, the implementation schedule is as follows.

Years 1-5:

- Coordinate one workshop or training each year for operators or staff on identifying aging and failing infrastructure: City of El Campo, Markham MUD, Midfield WWTF responsible.
- Identify the oldest parts of the collection system and areas with significant I/I, plan projects to repair or replace components, coordinate repairs with WWTF upgrades when possible: City of El Campo, Markham MUD, Midfield WWTF responsible.

Estimated Loading Reductions

Minimal load reductions are expected because the compliance and SSO history within the watershed has indicated minimal problems directly attributable to SSOs and infrastructure failure. Load reductions could not be calculated due to an insufficient number of events on which to base a calculation.

Table 27. Management Measure 9:

Identify problematic areas of the collection systems and set up schedule for repair or replacement. Repairs should be done during the driest times of the year when groundwater and stormwater are not a factor. Repairs can also coincide with routine scheduled maintenance or WWTF upgrades in order to eliminate dilution, exceedance of design capacity, and overflows.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
Not applicable	**Technical Assistance** TCEQ, TEEX, TRWA **Financial Assistance** Clean Water State Revolving Fund Economically Distressed Areas Program WWD Loans and Grants	Identify aging and failing infrastructure.	**Years 1-5** Coordinate workshops or trainings for operators or staff on identifying aging and failing infrastructure, identify the oldest parts of the collection system and areas with significant I/I, repair and plan projects to repair or replace components, coordinate repairs with WWTF upgrades when possible	The number of documented replacements and repairs of wastewater conveyance infrastructure The number of wastewater infrastructure failures reported to appropriate authorities The number of educational programs or materials delivered	**Years 1-5**: Number of unauthorized discharges, the amount of infrastructure repaired or replaced, number of educational hours or trainings delivered to staff	TCEQ CRP partner and watershed coordinator	City of El Campo Markham MUD Midfield WWTF

Sustainability

The TCEQ and stakeholders in TMDL implementation projects periodically assess the results of the planned activities, along with other information, to evaluate the effectiveness of the I-Plans. 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.

The TCEQ and stakeholders will track progress 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 affect an improvement in water quality.

Water Quality Indicators

The CRP will continue to monitor the status of water quality during implementation as funding and resources allow. Additional funding will be sought by the watershed coordinator to conduct supplemental monitoring in the watershed. Routine water quality monitoring activities will be conducted in Tres Palacios Creek Tidal (AU 1501_01). Station 12515, located at FM521, has been monitored for Enterococci since 2003 and is still monitored quarterly. Station 20636, located approximately 1 kilometer downstream of the confluence with Wilson Creek, was monitored quarterly for Enterococci from 2009 until 2012. Enterococci bacteria levels measured at the stations mentioned above can be used to measure improvement in water quality.

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 target.

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

Communication Strategy

The TCEQ will host annual meetings for up to five years so stakeholders may evaluate their progress. Stakeholders and responsible parties will continue to take part in annual meetings over the five-year period 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.

References

EPA 2001. Protocol for Developing Pathogen TMDLs. <www.epa.gov/owow/tmdl/pathogen_all.pdf>.

EPA 2003. Nonpoint Source Program and Grants Guidelines for States and Territories. <www.epa.gov/fedrgstr/EPA-WATER/2003/October/Day-23/w26755.htm>.

EPA 2010. Implementing Agricultural Best Management Practices Improves Water Quality. Nonpoint Source Program Success Story.

EPA 2016. Enforcement and Compliance History Online (ECHO). <echo.epa.gov/> Accessed May 15, 2016.

TCEQ 2012. Permitted Wastewater Outfalls. <www.tceq.state.tx.us/gis/download-tceq-gis-data>. Accessed October 22, 2014.

TCEQ 2015a. 2014 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d). <www.tceq.texas.gov/waterquality/assessment/14twqi/14txir>. Accessed Feb 22, 2015.

TCEQ 2016. TCEQ Assessment Units. <www.tceq.texas.gov/gis/download-tceq-gis-data>. Accessed May 26, 2015.

TIAER 2015b. Technical Support Document for Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal. <www.tceq.texas.gov/assets/public/waterquality/tmdl/108trespalacios/108-TresP_TSD_FINAL_5Apr16.pdf>. Accessed June 1, 2016.

Timmons, J. B., B. Higginbotham, R. Lopez, J. C. Cathey, J. Mellish, J. Griffin, A. Sumrall, and K. Skow. 2012. Feral Hog Population Growth, Density and Harvest in Texas. College Station, Texas. Texas A&M AgriLife Extension. Report SP-472. <feralhogs.tamu.edu/files/2010/04/FeralHogPopulationGrwothDensityandHervestinTexasedited.pdf>. Accessed June 1, 2016.

TWDB 2014. Complete Regional Population Projections in Texas. <www.twdb.state.tx.us/wrpi/data/proj/popproj.htm>. Accessed December 11, 2014.

USGS 2014. National Land Cover Database 2011 (NLCD2011). <gdg.sc.egov.usda.gov/GDGOrder.aspx?order=QuickState>. Accessed March 30, 2015.

Appendix A.
I-Plan Matrix

Table A-1. Management Measure 1: Implementation Schedule and Tasks

Develop and Implement Conservation Plans in Priority Areas of the Watershed

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1, 3, and 5			
	SWCDs, NRCS	– Develop and implement conservation plans	– Nine conservation plans developed and implemented annually in the Tres Palacios Creek watershed
	Watershed coordinator, AgriLife Extension	– Deliver education program	– Deliver Lone Star Healthy Streams education program
	Watershed coordinator, AgriLife Extension, SWCDs	– Hold management practice field days	– Hold management practice field days
2 and 4			
	SWCDs, NRCS	– Develop and implement conservation plans	– Nine conservation plans developed and implemented annually in the Tres Palacios Creek watershed
	Watershed coordinator, AgriLife Extension	– Deliver education program	– Deliver Riparian and Stream Ecosystem Management education program

Table A-2. Management Measure 2: Implementation Schedule and Tasks

Removal and Management of Feral Hogs

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1, 3, and 5			
	Landowners, land managers, lessees	– Voluntarily construct fencing around deer feeders to prevent feral hog utilization – Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers – Voluntarily shoot hogs; ensure lessees shoot hogs on site	– Number of fences built each year – Number of traps employed each year – Number of hogs shot each year
	Watershed coordinator, AgriLife Extension	– Deliver education program	– Deliver Feral Hog Education Workshop
	Watershed coordinator, AgriLife Extension, TPWD	– Deliver education program	– Deliver Wildlife Management education program
	Watershed coordinator, AgriLife Extension	– Promote use of Extension's online tracking tool to report hog harvest data	– Increased usage of Extension's online tracking tool
2 and 4			
	Landowners, land managers, lessees	– Voluntarily construct fencing around deer feeders to prevent feral hog utilization – Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce feral hog numbers – Voluntarily shoot hogs; ensure lessees shoot hogs on site	– Number of fences built each year – Number of traps employed each year – Number of hogs shot each year
	Watershed coordinator, AgriLife Extension	– Promote use of Extension's online tracking tool to report hog harvest data	– Increased usage of Extension's online tracking tool

Table A-3. Management Measure 3: Implementation Schedule and Tasks

Identification, Prioritization, and Remediation of OSSFs

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1			
	Counties, watershed coordinator	– Develop and submit proposal to fund OSSF replacement and repair program	– Development and submission of proposal
	Watershed coordinator, counties, AgriLife Extension	– Identify and inspect OSSFs	– Number of failing OSSFs identified
	Watershed coordinator, AgriLife Extension, counties	– Development of single OSSF database	– Maintenance of single OSSF database
	Watershed coordinator	– Administer OSSF repair or replacement program	– Administration of annual replacement program
	Watershed coordinator, OSSF owners, contractor	– Repair or replace failing OSSFs	– Repair or replace six OSSFs annually
	Watershed coordinator and AgriLife Extension	– Deliver OSSF O&M workshops	– Number of education programs/workshops delivered
	Watershed coordinator and AgriLife Extension	– Deliver OSSF Installer and Maintenance Provider Workshop	– Number of education programs/workshops delivered
2–5			
	Counties, watershed coordinator, AgriLife Extension	– Identify and inspect OSSFs	– Number of failing OSSFs identified
	Watershed coordinator, counties, AgriLife Extension	– Maintain single OSSF database	– Maintenance of single OSSF database
	Watershed coordinator	– Administer OSSF repair and replacement program	– Administration of annual replacement program
	Watershed coordinator, OSSF owners, contractor	– Repair or replace failing OSSFs	– Repair or replace six OSSFs annually
	Watershed coordinator and AgriLife Extension	– Implement Texas Well Owner Network	– Implementation of Texas Well Owner Network

Table A-4. Management Measure 4: Implementation Schedule and Tasks

Promote the Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1			
	Watershed coordinator and counties	– Submit proposal to acquire personnel, equipment, and to develop educational material	– Development and submission of proposal
	Watershed coordinator and counties	– Install and maintain signage throughout watershed	– Installation of five signs
	Watershed coordinator and AgriLife Extension	– Develop illegal dumping and animal carcass disposal education programs	– Development of education programs
2–5			
	Watershed coordinator and counties	– Continue to acquire equipment needed to reduce illicit dumping – Install and maintain signage throughout watershed	– Acquisition of equipment – Installation of five signs each year
	Watershed coordinator and AgriLife Extension	– Continued development of illegal dumping and animal carcass disposal education programs	– Development of education programs

Table A-5. Management Measure 5: Implementation Schedule and Tasks

Planning and Management for Urban Stormwater

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1			
	Watershed coordinator and City of El Campo	– Development and submittal of proposal to fund urban stormwater education programs	– Development and submission of proposal
	Watershed coordinator and City of El Campo	– Initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements	– Initiation of stormwater management planning and strategies
	Watershed coordinator and City of El Campo	– Deliver one stormwater education program per year	– One stormwater education program delivered per year
2–5			
	Watershed coordinator and City of El Campo	– Initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements	– Initiation of stormwater management planning and strategies
	Watershed coordinator and City of El Campo	– Deliver one stormwater education program per year	– One stormwater education program delivered per year

Table A-6. Management Measure 6: Implementation Schedule and Tasks

Installation of Urban Best Management Practices

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1			
	City of El Campo, watershed coordinator	– Initiate, plan, and prioritize areas for urban BMP stormwater demonstration projects; capture 50 acres total during five-year span	– Initiation of planning and prioritization of urban BMP stormwater projects
	Watershed Coordinator, City of El Campo	– Submit proposals for both education programs and BMP implementation	– Submission of proposals
2–5			
	City of El Campo, watershed coordinator, and contractors responsible	– Plan and construct urban BMP stormwater projects	– Construction of urban BMP stormwater projects capturing runoff from 50 acres
	Watershed coordinator, City of El Campo, AgriLife Extension	– Deliver one stormwater education program per year	– One stormwater education program delivered per year

Table A-7. Management Measure 7: Implementation Schedule and Tasks

Development and Implementation of Pet Waste Programs

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1			
	Watershed coordinator, City of El Campo, Matagorda and Wharton counties	– Submit proposals for funding of pet waste stations and education material delivery	– Submission of proposals
	Watershed coordinator, City of El Campo	– Install and maintain pet waste collection station	– Installation and maintenance of one pet waste collection system
	Watershed coordinator, City of El Campo, CCN holders, AgriLife Extension	– Provide and deliver education and outreach materials to pet owners	– Education and outreach materials distributed to pet owners
2-5			
	Watershed coordinator, City of El Campo, CCN holders and landowners	– Install and maintain pet waste collection stations	– Installation and maintenance of one pet waste collection system per CCN
	Watershed coordinator, City of El Campo, CCN holders, AgriLife Extension	– Provide and deliver education and outreach materials to pet owners	– Education and outreach materials distributed to pet owners

Table A-8. Management Measure 8: Implementation Schedule and Tasks

Planning and Implementation of Wastewater Reuse

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1			
	City of El Campo and watershed coordinator	– Submit proposals to fund the planning and implementation of wastewater reuse projects	– Submission of proposals
	City of El Campo and watershed coordinator	– Inventory, identify, and prioritize sites within El Campo that could utilize wastewater reuse	– Number of sites identified for wastewater reuse
	City of El Campo and watershed coordinator	– Plan and implement wastewater reuse projects as funding allows	– Number of sites reuse projects are implemented on
2-5			
	City of El Campo and watershed coordinator	– Inventory, identify, and prioritize sites within El Campo that could utilize wastewater reuse	– Number of sites identified for wastewater reuse
	City of El Campo and watershed coordinator	– Plan and implement wastewater reuse projects as funding allows	– Number of sites reuse projects are implemented on

Table A-9. Management Measure 9: Implementation Schedule and Tasks

Infrastructure Maintenance and Replacement

Plan Year	Responsible Parties	Implementation Measure	Implementation Milestones
1–5			
	City of El Campo, WWTF staff and operators	– Coordinate workshop or training for operators or staff on identifying aging and failing infrastructure	– Coordinate one workshop or training
	City of El Campo, Markham MUD, Midfield WWTF	– Identify the oldest parts of the collection system and areas with significant I/I – Plan projects to repair or replace components; coordinate repairs with WWTF upgrades when possible	– Identification of oldest parts of collection system and areas with significant I/I – Number of projects planned to repair or replace components

Appendix B.
Load Reduction Estimates

Load Reduction Estimates

Estimates for load reductions are based on the best available information regarding the effectiveness of recommended management, loading estimates informed by technical data sources, and local knowledge derived from stakeholder input. Real world conditions based on where implementation is completed will ultimately determine the actual load reduction achieved once complete. Stakeholder input was critical for deriving agricultural estimates, estimating existing management measures, and determining feasible management measures.

Agricultural Nonpoint Source Management Measures

Management Measure 1: Development and Implementation of Conservation Plans in Priority Areas of the Watershed

Cattle Loadings

Stakeholder input was critical to develop livestock population estimates across the watershed. Based on suggestions from the Agriculture work group, a five acres (ac) per one cattle stocking rate was agreed to as an average stocking rate across all pasture and rangeland in the watershed. The local NRCS recommended stocking rate is 3 ac/animal unit (An.U) for pasture and 7 ac/An.U for rangeland. Applying this estimate across appropriate land cover in the watershed generated an estimate of 13,131 cattle.

Using the SELECT methodology in the geographic information system (GIS) analysis, potential Enterococci loading from cattle was estimated across the watershed and for each subwatershed. The fecal coliform production rate was assumed to be 8.55×10^9 cfu/An.U×day^{-1}with the assumption that 1 An.U equals 1 cattle (Wagner and Moench, 2009). The conversion rate from fecal coliform to *E. coli* was assumed to be $\frac{126}{200}$ (Wagner and Moench, 2009). The conversion rate from *E. coli* to Enterococci was assumed to be $\frac{35}{126}$ (Wagner and Moench, 2009). Therefore, the daily potential Enterococci load from cattle was calculated as:

$$Potential\ Load = Head\ of\ Cattle \times \frac{8.55 \times 10^9 cfu\ fecal\ coliform}{Head \times day^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli}$$

Multiplied by 365 days/year, GIS analysis estimated a potential annual load of 7.23×10^{15} cfu/year across the entire watershed from cattle.

Load Reductions from Livestock Management

The potential load reduction that can be achieved by implementing conservation practices will depend on the specific BMPs implemented by each landowner, the number of cattle in each operation, existing practices, and existing land condition. The bacteria reduction efficiencies of these BMPs have been estimated in various research efforts and an estimated 69 percent median effectiveness for BMPs likely to be employed in the watershed was assumed (Table B-1).

Table B-1. Livestock management effectiveness

	Low	High	Median
Exclusionary Fencing[1]	30%	94%	62%
Filter Strips[2]	30%	100%	65%
Prescribed Grazing[3]	42%	66%	54%
Stream Crossing[4]	44%	52%	48%
Watering Facility[5]	51%	94%	72.5%

[1] Brenner et al. 1996, Cook 1998, Hagedorn et al. 1999, Line 2002, Line 2003, Lombardo et al. 2000, Meals 2001, Meals 2004, Petersen 2011

[2] Cook 1998, Coyne et al. 1995, Fajardo et al. 2001, Goel et al. 2004, Larsen et al. 1994, Lewis et al. 2010, Mankin and Okoren 2003, Roodsari et al. 2005, Stuntebeck and Bannerman 1998, Sullivan et al. 2007, Tate et al. 2006, Young et al. 1980

[3] Tate et al. 2004, EPA 2010

[4] Inamdar et al. 2002, Meals 2001

[5] Byers et al. 2005, Hagedorn et al. 1999, Sheffield et al. 1997

The total potential load reduction will be strongly influenced by the number of ranchers that participate and the number of cattle that will be impacted. Specific load reduction estimates are simply estimates that will strongly depend on the specific management practices implemented. Based on National Agricultural Statistics Service (NASS) data for Matagorda and Wharton counties we estimated there are 213 farms within the watershed (USDA NASS, 2014). Using the estimated 13,131 cattle in the watershed, there are an estimated 61 head per farm. Daily potential load reduction expected from cattle management practices were then estimated with:

$$Potential\ Load\ Reduction = Number\ of\ management\ plans \times \frac{cattle}{mgmt\ plan} \times \frac{8.55\times10^{9} cfu\ fecal\ coliform}{An.U\times day^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli} \times BMP\ reduction\ rate \times Proximity\ factor$$

The proximity factor is a percentage-based impact factor based on the assumed proximity of the management measures to the water body. Potential load reductions were calculated assuming that nine farms would adopt conservation measures per year for five years. The total annual potential load reduction after 45 farms adopted conservation measures was 2.61×10^{14} cfu/year of Enterococci.

Management Measure 2: Removal and Management of Feral Hogs

Feral Hog Loadings

The stakeholders determined 4,856 feral hogs as an appropriate population estimate based on values in nearby watersheds, and an estimated population density of one feral hog per 33.3 acres across all land covers in the watershed except for developed and open water. GIS analysis was used to estimate potential loadings from feral hogs across the watershed and within subwatersheds. To estimate loadings, the number of feral hogs were converted to An.Us with a conversion factor of 0.125. The assumed fecal coliform production rate for feral hogs was 1.21×10^{9} cfu/An.U×day^{-1} (Wagner and Moench, 2009). The conversion rate from fecal coliform to *E. coli* was assumed to be $\frac{126}{200}$. The conversion rate from *E. coli* to Enterococci was assumed to be $\frac{35}{126}$. Therefore, the daily potential Enterococci load from feral hogs was calculated as:

$$Potential\ Load = number\ of\ feral\ hogs \times \frac{0.125\ An.U}{feral\ hog} \times \frac{1.21\times10^{9} cfu\ fecal\ coliform}{An.U\times day^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli}$$

Multiplied by 365 days/year, GIS analysis estimated a potential annual load of 4.73×10^{13} cfu/year across the entire watershed from feral hogs.

Load Reductions from Feral Hog Management

The potential load reductions for feral hog management depend on how much the population can be directly reduced. Load reduction was calculated based on the number of hogs removed annually. Therefore, the same equation to calculate daily loading was used:

$$Potential\ Load\ Reduction = feral\ hogs\ removed \times \frac{1.21\times10^{9} cfu\ fecal\ coliform}{An.U\times day^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli}$$

Reducing the feral hog population by approximately 20 percent would be the equivalent of removing the potential load from 1,000 feral hogs from the watershed per year. This equates to an annual load reduction of 9.66×10^{12} cfu/year of Enterococci.

Management Measure 3: Identification, Prioritization, and Remediation of OSSFs

OSSF Loadings

Stakeholders estimated 1,490 OSSFs exist within the watershed based on residential 911 addresses within the watershed and outside WWTF service areas. Of these, 1,422 or 95 percent were on soils classified as 'very limited,' with an expected failure rate of 15 percent. Potential loadings were modeled in GIS for each subwatershed and across the entire watershed. For each address, the average number of persons per household was obtained using 2010 Census block data (2.4 people per household). The assumed fecal coliform concentration of a failing OSSF was 10×10^{6} cfu/100 ml (EPA, 2001). A sewage discharge rate of 70 gallons (gal)/person day^{-1} was used (Borel, et. al., 2015). The OSSF failure rate was assumed to be 15 percent. The conversion rate from fecal coliform to *E. coli* was assumed to be $\frac{126}{200}$. The conversion rate from *E. coli* to Enterococci was assumed to be $\frac{35}{126}$.

Daily potential load per household was calculated as:

$$Potential\ OSSF\ Load = Number\ of\ OSSFs \times \frac{number\ of\ people}{household} \times \frac{70\ gal}{person \times day^{-1}} \times 0.15\ Failure\ rate \times \frac{1\times10^{6}\ cfu\ fecal\ coliform}{100\ ml} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli} \times 3578.4\ {}^{mL}/_{gal}$$

Potential daily Enterococci loading from OSSF failure was estimated as 2.35×10^{11} cfu/day. Potential annual Enterococci loading from OSSF failure was estimated as 8.58×10^{13} cfu/year.

Load Reductions from Replacement of Faulty OSSFs

Total load reductions from the replacement of failing OSSF systems depend on the amount of effluent discharged by the system and proximity of the system to a water body. Because these actual values are not known before identification and replacement of a failing OSSF, approximate values are used to identify potential load reductions. For load reduction calculations, 2.4 people per household, a discharge rate of 70 gal/person day^{-1}, and a fecal coliform concentration of 1×10^{6} cfu/100 mL were assumed. Potential annual load reductions can be calculated as:

$$Potential\ Load\ Reduction = Number\ of\ OSSFs\ replaced\ per\ year \times \frac{2.4\ persons}{household} \times \frac{70\ gal}{person \times day^{-1}} \times \frac{1 \times 10^6\ cfu\ fecal\ coliform}{100\ mL} \times 3578.4\ {}^{mL}/_{gal} \times {}^{365\ days}/_{year}$$

Assuming that six failing OSSFs are replaced annually for five years, the potential annual load reduction is 1.22×10^{13} cfu/year.

Management Measure 6: Installation of Urban Best Management Practices

Urban Stormwater Loadings

GIS analysis was used to calculate potential loadings from stormwater runoff across the watershed and within subwatersheds. According to NLCD land cover data, 2,893 acres in the watershed consist of high, medium, or low intensity developed cover. Assuming that a typical fecal coliform loading rate for urban runoff is 5.60×10^9 cfu/hectare(ha)/year (Herrera, 2011), a fecal coliform to *E. coli* conversion rate of $\frac{126}{200}$, and *E. coli* to Enterococci conversion rate of $\frac{35}{126}$, potential urban runoff loading can be estimated by:

$$Potential\ Load = urban\ acreage \times \frac{5.60 \times 10^9 cfu\ fecal\ coliform}{ha \times yr^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli} \times 0.404686\ {}^{ha}/_{ac}$$

An estimated potential annual Enterococci load of 1.14×10^{12} cfu/year from urban runoff occurs across the watershed.

Load Reductions from Urban Stormwater BMPs

A wide variety of BMPs are available to control and treat urban stormwater runoff. The actual load reduction achieved depends on the appropriateness of the BMP chosen, BMP design, site characteristics, and long term maintenance. To estimate a load reduction potential, we assumed 50 additional acres of urban land cover would be treated by stormwater BMPs with an 88 percent fecal coliform reduction potential (as cited for dry basins in CWP, 2007).

$$Potential\ Load\ Reduction = urban\ acreage \times \frac{5.60\times10^{9} cfu\ fecal\ coliform}{ha\times yr^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli} \times 0.404686\ {}^{ha}/_{ac} \times 0.88$$

The potential annual Enterococci load reduction is estimated at 1.74×10^{10} cfu/year.

Management Measure 7: Development and Implementation of Pet Waste Programs

Domestic and Household Pet Loadings

Stakeholders estimated a population of 6,370 household pets (cats and dogs) in the watershed. This estimate was based on residential 911 addresses and the American Veterinary Medical Association (AVMA) estimated number of dogs (0.584) and cats (0.638) per household (AVMA, 2012). GIS analysis was used to estimate potential loadings across the watershed and in each subwatershed based on the number of households estimated within respective boundaries. The assumed fecal coliform production rate per animal was 5.0×10^{9} cfu/day (EPA, 2001). The conversion rate from fecal coliform to *E. coli* was assumed to be $\frac{126}{200}$. The conversion rate from *E. coli* to Enterococci was assumed to be $\frac{35}{126}$. Daily potential loading from household pets was calculated as:

$$Potential\ Load = household\ pets \times \frac{5.00\times10^{9} cfu\ fecal\ coliform}{animal\times day^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli}$$

Multiplied by 365 days/year, GIS analysis estimated a potential annual load of 2.05×10^{15} cfu/year across the entire watershed from household pets.

Load Reductions Household Pet Waste Management

Potential load reductions for household animal waste depend on the number of pets that contribute loading and the amount of pet waste that is picked up and disposed of properly. Assessing the number of pet owners that do not pick up pet waste or that would change behavior based on education or availability of pet waste stations is inherently difficult. However, some estimates currently exist that can be used as baseline assumptions. Survey data from the Chesapeake Bay Basin indicate 50 percent of dog owners walk their dogs, and 40 percent of those walkers do not currently pick up their dog's waste. Of those that do not pick up their dog's waste, 60 percent would be willing to change behavior (Swann, 1999). Therefore, daily potential load reduction was calculated as:

$$Potential\ Load\ Reduction = pet\ owners\ targeted \times 0.50 \times 0.40 \times 0.60 \times \frac{5.00 \times 10^{9} cfu\ fecal\ coliform}{An.U \times day^{-1}} \times \frac{126\ cfu\ E.coli}{200\ fecal\ coliform} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli}$$

Recognizing that landowners in rural areas of the watershed with high acreage properties are unlikely to pick up pet waste because pets have large areas to roam, subwatersheds with higher densities of households and pets were targeted (subwatersheds 1 and 12). Therefore, only 2,500 pet owners in the watershed were included in the load reduction calculation. The potential annual Enterococci load reduction is 9.58×10^{13} cfu/year.

Management Measure 8: Planning and Implementation of Wastewater Reuse

WWTF Loadings

There are three WWTFs in the Tres Palacios Creek watershed with discharge permits for bacteria. Potential loadings for each WWTF were modeled at respective maximum discharge and an *E. coli* concentration of 126 cfu/100ml, although monitoring data indicate discharge concentrations are routinely quite low. The conversion rate from *E. coli* to Enterococci was assumed to be $\frac{35}{126}$. Daily potential loading from WWTFs across the watershed was calculated as the sum of individual plant loadings, where individual plant loadings are calculated as:

$$Potential\ Load_{WWTP} = maximum\ permitted\ discharge\ (^{Gal}/_{day}) \times \frac{126\ cfu\ E.coli}{100\ ml} \times \frac{35\ cfu\ Enterococcus}{126\ cfu\ E.coli} \times 3785.2\ ^{ml}/_{Gal}$$

Potential daily Enterococci loading is estimated at 3.88×10^{9} cfu/day and potential annual loading is estimated at 1.42×10^{12} cfu/year.

Load Reductions from WWTF Management Measures

Potential load reductions can be achieved through the reduction of the total effluent discharged into the Tres Palacios Creek and its tributaries. The adoption of wastewater reuse by the City of El Campo WWTF could divert 100 percent of the wastewater effluent to irrigation or other non-potable uses. Potential load reduction is equivalent to the potential load at the El Campo WWTF, or 1.28×10^{12} cfu/year of Enterococci.

Appendix B References

AVMA (American Veterinary Medical Association). 2012. In: U.S. Pet Ownership and Demographics Sourcebook (2012 Edition). Retrieved May 1, 2015, from <www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx>.

Borel, K., Karthikeyan, R., Berthold, T.A., and Wagner, K. 2015. Estimating *E. coli* and Enterococcus loads in a coastal Texas watershed. Texas Water Journal. 6(1), 33-44.

Brenner, F.J., Mondok, J.J, McDonald, Jr, R.J. 1996. Watershed Restoration through Changing Agricultural Practices. Proceedings of the AWRA Annual Symposium Watershed Restoration Management: Physical, Chemical and Biological Considerations. Herndon, VA: American Water Resources Association. TPS-96-1, 397-404.

Byers, H.L., Cabrera, M.L., Matthews, M.K., Franklin, D.H., Andrae, J.G., Radcliffe, D.E., McCann, M.A., Kuykendall, H.A., Hoveland, C.S., Calvert II, V.H. 2005. Phosphorus, sediment, and *Escherichia coli* loads in unfenced streams of the Georgia Piedmont, USA. Journal of Environmental Quality. 34, 2293-2300.

Cook, M.N. 1998. Impact of Animal Waste Best Management Practices on the Bacteriological Quality of Surface Water. Master's Thesis. Virginia Polytechnic Institute and State University.

Coyne, M.S., Gilfillen, R.A., Rhodes, R.W., Blevins, R.L. 1995. Soil and fecal coliform trapping by grass filter strips during simulated rain. Journal of Soil and Water Conservation. 50, 405-408.

CWP (Center for Watershed Protection). 2007. National Pollutant Removal Performance Database Version 3. Ellicott City, MD: Center for Watershed Protection. Retrieved May 15, 2016, from <http://www.cwp.org/>.

EPA (United States Environmental Protection Agency). 2001. Protocol for developing pathogen TMDLs: source assessment. First edition. Washington D.C.: EPA Office of Water. 841-R-00-002.

EPA (United States Environmental Protection Agency). 2010. Implementing Best Management Practices Improves Water Quality. Washington D.C.: EPA Office of Water. 841-F-10-001F.

Fajardo, J.J., Bauder, J.W., Cash, S.D. 2001. Managing nitrate and bacteria in runoff from livestock confinement areas with vegetative filter strips. Journal of Soil and Water Conservation. 56, 185-191.

Goel, P.K., Rudra, R.P., Gharabaghi, B., Das, S., Gupta, N. 2004. Pollutants removal by vegetative filter strips planted with different grasses. ASAE/CSAE Annual International Meeting. 042177:1-15.

Hagedorn, C., Robinson, S.L., Filts, J.R., Grubbs, S.M., Angier, T.A., Reneau Jr., R.B. 1999. Determining sources of fecal pollution in a rural Virginia watershed with antibiotic resistance patterns in fecal streptococci. Applied and Environmental Microbiology. 65, 5522-5531.

Herrera. 2011. Best Available Science for Stormwater Management Alternatives. Retrieved from <http://www.co.san-juan.wa.us/cdp/docs/CAO_BASsynthesis/FINAL_Stormwater.pdf>.

Inamdar, S.P., Mostaghimi, S., Cook, M.N., Brannan, K.M., McClellen, P.W. 2002. A long-term, watershed scale, evaluation of the impacts of animal waste BMPs on indicator bacteria concentrations. Journal of the American Water Resources Association. 38, 15.

Larsen, R.E., Miner, J.R., Buckhouse, J.C., Moore, J.A. 1994. Water-quality benefits of having cattle manure deposited away from streams. Bioresource Technology. 48, 113-118.

Lewis, D.J., Atwill, E.R., Lennox, M.S., Pereira, M.D.G., Miller, W.A., Conrad, P.A., Tate, K.W. 2010. Management of microbial contamination in storm runoff from California coastal dairy pastures. Journal of Environmental Quality. 39, 1782-1789.

Line, D.E. 2002. Changes in land use/management and water quality in the Long Creek watershed. Journal of the American Society of Agronomy. 38, 1691-1701.

Line, D.E. 2003. Changes in a stream's physical and biological conditions following livestock exclusion. Transactions of the ASAE. 46, 287-293.

Lombardo, L.A., Grabow, G.L., Spooner, J., Line, D.E., Osmond, D.L., Jennings, G.D. 2000. Section 319 Nonpoint Source National Monitoring Program: Successes and Recommendations. NCSU Water Quality Group, Biological and Agricultural Engineering Department, NC State University, Raleigh, North Carolina.

Mankin, K.R., Okoren, C.G. 2003. Field evaluation of bacteria removal in a VFS. ASAE Annual International Meeting. 032150. 7.

Meals, D.W. 2004. Water quality improvements following riparian restoration in two Vermont agricultural watersheds. In T.O. Manley, P.L. Manley and T.B. Mihuc (Eds.), Lake Champlain: Partnerships and Research in the New Millennium. New York: Kluwer Academic/Plenum Publishers.

Peterson, J.L., Redmon, L.A., McFarland, M.L. 2011. Reducing Bacteria with Best Management Practices for Livestock: Heavy Use Area Protection. Texas A&M AgriLife Extension Service. ESP-406.

Roodsari, R.M., Shelton, D.R., Shirmohammadim A., Pachepsky, Y.A., Sadeghi, A.M., Starr, J.L. 2005. Fecal coliform transport as affected by surface condition. American Society of Agricultural Engineers. 48(3), 1055-1061.

Sheffield, R.E., Mostaghimi, S., Vaughan, D.H., Collins Jr., E.R., Allen, V.G. 1997. Off-stream water sources for grazing cattle as a stream bank stabilization and water quality BMP. Transactions of the ASAE. 40, 595-604.

Stuntebeck, T.D. and Bannerman R.T. 1998. Effectiveness of barnyard best management practices in Wisconsin. USGS Fact Sheet. FS-051-98.

Sullivan, T.J., Moore, J.A., Thomas, D.R., Mallery, E., Snyder, K.U., Wustenberg, M., Wustenberg, J., Mackey, S.D., Moore, D.L. 2007. Efficacy of vegetated buffers in preventing transport of fecal coliform bacteria from pasturelands. Environmental Management. 40(6), 958-965.

Swann, C. 1999. A Survey of Residential Nutrient Behaviors in the Chesapeake Bay. Widener-Burrows, Inc. Chesapeake Research Consortium. Ellicott City, Maryland: Center for Watershed Protection. Retrieved May 15, 2016, from <https://cfpub.epa.gov/npstbx/files/UNEP_all.pdf>.

Tate, K.W., Pereira, M.D.G., Atwill, E.R. 2004. Efficacy of vegetated buffer strips for retaining *Cryptosporidium parvum*. Journal of Environmental Quality. 33, 2243-2251.

Tate, K.W., Atwillm E.R., Bartolome, J.W., Nader, G. 2006. Significant *Escherichia coli* attenuation by vegetative buffers on annual grasslands. Journal of Environmental Quality. 35, 795-805.

USDA NASS (United States Department of Agriculture - National Agricultural Statistics Service). 2014. Quick Stats (2012 Census). Retrieved April 21, 2015, from <quickstats.nass.usda.gov/?source_desc=CENSUS>.

Wagner, K.L. and Moench, E. 2009. Education Program for Improved Water Quality in Copano Bay. Task Two Report. College Station, TX: Texas Water Resources Institute. TR-347.

Young, R.A., Huntrods, T., Anderson, W. 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Journal of Environmental Quality. 9, 483-487.