Approved August 28, 2019

Implementation Plan for Two Total Maximum Daily Loads for Indicator Bacteria in the Navasota River below Lake Limestone

Segment 1209

Assessment Units 1209_03, 1209_05

Prepared by the Stakeholders of the Navasota River below Lake Limestone

With Support from the Texas Water Resources Institute and the Water Quality Planning Division, Office of Water, Texas Commission on Environmental Quality

Prepared by the Stakeholders of the Navasota River below Lake Limestone and the Texas Water Resources Institute

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

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

This plan is based in part on technical reports prepared for the TCEQ by:
Texas Water Resources Institute
and in large part on the recommendations of the
stakeholders in the Navasota River watershed

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

Contents

Figures

Tables

Abbreviations

ac	acres
AgriLife Extension	Texas A&M AgriLife Extension Service
AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
CAFO	concentrated animal feeding operation
cfs	cubic feet per second
CIG	Conservation Innovation Grants
cfu	colony forming unit
CFR	Code of Federal Regulations
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
E. coli	*Escherichia coli*
EQIP	Environmental Quality Incentives Program
FDA	fractional drainage area
FG	future growth
GIS	geographic information system
HOA	homeowner's association
I&I	inflow and infiltration
I-Plan	Implementation Plan
LA	load allocation
MGD	million gallons per day
mL	milliliter
MOS	margin of safety
MPN	most probable number
MS4	Municipal Separate Storm Sewer System
NEIWPCC	New England Interstate Water Pollution Control Commission
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
RC&D	Resource Conservation & Development
RCPP	Regional Conservation Partnership Program
SEP	Supplemental Environmental Projects
SSO	sanitary sewer overflow
SWCD	Soil and Water Conservation District
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department

TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	wasteload allocation
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

Implementation Plan for Two TMDLs for Indicator Bacteria in the Navasota River below Lake Limestone

Executive Summary

In 2019, the Texas Commission on Environmental Quality (TCEQ) will consider adoption of *Two Total Maximum Daily Loads (TMDLs) for Indicator Bacteria in the Navasota River below Lake Limestone*.

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 uses in Segment 1209 in assessment units (AUs) 1209_03 and 1209_05 by reducing elevated concentrations of indicator bacteria to levels established in the TMDLs. *Escherichia coli* (*E. coli*) are widely used as an indicator bacteria to assess attainment of the contact recreation use in freshwater bodies. *E. coli* are the relevant indicator for the impaired AUs. The criteria for assessing attainment of the contact recreation use are expressed as the number (or "counts") of *E. coli* bacteria, typically given as the most probable number (MPN) but also referred to as colony forming units (cfu). The primary contact recreation use is not supported when the geometric mean of *E. coli* samples collected during the assessment period exceeds 126 MPN per 100 milliliters (mL).

The TMDL identified regulated and unregulated sources of indicator 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 indicator bacteria load in the watershed include domestic animals (cows, sheep, dogs, horses, poultry), failing on-site sewage facilities (OSSFs), and wildlife and other unmanaged animals (e.g. deer, feral hogs).

This I-Plan includes five management measures that will be used to reduce indicator bacteria in the Navasota River below Lake Limestone watershed. Management measures refer to strategies for reducing unregulated pollutants

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. *Promote feral hog management through technical and operational assistance to landowners.*
2. *Develop property-specific conservation plans and Water Quality Management Plans.*
3. *Identify, inspect, and repair or replace failing OSSFs and provide education and outreach to OSSF landowners.*
4. *Promote proper pet waste management.*
5. *Address inflow and infiltration (I&I).*

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 Navasota River below Lake Limestone 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 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 review 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 (USEPA, 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 developed to implement nonpoint source (unregulated) elements of this plan that also meet the grant program conditions may be eligible for funding under the United States Environmental Protection Agency's (USEPA) Section 319(h) incremental grant program.

Watershed Overview

The Navasota River below Lake Limestone watershed is located in East-Central Texas and contains parts of six counties including Brazos, Grimes, Leon, Limestone, Madison, and Robertson. There are two reservoirs on the main stem of the Navasota River; thus, the watershed is divided into three primary segments: the Navasota River below Lake Limestone (1209), the Navasota River above Lake Mexia (1210A), and the Navasota River below Lake Mexia (1253). This segment of the Navasota River (1209) flows from the Sterling C. Robertson Dam, which forms Lake Limestone, downstream to its confluence with the Brazos River, south of State Highway 105 and west of the city of Navasota (Figure 1). The dam forms a major hydrological divide in the watershed and a logical breakpoint for assessment and evaluation purposes. The area of the watershed below Lake Limestone is 1,006,329 acres of mostly rural landscapes that consist of pastures, hay fields, and hardwood forests in bottomland and upland areas. Urbanization is not widespread but is primarily in the Bryan and College Station area in Brazos County. The river is a perennial freshwater stream, but the operations of Lake Limestone strongly influence its flow.

Segment and AU descriptions in the *2014 Texas Integrated Report of Surface Water Quality* (2014 Integrated Report) of the impaired portions of the watershed include:

- Segment 1209 - Navasota River below Lake Limestone: From the confluence with the Brazos River in Grimes County to Sterling C. Robertson Dam in Leon/Robertson County
  - AU 1209_03: Portion of the Navasota River from confluence with Sandy Branch upstream to confluence with Shepherd Branch in Madison County
  - AU 1209_05: Portion of the Navasota River from confluence with Camp Creek upstream to Lake Limestone Dam in Robertson County

Land Use

Land use/land cover for the watershed is divided according to the National Land Cover Database (NLCD) map classifications. Most of the land in the Navasota River below Lake Limestone watershed is pasture/hay land (37.9 percent) and forest (24.8 percent) (Table 1). There is limited cultivated crop production. Crop data from the U.S. Department of Agriculture (USDA) suggested that minimal corn and cotton production occur in isolated areas within the southern portion of the watershed. The only large concentration of developed land in the watershed is within the cities of Bryan and College Station in the southwestern portion of the watershed.

The land use/land cover data for the Navasota River below Lake Limestone watershed were obtained from the U.S. Geological Survey (USGS) 2011 NLCD (Figure 2) and are represented by the following categories and definitions (USGS, 2014).

Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.

Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.

Developed, Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.

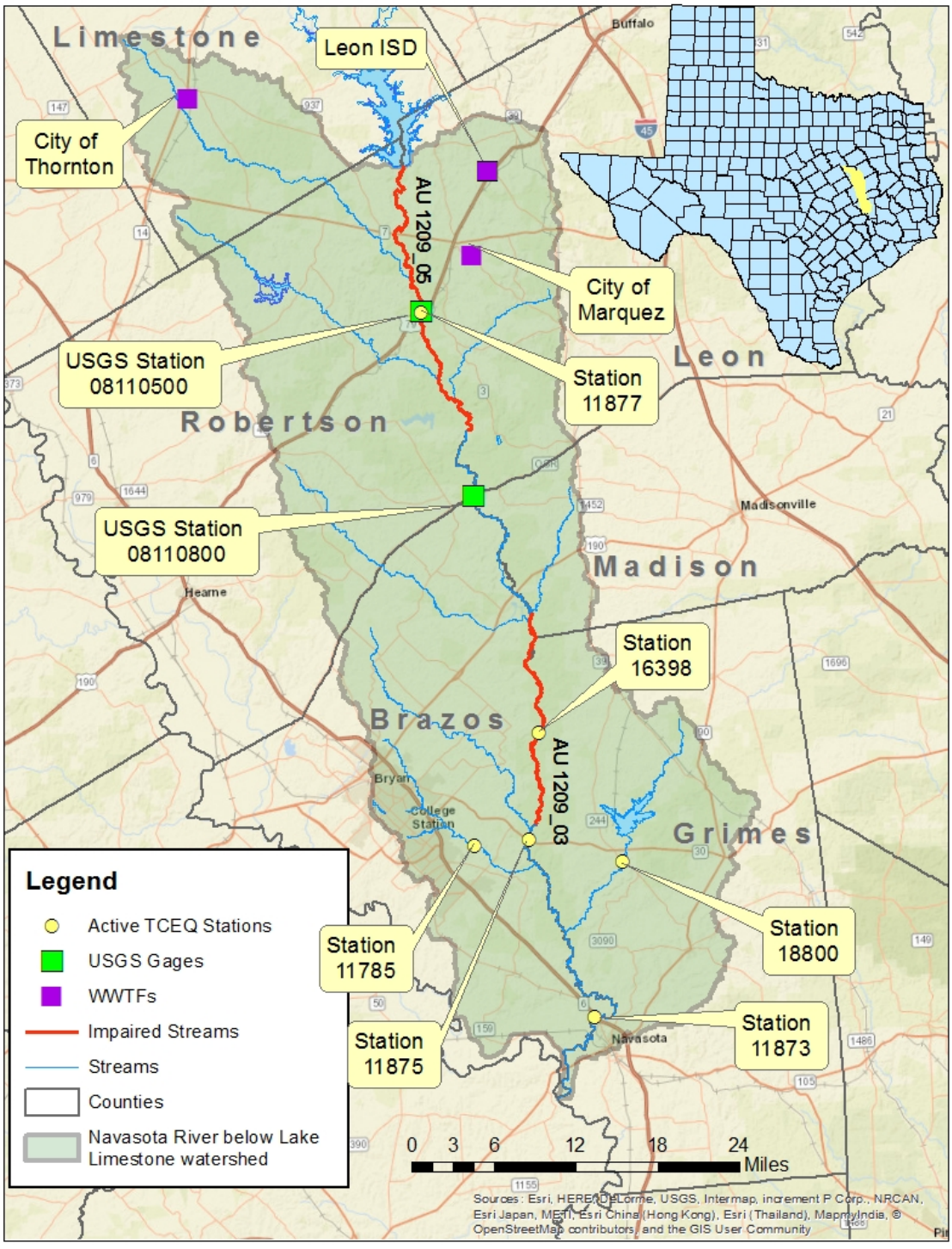

Figure 1. Navasota River below Lake Limestone watershed, including the impairments, municipal wastewater outfalls, USGS stream gages, and TCEQ monitoring stations

Table 1. Land use/land cover in the Navasota River below Lake Limestone watershed

2011 NLCD Classification	Acres	% Total
Open Water	10,987	1.1
Developed (Open Space; Low, Medium, and High Intensity)	77,367	7.7
Barren Land (Rock/Sand/Clay)	9,517	0.9
Forest (Deciduous, Evergreen, and Mixed)	249,547	24.8
Shrub/Scrub	93,072	9.2
Grassland/Herbaceous	81,117	8.1
Pasture/Hay	381,727	37.9
Cultivated Crops	19,222	1.9
Wetlands (Woody and Emergent Herbaceous)	83,773	8.4
Total	**1,006,329**	**100%**

Developed High Intensity - highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial areas. Impervious surfaces account for 80 percent to 100 percent of the total cover.

Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.

Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

Shrub/Scrub - areas dominated by shrubs less than 5 meters tall, with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

Grassland/Herbaceous - areas dominated by graminoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover, and the soil or substrate is periodically saturated with or covered with water.

Emergent Herbaceous Wetlands - areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover, and the soil or substrate are periodically saturated with or covered with water.

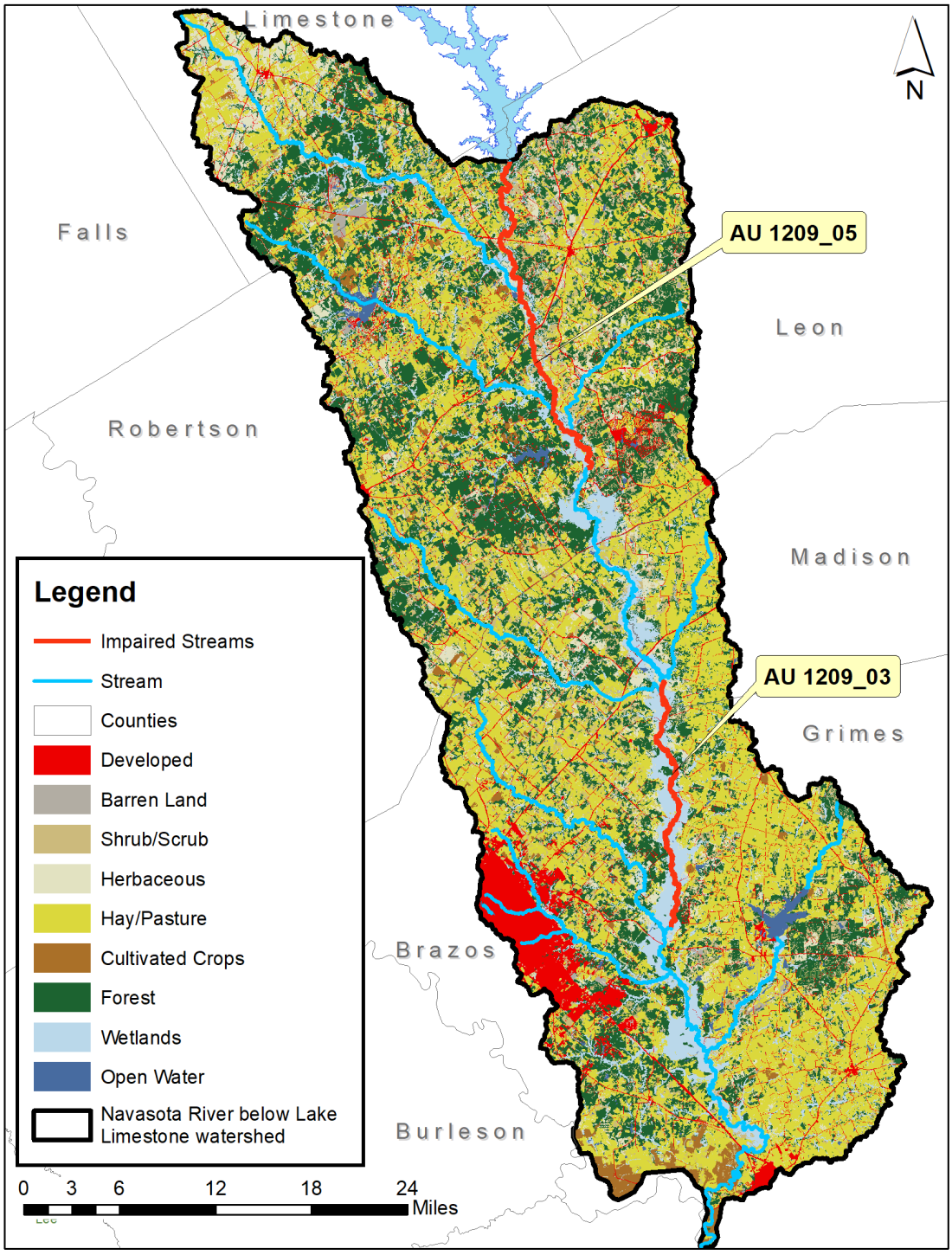

Figure 2. 2011 NLCD land use/land cover within the Navasota River below Lake Limestone watershed

Watershed Population and Population Projections

Approximately 83 percent of the watershed population is estimated to reside in the Bryan and College Station area. Estimates from the 2010 United States Census Bureau (USCB) population census for the portion of each county in the watershed range from 1,419 in Madison County to 156,941 in Brazos County. Significant population growth is anticipated over the next 50 years in the Navasota River below Lake Limestone watershed. Combining estimates for each county, populations are expected to increase 79.2 percent by 2070 (Table 2). The Navasota River below Lake Limestone watershed is predominantly rural, with most of the urban development centered around the cities of Bryan and College Station (Figure 3).

Table 2. Population, population density, and projections in the Navasota River below Lake Limestone watershed

County	2010 County Population in Watershed	Population Density Per Square Mile	Projected Populations by Year (entire county)						Projected 50-year Increase (entire county)
			2020	2030	2040	2050	2060	2070	
Brazos	156,941	376.5	227,654	264,665	302,997	349,894	400,135	455,529	100.1 %
Grimes	11,170	34.5	29,441	32,179	34,258	36,454	38,277	39,867	35.4 %
Madison	1,419	20.2	14,753	15,817	16,786	17,872	18,886	19,877	34.7 %
Leon	5,235	21.3	18,211	19,536	20,603	22,071	23,340	24,582	35.0 %
Limestone	1,735	11.5	25,136	26,615	27,817	29,134	30,206	31,152	23.9 %
Robertson	4,540	12.4	18,358	20,150	21,801	23,525	25,174	26,771	45.8 %
Totals	181,040	n/a	333,553	378,962	424,262	478,950	536,018	597,778	79.2 %

Source: Texas Water Development Board, 2014

Source Analysis

Pollutants may come from several sources, both regulated and unregulated. Regulated pollutants, referred to as “point sources,” come from a single definable point, such as a pipe, and are regulated by permit under the Texas Pollutant Discharge Elimination System (TPDES) or the National Pollutant Discharge Elimination System (NPDES). WWTFs and stormwater discharges from industries, construction, and municipal separate storm sewer systems (MS4s) are considered point sources of pollution.

Unregulated sources are typically nonpoint in origin, meaning the pollutants originate from multiple locations and can be carried primarily by rainfall runoff into surface waters. Nonpoint sources are not regulated by permit.

With the exception of WWTFs, which receive individual wasteload allocations (WLAs) (see the “Wasteload Allocation” section), the regulated and unregulated

sources in this section are presented to give a general account of the different sources of bacteria identified in the watershed. These are not meant to be used for allocating bacteria loads or interpreted as precise inventories and loadings.

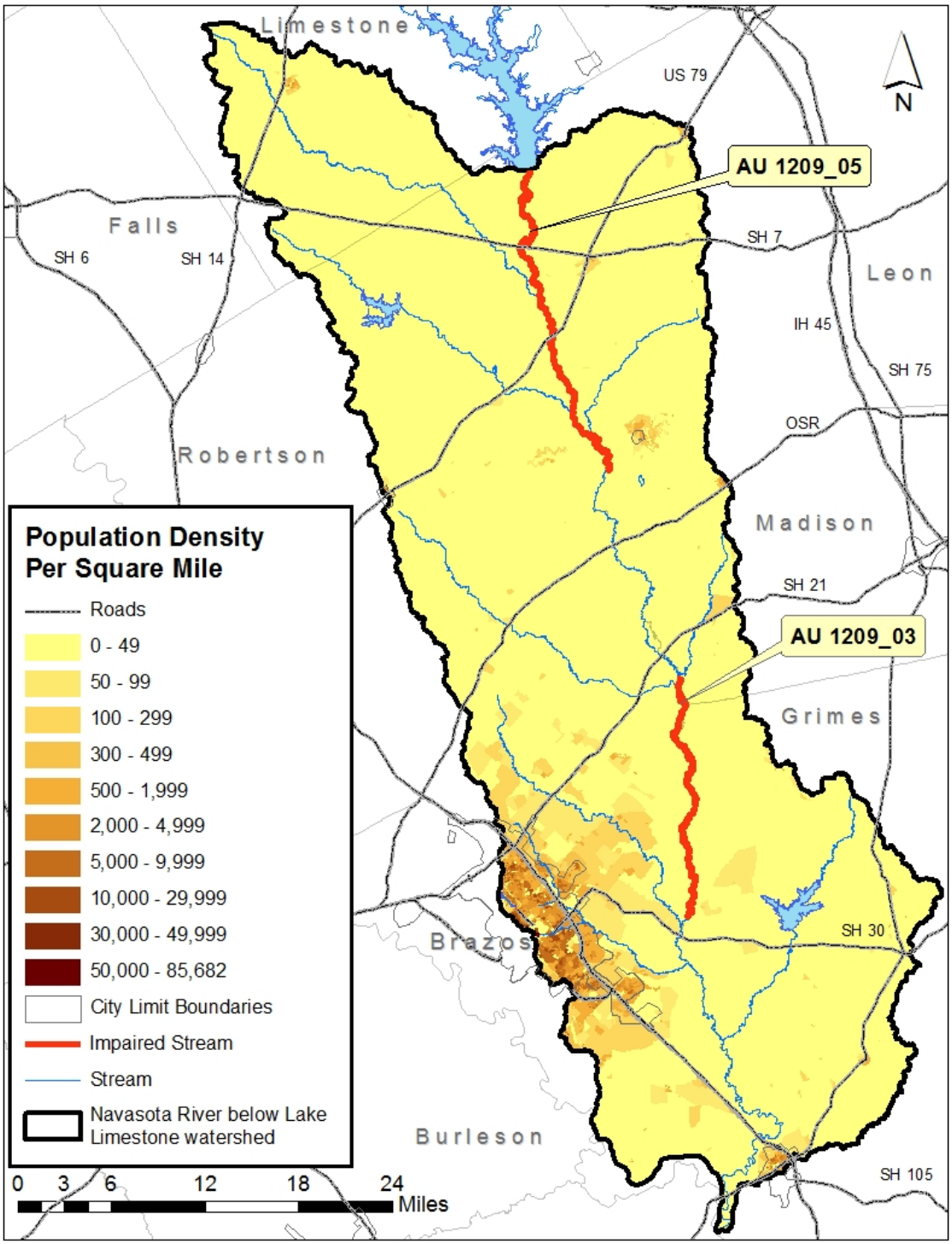

Figure 3. Population density per square mile in the Navasota River below Lake Limestone watershed

Regulated Sources

Regulated sources are controlled by permit under the TPDES and NPDES programs. The regulated sources in the TMDL watershed include domestic WWTF outfalls and stormwater discharges from industries and construction.

Domestic and Industrial Wastewater

Domestic WWTFs treat wastewater and generally discharge limited amounts of *E. coli.* While there are 13 individual domestic WWTFs in the Navasota River below Lake Limestone watershed, only three WWTFs, for the entities of City of Marquez, Leon ISD, and City of Thornton, have *E. coli* limits in their permits and discharge to one of the impaired AUs.

Table 3 lists the individually permitted discharge facilities in the Navasota River below Lake Limestone watershed. As of February 2017, there were 22 TPDES/NPDES permits for facilities in the watershed. These include wastewater permits, cooling water discharge permits, industrial discharges, and mine dewatering discharge permits.

There are nine individual industrial WWTFs in the watershed of the Navasota River below Lake Limestone, five of which discharge to the impaired AUs. Effluents from industrial WWTFs vary and may include a combination of treated wastewater, stormwater, and treated domestic wastewater. The effluent from the five industrial WWTFs discharging to the impaired AUs do not include treated domestic wastewater and are therefore not included in the TMDL allocations for regulated wastewater. Of these, two facilities (Oak Grove Management Co, LLC – WQ0001986000 and Luminant Mining Co, LLC – WQ0002699000) are authorized to discharge stormwater. These facilities will be included in the TMDL allocations for regulated stormwater.

Table 3. Permitted discharge facilities in the Navasota River below Lake Limestone watershed

TPDES Permit Number	NPDES Permit Number	Facility Name (effluent type)[a]	Final Receiving Navasota River (1209) AU	Final Permitted Discharges (MGD)[b]	Recent Discharge (MGD)[c]
WQ0013980001	TX0117579	City of Marquez WWTF (WW)	1209_05	0.040	0.020[d]
WQ0010824001	TX0075639	City of Thornton WWTF (WW)	1209_05	0.041	0.016
WQ0014659002	TX0135127	Leon ISD WWTF (WW)	1209_05	0.020	*
WQ0004770000	TX0124401	Linde Gas North America, LLC Jewett Plant (IW)	1209_05	0.040	0.011
WQ0001986000	TX0068021	Oak Grove Management Co, LLC Oak Grove Steam Electric Station (CW/IW/SW)	1209_05	1610	1542
WQ0002699000	TX0076465	Luminant Mining Co, LLC Oak Grove Lignite Mining Area (IW/SW)	1209_05	Intermittent and Flow-variable	2
WQ0005138000	TX0135615	Sanderson Farms, Inc Franklin Feed Mill (IW)	1209_05	0.040	0.014
WQ0001176000	TX0001368	U.S. Silica Co Kosse Plant (IW)	1209_05	2.500	1.600
WQ0013931001	TX0116378	City of Anderson WWTF (WW)	1209_01	0.065	0.008[e]
WQ0010231001	TX0071790	City of Navasota WWTF (WW)	1209_01	1.800	0.637
WQ0014879001	TX0131440	Ni America Texas Development, LLC Myers Reserve WWTF (WW)	1209_01	0.075	*
WQ0010426001	TX0022616	City of Bryan Burton Creek WWTF (WW)	1209_02	8.000	4.590
WQ0013153001	TX0098663	City of College Station Carter Lake WWTF (WW)	1209_02	0.009	0.006
WQ0010024003	TX0093262	City of College Station Lick Creek WWTF (WW)	1209_02	2.000	1.178
WQ0010024006	TX0047163	City of College Station Carters Creek WWTF (WW)	1209_02	9.500	6.330

TPDES Permit Number	NPDES Permit Number	Facility Name (effluent type) [a]	Final Receiving Navasota River (1209) AU	Final Permitted Discharges (MGD) [b]	Recent Discharge (MGD) [c]
WQ0012296001	TX0085456	ILP College Station, LLC Glen Oaks Mobile Home Park WWTF (WW)	1209_02	0.013	0.001
WQ0015556001	TX0137570	Smiling Mallard Development, Ltd. Lakes & South College Station Development WWTF (WW)	1209_02	0.250	*
WQ0003996000	TX0120146	Tenaska Frontier Partners, Ltd Tenaska Frontier Generating Station (IW/SW)	1209_02	2.500	0.764
WQ0004002000	TX0002747	Texas A&M University Central Utilities Plant (IW/SW)	1209_02	0.930	0.580
WQ0002120000	TX0074438	Texas Municipal Power Agency Gibbons Creek Steam Electric Station (IW/SW/WW)	1209_02	Intermittent and flow-variable	1.140
WQ0002460000	TX0083101	Texas Municipal Power Agency Gibbons Creek Lignite Mine (SW)	1209_02	Intermittent and flow-variable	3.888
WQ0001906000	TX0027952	City of Bryan Atkins Street Power Plant (IW/SW)	1209_02	0.385	0.073

[a] CW (cooling water), IW (industrial wastewater), SW (stormwater), WW (domestic wastewater)

[b] MGD = million gallons per day

[c] Based on average discharge from July 7, 2013 to June 30, 2016

[d] Based on average discharge from January 2015 to January 2017

[e] Based on average discharge from November 2011 to December 2016

* No data to report

General Wastewater Permits

Discharges of processed wastewater from certain types of facilities are required to be covered by one of several TPDES general permits:

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production facilities
- TXG340000 – petroleum bulk stations and terminals
- TXG500000 – quarries in John Graves Scenic Riverway
- TXG670000 – hydrostatic test water discharges
- TXG830000 – water contaminated by petroleum fuel or petroleum substances

- TXG920000 – concentrated animal feeding operations
- WQG100000 – wastewater evaporation
- WQG20000 – livestock manure compost operations (irrigation only)

A review of general wastewater permits was conducted to understand the regulated activities occurring in the Navasota River below Lake Limestone. Many general wastewater permits do not authorize discharges and those that do are not expected to contain domestic wastewater. One concentrated animal feeding operation (CAFO) was found (TXG920363) in the watershed of the impaired AUs. CAFOs do not discharge to water bodies when operating, according to their permits, but may do so if a system failure occurs.

Sanitary Sewer Overflows

SSOs are unauthorized discharges that must be addressed by the responsible party, either the TPDES permittee or the owner of the collection system that is connected to a permitted system. SSOs in dry weather most often result from blockages in the sewer collection pipes caused by tree roots, grease, and other debris. I&I are typical causes of SSOs under high flow conditions in the WWTF system. Blockages in the line may exacerbate the I&I problem. Other causes, such as a collapsed sewer line, may occur under any condition. Data presented in the Consolidated Compliance and Enforcement Data Systems database, maintained by the TCEQ's Office of Compliance and Enforcement, may not represent all SSOs nor do permitted entities always know when an SSO occurs. As of January 1, 2016, 54 SSOs were reported in the watershed totaling 158,895 gallons. However, none of these incidences occurred in the impaired AUs.

TPDES-Regulated Stormwater

When evaluating stormwater for a TMDL allocation, a distinction must be made between stormwater originating from an area under a TPDES or NPDES-regulated discharge permit and stormwater originating from areas not under a TPDES or NPDES-regulated discharge permit. Stormwater discharges fall into two categories:

1) Stormwater subject to regulation, which is any stormwater originating from TPDES/NPDES regulated MS4s, industrial facilities, and regulated construction activities.
2) Stormwater runoff not subject to regulation.

The portion of the Navasota River below Lake Limestone watershed for the impaired AUs does not include any areas with Phase I or Phase II MS4 permits.

In the absence of areas regulated by Phase I and Phase II MS4 areas, a review of other stormwater permits is conducted. The area of the watershed with regulated stormwater is estimated by determining coverage by individual

industrial stormwater WWTFs, multi-sector, and construction permits. As of April 30, 2018, 270 stormwater authorizations were issued under a general permit, with 234 of these facilities located in Brazos County. The remaining facilities with stormwater permit authorizations are located in Grimes (17), Limestone (5), Leon (7), and Robertson (7) counties. Brazos County stormwater permit authorizations include authorizations for construction activities, industrial activities, and Phase II MS4s. In addition to the general stormwater authorizations, there are two individual industrial WWTFs (Oak Grove Management Co, LLC – WQ0001986000 and Luminant Mining Co, LLC – WQ0002699000) that are authorized to discharge stormwater.

Municipal Separate Storm Sewer Systems

There are three Phase II and one Phase I MS4 permit authorizations in the watershed, which account for the bulk of permitted stormwater in the watershed (Table 4); however, these entities are downstream of the impaired AUs, and are not included in the TMDL calculations.

Table 4. MS4 permits associated with the Navasota River below Lake Limestone watershed

Regulated Entity Name	NPDES Permit Number
Brazos County	TXR040172
City of Bryan	TXR040336
City of College Station	TXR040008
Texas Department of Transportation	TXS002101

Illicit Discharges

Pollutant loads can enter streams from MS4 outfalls that carry authorized sources as well as illicit discharges under both dry- and wet-weather conditions. The term “illicit discharge” is defined in TPDES General Permit TXR040000 for Phase II MS4s as “Any discharge to a municipal separate storm sewer that is not entirely composed of stormwater, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency firefighting activities.” Illicit discharges can be categorized as either direct or indirect contributions. Examples of illicit discharges identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003) include:

Direct Illicit Discharges:

- sanitary wastewater piping that is directly connected from a home to the storm sewer,
- materials that have been dumped illegally into a storm drain catch basin,
- a shop floor drain that is connected to the storm sewer, and

- a cross-connection between the sanitary sewer and storm sewer systems.

Indirect Illicit Discharges:

- an old and damaged sanitary sewer line that is leaking fluids into a cracked storm sewer line, and
- a failing septic system that is leaking into a cracked storm sewer line or causing surface discharge into the storm sewer.

Unregulated Sources

Unregulated sources of bacteria are generally nonpoint. Nonpoint source loading can enter streams through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities, agricultural animals, land application fields, failing OSSFs, unmanaged and feral animals, and domestic pets.

Unregulated Agricultural Activities and Domesticated Animals

A number of agricultural activities that do not require permits can be potential sources of fecal bacteria loading. Livestock are present throughout rural portions of the project watershed.

Estimated numbers of selected livestock in the watershed were aggregated from the 2012 Census of Agriculture conducted by the USDA (USDA National Agricultural Statistics Service, 2014b) (Table 5). The county-level estimated livestock populations were distributed based on geographic information system (GIS) calculations of Pasture/Hay land use/land cover in the watershed, per the 2011 NLCD (USGS, 2014). Local stakeholders, including local soil and water conservation district board members and staff from the Texas State Soil and Water Conservation Board (TSSWCB), reviewed livestock population estimates. These livestock numbers, however, were not used to develop an allocation of allowable bacteria loading to livestock.

Table 5. Grazing livestock populations in the Navasota River below Lake Limestone watershed

County	Cattle	Horses	Goats	Sheep
Brazos	18,501	1,978	1,314	590
Grimes	23,705	1,274	484	78
Leon	12,104	662	414	83
Limestone	7,723	442	248	75
Madison	5,528	51	149	52
Robertson	24,477	215	515	264
TOTAL	**92,038**	**4,622**	**3,124**	**1,142**

The number of head from the 2012 USDA census was obtained and divided by the county area (square miles) to get number per square mile (#/mi^2). The county area in the watershed was calculated and multiplied by the previous #/mi^2 to get the final livestock head in the table.

Commercial poultry operations, not tracked in the Census of Agriculture, also exist in the watershed. According to the TSSWCB, as of 2015 there were 57 poultry facilities in the watershed that house almost 9.9 million birds. Poultry facilities are required to obtain a Water Quality Management Plan (WQMP) before operations begin. WQMPs prescribe proper handling and utilization of produced litter to ensure adequate water quality protection. As a result, this potential source of *E. coli* in the watershed is not considered significant.

Wildlife and Unmanaged Animals

E. coli bacteria are common inhabitants of the intestines of all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify by watershed the potential for bacteria contributions from wildlife. Wildlife are naturally attracted to the riparian corridors of streams and rivers. With direct access to the stream channel, the direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Fecal bacteria from wildlife are also deposited onto land surfaces, where they may be washed into nearby streams by rainfall runoff.

Quantitative estimates of wildlife numbers are difficult and sometimes impossible to calculate accurately. For this reason, only approximate numbers for deer are calculated using Texas Parks and Wildlife Department (TPWD) surveys conducted within the watershed, and stakeholder feedback is used for feral hog estimates.

Feral hog estimates are based on watershed stakeholder feedback and reflect the importance of habitat. Estimates of eight acres (ac) per hog in wetlands and 13 ac/hog in forests and shrub/scrub were derived, yielding a watershed total of 36,827 hogs.

The deer population density is estimated from annual survey data from TPWD at 32 ac/deer of land suitable for deer (pasture/hay, grassland/herbaceous, shrub/scrub, cropland, forests, wetlands). This yields an estimate of 28,392 deer.

Numerous other wildlife species reside in the Navasota River below Lake Limestone watershed and rely on the river, its tributaries, and habitat across the watershed for their survival. The quality and quantity of riparian habitat throughout the watershed naturally concentrates many of the wildlife near water bodies where their deposited fecal matter can have a more direct effect on instream water quality than that deposited in upland areas farther from the stream.

Dogs and other urban animals can also contribute fecal bacteria to water bodies. The American Veterinary Medical Association (AVMA) estimates 0.584 dogs per household. Using 2010 USCB data, the number of households within each county in the watershed were estimated. Combining AVMA estimates with

household numbers allowed a watershed estimate for dogs to be established (Table 6). Watershed stakeholders did not feel that cats were a major contributor of *E. coli* in the watershed and their population was not estimated.

Table 6. Estimated dog population in the Navasota River below Lake Limestone watershed

County	Households	Estimated Dog Population
Brazos	50,616	29,559
Grimes	3,582	2,092
Limestone	1,369	799
Leon	1,565	914
Madison	622	363
Robertson	2,764	1,614
TOTAL	**60,518**	**35,341**

Source: AVMA, 2012; U.S. Census Bureau, 2010

On-Site Sewage Facilities

Private residential OSSFs, commonly referred to as septic systems, consist of various designs based on the physical conditions of the local soils. Typical designs consist of 1) one or more septic tanks and a drainage or distribution field (anaerobic system) or 2) aerobic systems that have an aerated holding tank and often an above-ground sprinkler system for distributing the effluent. In simplest terms, household waste flows into the septic tank or aerated tank, where solids settle out. The liquid portion of the waste flows to the distribution system, which may consist of buried perforated pipes or an above-ground sprinkler system.

Several pathways of the liquid waste in OSSFs afford opportunities for bacteria to enter ground and surface waters, if the systems are not properly operating. However, if properly designed and operated, OSSFs are expected to contribute virtually no fecal bacteria to surface waters. For example, it has been reported that less than 0.01 percent of fecal coliforms originating in household wastes move further than 6.5 feet down gradient of the drainfield of a properly functioning OSSF (Weikel et al., 1996). However, OSSFs are prone to failure if not properly designed, installed, or maintained. In the Navasota River below Lake Limestone watershed, failure estimates were derived by discussing failures with County Designated Representatives. Collectively, an estimated failure rate of 10.2 percent was deemed appropriate.

The number of OSSFs expected in the watershed was derived by applying a multifaceted estimation approach that uses 2010 USCB household estimates, 911 address data, and satellite imagery to approximate the number and location of OSSFs (Gregory et al., 2013). Using this approach, approximately 17,149

OSSFs are presumed to be in the Navasota River below Lake Limestone watershed; however, this number is increasing. Of these, 1,749 OSSFs may be failing based on the estimated 10.2 percent failure rate. Table 7 shows the OSSFs for each impaired AU. Other OSSFs in the watershed are located downstream of the impaired AUs and thus are not contributing to bacteria concentrations.

Table 7. OSSF estimates for the impaired AUs

AU	Estimated OSSFs
1209_03	10,997
1209_05	3,730

Source: Census Bureau, 2010; Gregory et al., 2013

Summary of TMDLs

This section summarizes the information developed for *Two Total Maximum Daily Loads for Indicator Bacteria in the Navasota River below Lake Limestone.* Additional background information, including the problem definition, endpoint identification, source analysis, linkages between sources and receiving waters, and pollutant load allocations can be found in the TMDL report.

Pollutant Sources and Loads

Wasteload Allocation

The WLA is the sum of loads from regulated sources. This variable consists of two parts—the waste load from the allocated TPDES-regulated WWTFs (WLA_{WWTF}) and waste load that is allocated to stormwater dischargers (WLA_{SW}). The equation below is used to calculate the WLA.

$$WLA = WLA_{WWTF} + WLA_{SW}$$

WWTFs

TPDES-permitted WWTFs are allocated a daily waste load (WLA_{WWTF}) calculated as the total sum of loads from regulated WWTF loading. This is expressed in the following equation:

$$WLA_{WWTF} = Criterion * Flow * Conversion\ Factor$$

Where:

Criterion = 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 * 28,316.846 mL/ft3 * 86,400 sec/day

Daily allowable loading of *E. coli* for WLA_{WWTF} was determined by the full permitted discharge from each WWTF using the above equation. Table 8 shows the WWTFs within the TMDL watershed that contribute treated wastewater to impaired AUs 1209_03 and 1209_05. The three WWTFs discharge to the upstream impaired AU (1209_05) and are included in downstream AU (1209_03) allocations.

Table 8. Wasteload allocations for the TPDES permitted facilities within the Navasota River below Lake Limestone watershed that contribute flow to the impaired AUs

TPDES Permit Number	Facility	Final Receiving AUs	Final Permitted Discharges (MGD) [a]	*E. coli* WLA_{WWTF} (Billion MPN/day) [b]
WQ0013980001	City of Marquez WWTF	1209_05	0.040	0.190
WQ0010824001	City of Thornton WWTF	1209_05	0.041	0.195
WQ0014659002	Leon ISD WWTF	1209_05	0.020	0.095
			Total for Both AUs	**0.480**

[a] Permitted Flow from Table 3

[b] WLA_{WWTF} = Criterion * Flow * Conversion Factor

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered 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 the *Two Total Maximum Daily Loads for Indicator Bacteria in the Navasota River below Lake Limestone.* The calculation for allowable loads from regulated stormwater is expressed by the following equation:

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

Where:

WLA_{SW} = sum of all regulated stormwater loads

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety

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

Table 9 provides a summary of the regulated stormwater area. In order to calculate WLA_{SW}, the Future Growth (FG) term must be known. The calculation for the FG term is presented in the next section, but the results will be included here for continuity. Table 10 provides the information needed to compute WLA_{SW}.

Table 9. Stormwater General Permit areas and calculation of the FDA_{SWP} term

AU	MS4 General Permit (acres)	Industrial (acres)	Construction Activities (acres)	Total Area of Permits (acres)	Watershed Area (acres)	FDA_{SWP}
1209_03	0	8,357.47	1,258.6	9,616.07	719,434.2	0.013
1209_05	0	4,589.6	520.2	5,109.8	227,062	0.022

Table 10. Regulated stormwater allocation calculations

All loads expressed as Billion MPN/day

AU	TMDL	WLA_{WWTF} [a]	FG [b]	MOS	FDA_{SWP} [c]	WLA_{SW}
1209_03	11,084.534	0.480	0.145	554.226	0.013	136.885
1209_05	3,500.666	0.480	0.145	175.033	0.022	73.150

[a] WLA_{WWTF} from Table 8

[b] FG from Table 12

[c] FDA_{SWP} from Table 9

Load Allocation

The LA is the remaining load from unregulated sources, and 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 = sum of future growth loads from potential regulated facilities

MOS = margin of safety

The calculation results are shown in Table 11.

Table 11. Load allocations for the Navasota River below Lake Limestone watershed

All loads expressed as Billion MPN/day

AU	TMDL	WLA_{WWTF} [a]	WLA_{SW} [b]	FG [c]	MOS	LA [d]
1209_03	11,084.534	0.480	136.885	0.145	554.226	10,392.798
1209_05	3,500.666	0.480	73.150	0.145	175.033	3,251.858

[a] WLA_{WWTF} from Table 8

[b] WLA_{SW} from Table 10

[c] FG from Table 12

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

Allowance for Future Growth

The 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 loads if the pollutant concentrations meet the criteria in the Texas Surface Water Quality Standards.

Currently, there are 13 domestic WWTFs in the watershed that discharge waste with *E. coli* limits, but only three of them directly affect the impaired AUs in the watershed (Table 12). The City of Thornton WWTF is located in Limestone County and is within the Steele Creek subbasin. Steele Creek flows into AU 1209_05 of the Navasota River. The City of Marquez WWTF and Leon ISD WWTF are located in Leon County and also contribute flow to AU 1209_05. Together, these contributions also impact Navasota River AU 1209_03 downstream. The FG equation (below) contains an additional term to account for projected population growth for Limestone and Leon counties between 2020 to 2070 (Table 12). This inherently includes the assumption that the population served by existing WWTFs will increase proportionally to that of the counties they are within.

$FG = Criterion * [\%POP_{2020\text{-}2070} * WWTF_{FP}] * Conversion\ Factor$

Where:

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

$\%POP_{2020\text{-}2070}$ = estimated % increase in population between 2020 and 2070

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

Conversion Factor = 1.54723 cfs/MGD * 28,316.846 mL/ft^3 * 86,400 sec/day

Table 12. Future growth of current WWTFs in the Navasota River below Lake Limestone watershed

TPDES Permit Number	Facility	Full Permitted Flow (MGD)	Type/ Location of Outfall	Percent Population Increase (2020-2070)	2070 Permitted Flow (Future Growth) (MGD) [a]	FG *E. coli* (Billion MPN/ day) [b]
WQ0013980001	City of Marquez WWTF	0.040	Municipal/ Leon	35%	0.014	0.066
WQ0010824001	City of Thornton WWTF	0.041	Municipal/ Limestone	23.9%	0.009	0.046
WQ0014659002	Leon ISD WWTF	0.020	School/ Leon	35%	0.007	0.033
				Total:	**0.030**	**0.145**

[a] Significant digits based on full permitted flow

[b] FG = Criterion * [$\%POP_{2010\text{-}2070}$ * $WWTF_{FP}$] * Conversion Factor

Total Maximum Daily Loads

Table 13 summarizes the TMDL calculations for the Navasota River below Lake Limestone watershed. The TMDL was calculated based on the median value (five percent exceedance) within the high flow regime from the load duration curve developed for each impaired segment. Allocations are based on geometric mean criterion for *E. coli* of 126 MPN/day and include a five percent explicit MOS.

The final TMDL allocations comply with the requirements of 40 Code of Federal Regulations (CFR) §130.7.

Table 13. Final TMDL allocation summary for the Navasota River below Lake Limestone watershed

All loads expressed as Billion MPN/day

AU ID	TMDL	WLA_{WWTF} [a]	WLA_{SW} [b]	LA [c]	FG [d]	MOS
1209_03	11,084.534	0.480	136.885	10,392.798	0.145	554.226
1209_05	3,500.666	0.480	73.150	3,251.858	0.145	175.033

[a] WLA_{WWTF} from Table 8

[b] WLA_{SW} from Table 10

[c] LA from Table 11

[d] FG from Table 12

Implementation Strategy

This plan documents five management measures to reduce bacteria loads. Management measures were selected based on feasibility, costs, implementation timing, and stakeholder support. The Navasota River below Lake Limestone watershed was divided into 13 subwatersheds to help prioritize the efforts of each management measure. This prioritization was accomplished using the SELECT model's prediction of potential loading to each subwatershed. 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, stakeholders will periodically assess progress using the implementation schedule, 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 can be adjusted.

Activities and Milestones

The stakeholders of the Navasota River below Lake Limestone watershed, via general consensus, determined appropriate activities and schedules to accomplish the management activities in the plan. Collectively, nine formal public meetings and numerous individual and small group meetings were held

to develop this I-Plan. Consensus-based action plans resulted from this approach and planned implementation activities are described in the following section.

Management Measures

The Navasota River below Lake Limestone watershed I-Plan includes five management measures.

- *Promote feral hog management through technical and operational assistance to landowners.*
- *Develop property-specific conservation plans and WQMPs.*
- *Identify, inspect, and repair or replace failing OSSFs and provide education and outreach to OSSF landowners.*
- *Promote proper pet waste management.*
- *Address I&I.*

Management Measure 1

Promote feral hog management through technical and operational assistance to landowners.

The purpose of this management measure is to reduce the feral hog population in the watershed. Bacteria loadings from feral hogs are considerable. Feral hogs produce extensive damage to the riparian areas since they occupy dense habitat with available food and water resources. This leads to excess stream bank degradation due to rooting and wallowing. This increases soil erosion by destabilizing the banks and degrading the ground cover. Increased erosion causes enhanced pollution transport during runoff events to the water body.

Physically removing hogs is a strategy for reducing their impact on water quality, as removing the hogs will reduce bacteria, nutrient, and sediment loading through a decrease in soil erosion and direct deposition. Currently, the most efficient means of removing the hogs is trapping. Trapping feral hogs can successfully remove many at once. Trapping also allows the landowners to potentially receive a return on their investment in trapping efforts by selling the hogs at approved buying stations. The State of Texas allows approved feral hogs to be transported to facilities where the hogs can be sold. There are currently three facilities in the watershed. Another method used to remove feral hogs from the watershed is hunting. This method is not as efficient compared to trapping, as only one or a few hogs are removed at a time. An additional method after physically removing the feral hogs from the lands is to exclude feral hogs from supplemental feed. Feral hogs are intelligent animals and opportunistic

feeders. Creating fences around deer feeders has proven to reduce the ability of feral hogs to access these food sources (Rattan et al., 2010).

Figure 4 shows the total potential *E. coli* loading from feral hogs in cfu/day. Higher potential loads are estimated in more rural areas of the watershed while lower loads are estimated in more urban areas around the Bryan and College Station area. While the feral hog population appears to be larger in the northern section of the watershed, they have a tendency to travel great distances in search of food, water, and habitat. Because of this, all subwatersheds will be given a priority.

Education about feral hogs in workshops and programs will be used to improve the effectiveness of feral hog removal. AgriLife Extension provides a variety of resources for the public at <https://feralhogs.tamu.edu/>. Providing the landowners with accurate and up-to-date information will be crucial to ensuring the management measurement is successful.

It is assumed that a 15 percent reduction in feral hog populations will result in a 15 percent reduction in *E. coli* loads.

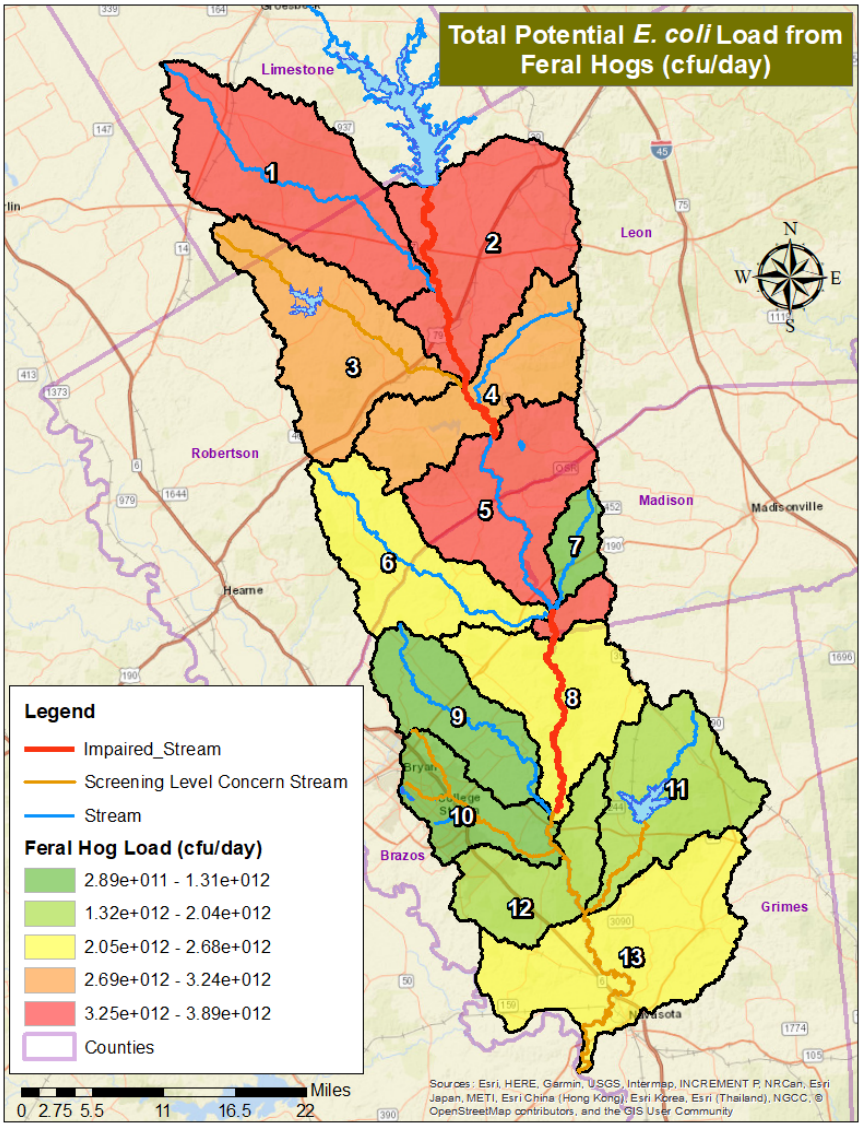

Figure 4. Spatial distribution of potential *E. coli* daily loading from feral hogs

Responsible Parties and Funding

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

- Watershed coordinator - Texas Water Resources Institute (TWRI) will serve as the watershed coordinator for this watershed. The watershed coordinator will work with entities to develop and secure funding resources. The watershed coordinator will work with other entities and organizations to organize, develop, and/or deliver education and outreach components of Management Measure 1.

- Texas A&M AgriLife Extension Service - AgriLife Extension will work with the watershed coordinator, TWRI, to develop and deliver education and outreach programs related to Management Measure 1.
- Local stakeholders - Landowners will assess which feral hog management strategy options work best for their land. Landowners will be responsible for trapping, hunting, or placing fences around feeders to remove the feral hogs from the land, within reason.
- The Texas Department of Agriculture - Feral Hog Abatement Program provides grant funding for practical and effective feral hog abatement strategies. AgriLife Extension and TPWD currently receive funding through this program. Individual stakeholders and other organizations may also apply for grant money from the program.

Estimated Load Reductions

Removing feral hogs from the watershed will directly influence the bacteria loading potential into the water bodies. A 15 percent reduction in the hog population is expected to yield a 15 percent reduction in *E. coli* loads, or 3.49×10^{15} cfu/year.

Measurable Milestones

Contingent upon the receipt of proposed project funding and voluntary implementation, the measurable milestones are as follows.

Years 1-10:

- Local stakeholders will install as many deer feeder excluders as feasible.
- Local stakeholders will remove as many feral hogs as possible by trapping or hunting.
- The watershed coordinator, TWRI, and AgriLife Extension will continue to deliver education material through outreach and one feral hog management workshop in years 1, 4, and 8.

Table 14. Management Measure 1: Promote feral hog management through technical and operational assistance to landowners

Causes and Sources: Fecal depostion from feral hogs directly and indirectly in the stream.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entities
3.49×10^{15} cfu/year or 15% of the current load	Technical: – Education and outreach workshops to ensure landowners have up-to-date information about feral hogs and how to manage them – Assistance for landowners to install deer feeder excluders and feral hog traps Financial Estimate: $200/feeder excluder and $7,500/feral hog education workshop	Landowners will receive education and outreach about feral hogs through workshops. This will include information about the different management practices that can be taken to manage the feral hog population. Education and outreach will be delivered from AgriLife Extension.	Years 1-10: – Local stakeholders will install as many deer feeder excluders as feasible. Local stakeholders will remove as many feral hogs as possible by trapping or hunting the population Years 1, 4, and 8: – Deliver education and outreach programs	Number of landowners attending the workshops provided Number of workshops held Estimated feral hogs removed from the watershed	Funding attained to develop feral hog workshops Number of education and outreach programs completed Number of feral hogs removed from the watershed	Landowners will be asked to report their observations on how many feral hogs they have removed to the watershed coordinator when requested The watershed coordinator will count the number of people attending each workshop	Watershed coordinator AgriLife Extension Local stakeholders

Management Measure 2

Develop property-specific conservation plans and Water Quality Management Plans

The purpose of this management measure is to develop and implement conservation plans and WQMPs on grazed lands in prioritized subwatersheds. Bacteria loadings in the Navasota River below Lake Limestone watershed from grazed lands are likely to be relatively high compared to other evaluated sources. Compared to other sources, the fate and transport of fecal bacteria in livestock waste is less certain. Livestock waste is often deposited in upland areas and transported to water bodies during runoff events. In between deposition and transport, much of the *E. coli* bacteria in livestock waste dies; however, livestock may spend significant amounts of time in and around water bodies, thus resulting in more direct impact on water quality.

Importantly, livestock behavior and where they spend time can be modified through changes to their food, shelter, and water availability. Cattle grazing is highly dependent upon proximity to these resources, especially water. Fecal loading is subsequently 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 that livestock spend in riparian pastures through rotational grazing, alternative water supplies, shade structures, and supplemental feeding locations can directly reduce the potential for bacteria to enter the creek.

A variety of best management practices (BMPs) are available to achieve goals of improving forage quality, distributing livestock across a property, and making water resources available to livestock. Table 15 provides a list of identified practices available to producers. However, the list of practices available to producers is not limited to those in the table. The actual appropriate practices will vary by operation and should be determined through technical assistance from the Natural Resources Conservation Service (NRCS), the TSSWCB, and local soil and water conservation districts (SWCDs) as appropriate.

The NRCS and the TSSWCB provide technical and financial assistance to producers to plan and implement property-specific BMPs. The NRCS offers a variety of programs to implement operation-specific conservation plans. The TSSWCB, through local SWCDs, provides technical and financial assistance to develop and implement property-specific WQMPs through planning, implementation, and maintenance of each practice.

Table 15. Available pasture and rangeland practices to improve water quality

Practice	NRCS Code	Focus Area or Benefit
Brush Management	314	Livestock, water quality, water quantity, wildlife
Fencing	382	Livestock, water quality
Filter strips	393	Livestock, water quality, wildlife
Grade stabilization structures	410	Water quality
Grazing land mechanical treatment	548	Livestock, water quality, wildlife
Heavy use area protection	562	Livestock, water quantity, water quality
Pond	378	Livestock, water quantity, water quality, wildlife
Prescribed burning	338	Livestock, water quality, wildlife
Prescribed grazing	528	Livestock, water quality, wildlife
Range/Pasture planting	550/512	Livestock, water quality, wildlife
Shade structure	NA	Livestock, water quality, wildlife
Stream crossing	578	Livestock, water quality
Supplemental feed location	NA	Livestock, water quality
Water well	642	Livestock, water quantity, wildlife
Watering facility	614	Livestock, water quantity

Education and outreach will be an important component of this management measure to increase adoption of practices. The watershed coordinator and AgriLife Extension will work to provide delivery of Lone Star Healthy Streams, which educate landowners on how to reduce operation impacts on water quality. Agricultural Management Practice Field Days will also be held to demonstrate the implementation of various practices on actual agricultural operations.

Although livestock consists of cattle, horses, goats, and sheep, this particular watershed is predominately cattle. Figure 5 shows the spatial distribution of where the cattle are located in the watershed and the estimated daily bacteria loading from each subwatershed. The priority subwatersheds in Navasota River below Lake Limestone watershed are 1, 2, 3, 5, 6, 8, 11, and 13. While there are priority subwatersheds, all areas of the watershed are encouraged to implement some of the BMPs as deemed appropriate.

Education and outreach to landowners and stakeholders will be delivered through the Lone Star Healthy Streams program to ensure the landowners and stakeholders stay informed about new technologies, requirements, and resources.

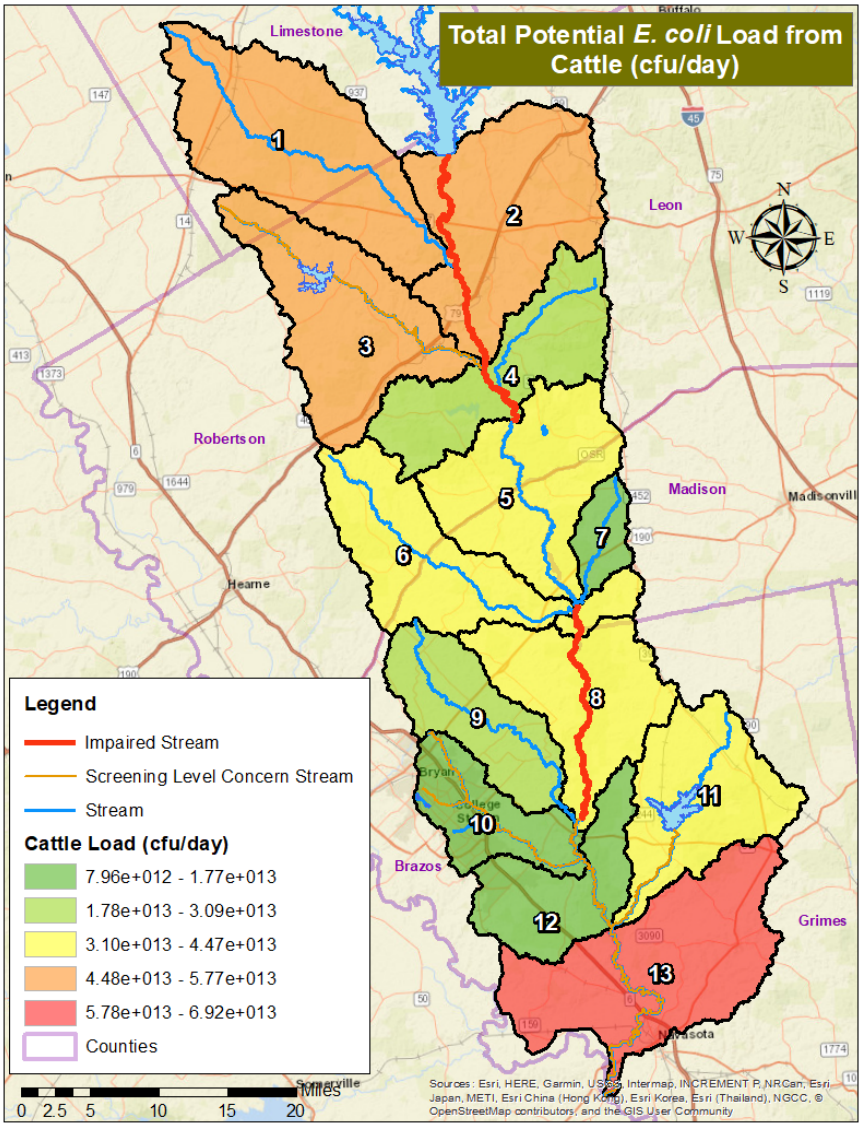

Figure 5. Spatial distribution of potential *E. coli* daily loading from cattle

Responsible Parties and Funding

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

- Watershed coordinator - TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with entities to develop and secure funding resources. The watershed coordinator will work with other entities and organizations to organize, develop, and/or deliver education and outreach components of Management Measure 2.
- Texas A&M AgriLife Extension Service - AgriLife Extension will work with the watershed coordinator, TWRI, to develop and deliver the education and outreach programs relative to this Management Measure 2.

- Local stakeholders - Local stakeholders, specifically landowners and producers, will evaluate the option of adopting WQMPs and conservation plans. If feasible, the individual stakeholder will be responsible for approaching the appropriate agency and working with that agency to develop the WQMP or conservation plan to mitigate operational impacts on water quality. Stakeholders that adopt WQMPs or conservation plans should adhere to the requirements written into their specific plans. Stakeholders will receive assistance from other responsible parties to adopt and implement conservation plans and WQMPs.
- Texas State and Soil and Water Conservation Board - TSSWCB is the lead agency responsible for implementing, managing, and planning programs and practices to reduce agricultural and silvicultural nonpoint source (NPS) pollution in Texas. TSSWCB is responsible for administrating the WQMP Program that provides funding and assistance for management practices on agricultural lands. TSSWCB will provide technical assistance to the landowners.
- Soil and Water Conservation Districts - SWCDs (Navasota SWCD #440, Limestone-Falls SWCD #501, Brazos County SWCD #450, Robertson County SWCD #451, and Bedias Creek SWCD #428) are responsible for collaborating with TSSWCB and NRCS to provide technical assistance to stakeholders for preparation of WQMPs.
- U.S. Department of Agriculture Natural Resources Conservation Service - USDS NRCS is responsible for planning, implementing, and working with landowners and organizations to develop conservation plans. Through the Farm Bill Programs authorized by Congress, NRCS is able to allocate funding for different conservation practices, which are described in the Field Office Technical Guide and adapted to local environments. NRCS also works with individuals engaged in livestock or agriculture to participate in the Environmental Quality Incentives Program (EQIP). Local stakeholders in the watershed are encouraged to participate in their local NRCS Work Groups to promote Management Measure 2.

The entities mentioned in this section provide technical and financial assistance for Management Measure 2, but funding sources for this management measure need not be limited to these entities. The intent is for the agencies listed under Management Measure 2 to work with landowners to voluntarily implement WQMPs and conservation plans. Technical assistance to agricultural producers for developing WQMPs and conservation plans is provided through the TSSWCB's WQMP Program, which is funded through state general revenue.

The TSSWCB, SWCDs, and NRCS will continue to provide appropriate levels of cost-share assistance to agricultural producers that will facilitate the implementation of BMPs, conservation plans, and WQMPs in the Navasota River below Lake Limestone watershed, as described in Management Measure 2. However, it is anticipated that additional levels of funding will be needed to

meet implementation needs. Potential outside sources of funding to assist implementation are outlined below.

- Conservation Innovation Grants (CIG) - The voluntary CIG program is 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 (CSP) - The CSP helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Participants earn CSP payments for conservation performance — the higher the performance, the higher the payment.
- Conservation Reserve Program (CRP) - The CRP is a voluntary program for agricultural landowners administered by the USDA Farm Service Agency. Individuals may receive annual rental payments to establish long-term, resource conserving covers on environmentally sensitive land. The goal of the program is to reduce runoff and sedimentation to protect and improve lakes, rivers, ponds, and streams. Financial assistance covering up to 50 percent of the costs to establish approved conservation practices, enrollment payments, and performance payments are available through the program.
- Environmental Quality Incentives Program - 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 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.
- Federal and State Clean Water Act (CWA) Section 319(h) Grants - The USEPA provides grant funding to Texas to implement the state's approved Nonpoint Source Management Program. The USEPA-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. USEPA-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 percent match through local funding or in-kind services.
- Regional Conservation Partnership Program (RCPP) - The RCPP is a 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.

- 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, the TSSWCB may be able to provide financial assistance for implementing a portion of the practices. It should be noted that the TSSWCB's WQMP Program is dependent on continued appropriations from the Texas Legislature.

Estimated Load Reductions

The estimated load reduction for this management measure is 1.83×10^{15} cfu/year for cattle alone. This load estimate is calculated based on the assumption that 130 conservation plans and WQMPs will be developed to adequately address livestock management in the watershed through prescribed grazing, cross-fencing, and alternate water facilities. Additional reductions may be possible if additional practices are implemented. Nutrient and sediment loading reductions are also expected and can range from an 8 percent to 89 percent decrease depending on which BMPs are chosen and implemented.

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

Years 1-10:

- TSSWCB, SWCDs, NRCS, and local stakeholders will develop and implement 13 WQMPs or conservation plans annually.
- AgriLife Extension will deliver at least one Agricultural Management Practice Field Day focused on improved grazing land management annually.
- The watershed coordinator, TSSWCB, SWCDs, NRCS, and local stakeholders will work to secure funding for a regional or watershed field technician, conservation plans, and WQMPs in year 1.
- The watershed coordinator and AgriLife Extension will deliver educational material through the Lone Star Healthy Streams program in years 3 and 8.

Table 16. Management Measure 2: Develop property-specific conservation plans and Water Quality Management Plans

Causes and Sources: Direct and indirect livestock fecal depostion in the stream or riparian area.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entities
1.83×10^{15}cfu/year	Technical: – A WQMP technician will be needed to assist with the development of WQMPs Financial: – Significant financial needs are anticipated, with an estimated $75,000 per year for a WQMP technician; and an estimated $15,000 to develop, implement, and provide cost share per conservation plan or WQMP	Education and outreach will be required to demonstrate benefits to producers and their operations The Lone Star Healthy Streams program and Management Practice Field days will be delivered to livestock producers in the watershed	Year 1: – Secure funding for a regional or watershed field technician, conservation plans, and WQMPs. Years 1-10: – Develop and implement 13 conservation plans and WQMPs annually as appropriate to address direct and indirect fecal loading: (130 plans in total). – Deliver annual Agricultural Management Practice Field Day Years 3 and 8: – Deliver Lone Star Healthy Streams program	Number of WQMPs and conservation plans developed Number of education and outreach programs delivered	Funding leveraged for a WQMP technician Number of plans developed Amount of funding leveraged for WQMPs and conservation plans Number of education and outreach programs delivered	Watershed coordinator will request reports from TSSWCB, NRCS, and SWCDs on number of plans implemented Watershed coordinator will track grants and other funding applied for Watershed coordinator will track the education and outreach programs Special BMP effectiveness monitoring as funding allows	Watershed coordinator AgriLife Extension Local stakeholders TSSWCB SWCDs NRCS

Management Measure 3

Identify, inspect, and repair or replace failing OSSFs and provide education and outreach to OSSF landowners.

The purpose of this management measure is to reduce the number of OSSFs failing in the watershed. GIS analysis indicated OSSFs are a relatively moderate contributor to potential bacterial loadings across the watershed. Nearly all the soils in the watershed are classified as "somewhat limited" or "severely limited" for OSSF drain fields. This indicates that conventional septic tank systems are not suitable for the proper treatment of household wastewater. In these areas, advanced treatment systems, most commonly aerobic treatment units, are suitable alternative options for wastewater treatment. While advanced treatment systems are highly effective, the operation and maintenance needs for these systems are rigorous compared to conventional septic systems. Limited awareness and lack of maintenance can lead to system failures.

Failing OSSFs were raised as a concern by watershed stakeholders. Using local knowledge from entities charged with permitting and enforcement, it is estimated there are 1,749 failing OSSFs in the watershed. Improper system design or selection, improper maintenance, and lack of education are likely reasons contributing to OSSF failure. In some cases, systems can be treated and repaired, while in other cases, systems need to be redesigned and replaced; however, homeowners must have the awareness and resources to address OSSF problems when they arise.

Management Measure 3 will address failing OSSFs in the watershed by providing education outreach to homeowners and by working to correct identified issues through system repairs or replacement.

Watershed stakeholders established a goal of identifying and repairing or replacing 150 OSSFs in the watershed with a preference for areas within 150 yards of a waterway and on unsuitable soils. GIS analysis indicates that the southeastern part of the watershed (subwatersheds 13, 11, 12, and 8) has the highest potential for OSSF failure; however, the need to address failing systems exists across the watershed, especially in more rural areas adjacent to the impaired AUs (Figure 6).

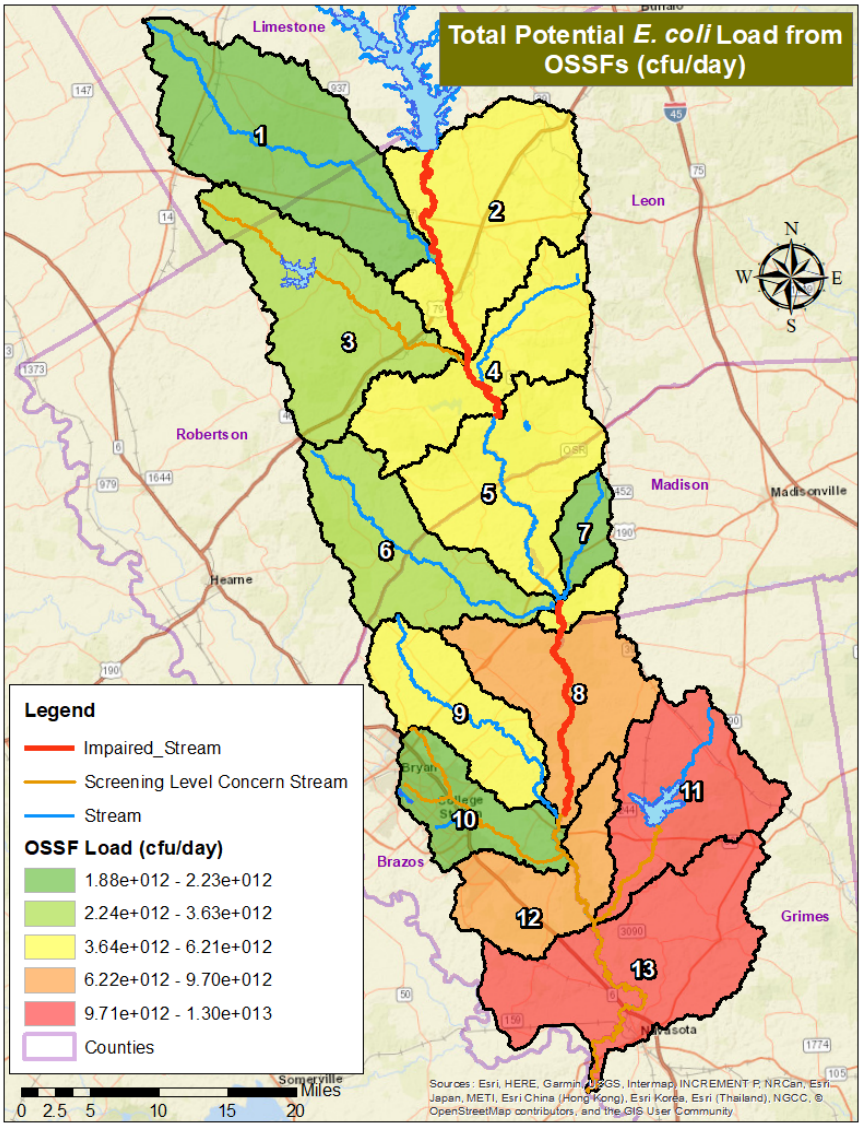

Figure 6. Spatial distribution of potential *E. coli* daily loading from failing OSSFs

Responsible Parties and Funding

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

- Watershed coordinator - TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with entities to develop and secure funding resources. The watershed coordinator will work with other entities and organizations to organize, develop, and/or deliver education and outreach components of Management Measure 3.
- Texas A&M AgriLife Extension Service - AgriLife Extension will work with the watershed coordinator to develop and deliver education outreach on OSSFs.

- Local stakeholders - Local stakeholders, specifically homeowners, are responsible for repairing or replacing faulty OSSFs on their own properties. The watershed coordinator will work with local stakeholders and organizations to leverage funding resources where needed to provide cost share if the need is identified.
- Brazos County Health Department - Brazos County Health Department will help instructors by providing education of rules and regulations on OSSFs throughout the watershed.
- Counties - Brazos, Grimes, Leon, Limestone, Madison, and Robertson counties' Designated Representatives will continue implementing and enforcing rules pertaining to OSSFs in their respective counties. This includes permitting, reviewing designs, inspecting installations, responding to complaints, and taking enforcement actions. Designated Representatives will also work with the watershed coordinator as needed in the identification and development of programmatic needs, such as OSSF repair and replacement programs.
- Post Oak Resource Conservation & Development - Post Oak RC&D will work with counties and the watershed coordinator to identify, secure, and distribute funds to support OSSF repair and replacement programs watershed-wide.

The above entities will provide technical resources and/or financial assistance for Management Measure 3. Funding for this management measure is not limited to the above entities. Below are more entities that can potentially provide funding to identify, repair, and replace OSSFs.

- Clean Water Act Section 319(h) Nonpoint Source Grant Program - USEPA provides funding to the state of Texas to implement NPS pollution projects. TCEQ and TSSWCB administer the grants. TSSWCB administers grants to address agriculture and silvicultural NPS pollution. TCEQ administers grants to address urban and other areas.
- Rural Development Water and Environmental Programs – USDA provides grants to low income residents and communities for potable and wastewater system construction.
  - Rural Repair and Rehabilitation Loans and Grants provide assistance to make repairs to low income homeowners' housing to improve or remove health and safety hazards.
  - Technical Assistance and Training Grants for Rural Waste Systems provide grants to non-profit organizations that offer technical assistance and training for water delivery and waste disposal.
  - Water and Waste Disposal Direct Loans and Grants assist in developing water and waste disposal systems in rural communities with populations of less than 10,000 individuals.

- Supplemental Environmental Projects - SEP is administered by TCEQ, which is responsible for directing fines, fees, and penalties for environmental violations to reduce pollution. Entities undergoing an enforcement action can choose to pay into SEP instead of the Texas General Revenue Fund. SEP funds many environmental projects, including OSSF repair.

Estimated Load Reductions

The total estimated load reduction for this management measure is 1.05×10^{15} cfu if 150 OSSFs are repaired or replaced. For OSSFs in very limited soils, the load reduction is expected to be 8.07×10^{12} cfu/system/year. The load reduction in OSSFs replaced or repaired in somewhat limited soils is expected to be 4.84×10^{12} cfu/system/year.

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

Years 1-10:

- The watershed coordinator, counties, Post Oak RC&D and stakeholders will coordinate to secure funding and resources to develop an OSSF repair or replacement initiative.

Years 1-2:

- Local homeowners, in coordination with appropriate counties, will repair or replace 15 failing OSSFs. The watershed coordinator will coordinate with local stakeholders, AgriLife Extension, and counties to leverage funding to provide cost-share assistance where needed.
- The watershed coordinator and AgriLife Extension will deliver one OSSF Operations and Maintenance Program.

Years 3-5:

- Local homeowners, in coordination with appropriate counties, will repair or replace 35 failing OSSFs. The watershed coordinator will coordinate with local stakeholders, AgriLife Extension, and counties to leverage funding to provide cost-share assistance where needed.
- The watershed coordinator and AgriLife Extension will deliver two OSSF Operations and Maintenance Programs.

Years 6-10:

- Local homeowners, in coordination with appropriate counties, will repair or replace 100 failing OSSFs. The watershed coordinator will coordinate with

local stakeholders, AgriLife Extension, and counties to leverage funding to provide cost-share assistance where needed.

- The watershed coordinator and AgriLife Extension will deliver two OSSF Operations and Maintenance Programs.

Table 17. Management Measure 3: Identify, inspect, and repair or replace failing OSSFs and provide education and outreach to OSSF landowners

Causes and Sources: Pollutant loading from failing OSSFs.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entities
1.05×10^{15} cfu	Technical: – Resources/staff to identify and prioritize repair and replacement of failing OSSFs Financial: – Administer OSSF repair/replace program at $10,000/year – Identify/inspect OSSFs in priority areas at $750/inspection – Repair/replace OSSF at $7,500/system – Home/land owner education at $3,500/program; – Designers/installers/ providers education at $3,500/program	Deliver education and outreach material to inform homeowners and landowners in years 1, 3, 5, 7, and 10 Deliver education and outreach material to inform installers and maintenance providers in years 1, 3, 5, 7, and 10	Years 1-2: – Repair/replacement 15 failing OSSFs; deliver one education program Years 3-5: – Repair/replacement 35 failing OSSFs; deliver two education programs Years 6-10: – Repair/replacement 100 failing OSSFs; deliver two education programs Years 1-10: – Secure funding and resources to develop an OSSF repair or replacement initiative	Number of workshops held Number of landowners attending the workshops Number of OSSFs repaired or replaced	Funding leveraged for OSSF replacement and repair Number of education and outreach programs Number of attendees at the workshops Number of failing OSSFs repaired or replaced	Watershed coordinator will track funding applied for and received for OSSF repair or replacement through a repair/replacement program. The Watershed coordinator will track education outreach programs delivered in the watershed Special BMP effectiveness monitoring as funding allows	Watershed coordinator AgriLife Extension Local stakeholders Brazos County Health Department Watershed Counties Post Oak RC&D

Management Measure 4

Promote proper pet waste management.

The purpose of this management measure is to reduce bacteria loadings associated with pets through proper pet waste management. Load analysis identified pets as the second largest potential *E. coli* source in the watershed. If not managed properly, pet waste and the *E. coli* it contains can be transported to water bodies during rainfall or irrigation events that produce runoff. Since dogs and humans are closely linked, managing this potential *E. coli* source is easier compared to other sources. Proper disposal of pet waste into a trash can is a simple and effective way of reducing *E. coli* loads in the watershed.

Management Measure 4 includes installing pet waste stations in parks and other public areas to facilitate increased collection and proper disposal of dog waste and providing educational resources to homeowners through their utility bills and other relevant avenues. However, the probability of widespread adoption is low, especially in rural areas where the human and dog population is more diffuse. The bulk of the pet population in the watershed is located in Brazos County (subwatersheds 10 and 12); however, these measures are applicable watershed-wide.

Responsible Parties and Funding

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

- Watershed coordinator - TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with entities to develop and secure funding resources. The watershed coordinator will work with other entities and organizations to organize, develop, and/or deliver education and outreach components of Management Measure 4.
- Texas A&M AgriLife Extension Service - AgriLife Extension will work with the watershed coordinator in the continued development and delivery of education and outreach programs related to this management measure.
- Local public works/park departments and Home Owners Associations - Local public works/park departments and HOAs will work to maintain existing pet waste stations across the watershed and distribute education and outreach materials as appropriate.
- Developers - Developers will install pet waste stations in outdoor common areas or parks in newly developed areas.

The entities mentioned above in this section provide technical resources or financial assistance for Management Measure 4. The list below shows potential funding sources for the management measure. The potential funding sources are not limited to those listed below.

- Clean Water Act Section 319(h) Nonpoint Source Grant Program - USEPA provides funding to the state of Texas to implement NPS pollution projects. TCEQ and TSSWCB administer the grants. TSSWCB administers grants related to agriculture and silvicultural NPS pollution. TCEQ administers grants related to urban and other areas.

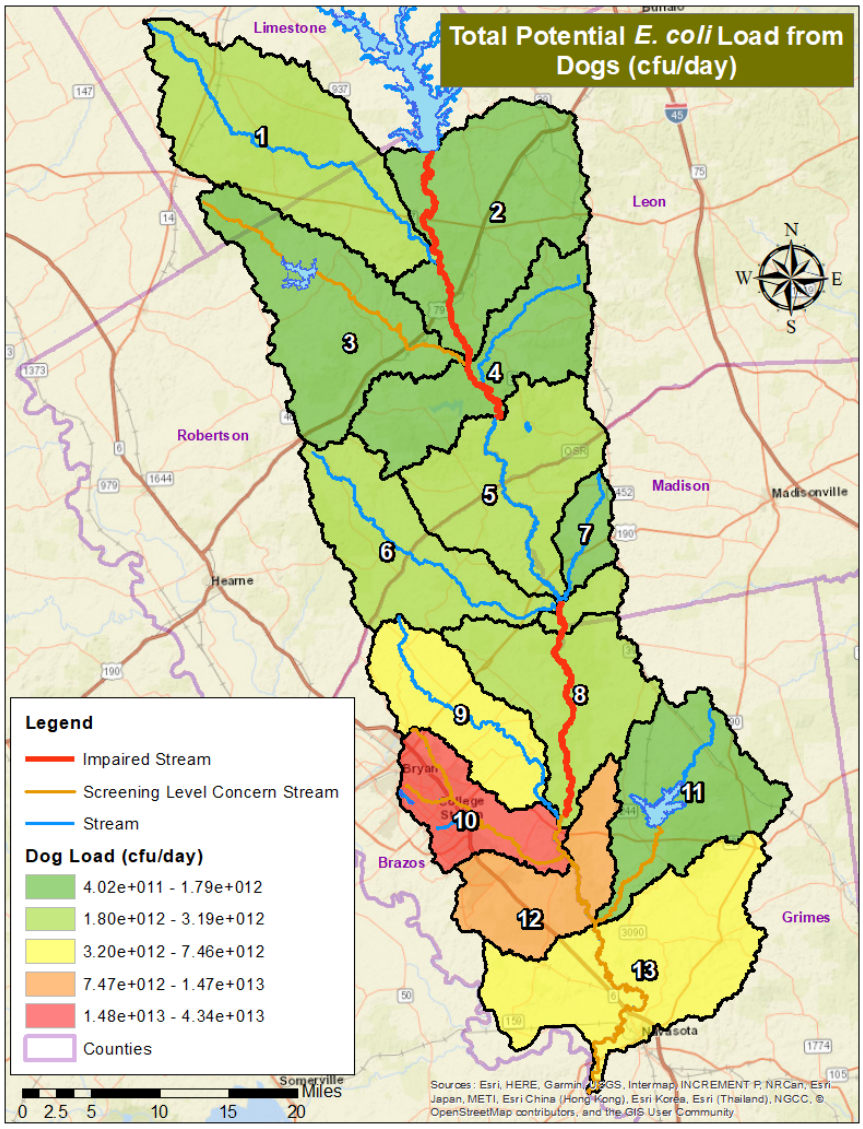

Figure 7. Spatial distribution of potential *E. coli* daily loading from dogs

Estimated Load Reductions

The estimated load reduction for this management measure is 4.84×10^{15} cfu/year. This calculation assumes that 20 percent of households with dogs will appropriately dispose of pet waste and that only 75 percent of *E. coli* in dog waste is removed during disposal.

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

Years 1-10:

- The watershed coordinator will coordinate with local public works and/or park departments and AgriLife Extension to develop educational material for residents within the watershed.
- Entities with existing pet waste stations will maintain and stock stations with needed disposal supplies.
- As new development progresses, install pet waste stations in parks/public areas.
- Distribute educational resources about pet waste management via utility bills and other outlets (e.g. Earth Day event, social media, etc.).

Table 18. Management Measure 4: Promote proper pet waste management

Causes and Sources: Direct and indirect *E. coli* loading from improperly disposed 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
4.84×10^{15}cfu/year	Technical: Entities with pet waste stations will maintain them. As development occurs, new pet waste stations will be installed in public areas Financial: Annual pet waste station operation costs estimated at $85 each; or $85,000 over 10 years; estimated at 100 stations	The watershed coordinator, AgriLife Extension, and local entities will deliver educational materials to pet owners via existing avenues (utility inserts, local events and programs, etc.)	Years 1 - 10: – Develop and deliver educational materials to the public – Maintain existing pet waste stations – Install new pet waste stations as development ensues	Number of pet waste stations created Number of educational materials developed and delivered Station maintenance completed	Annual maintenance ongoing Number of pet stations installed Number of education and outreach materials delivered	The watershed coordinator will track funding resources applied for and received The watershed coordinator will track number of pet stations installed The watershed coordinator will track number of education and outreach materials delivered Special BMP effectiveness monitoring as funding allows	Watershed coordinator AgriLife Extension Local public works and/or public parks departments HOAs Developers

Management Measure 5

Address inflow and infiltration (I&I)

The purpose of this management measure is to work with WWTFs in the watershed to continue and expand system inspections to identify I&I problem areas. I&I is surface runoff that enters the sewer collection system through manhole covers, sewer cleanouts, damaged pipes, and faulty connections. As runoff enters the sewer collection system, there is increased potential for collection system and WWTF overload. This can result in unauthorized discharge of raw sewage or have a dilution effect that decreases treatment efficiency.

Cities with WWTFs in the watershed already use a combination of inspection techniques to aid them in prioritizing collection system repairs and replacements. Aging infrastructure is being replaced or repaired in the watershed as funding resources are available. I&I also occurs as a result of failures in the collection system on private property. As a result, periodic information dissemination to the public is recommended to promote repairs on personal property and inform property owners of proper operation and maintenance of their sewerage systems.

Only WWTFs in subwatersheds 1 and 2 (Figure 8) impact impaired portions of the Navasota River and are the priority for this management measure; however, WWTFs within the entire watershed will work to address the AU of concern in subwatersheds 10, 12, and 13 and prevent impairment in other subwatersheds.

Responsible Parties and Funding

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

- Watershed coordinator - TWRI will serve as the watershed coordinator for this watershed. The watershed coordinator will work with entities to develop and secure funding resources. The watershed coordinator will work with other entities and organizations to organize, develop, and/or deliver education and outreach components of Management Measure 5.
- Private Property Owners - Private property owners are responsible for maintenance and repair of the sewage drain pipes on their property.
- WWTF Operating Entities - WWTF operating entities are responsible for testing the infrastructure, prioritizing, and completing needed repairs.

The entities mentioned above in this section provide technical resources or financial assistance for this management measure. The list following shows potential funding sources for Management Measure 5. Potential funding sources are not limited to those listed.

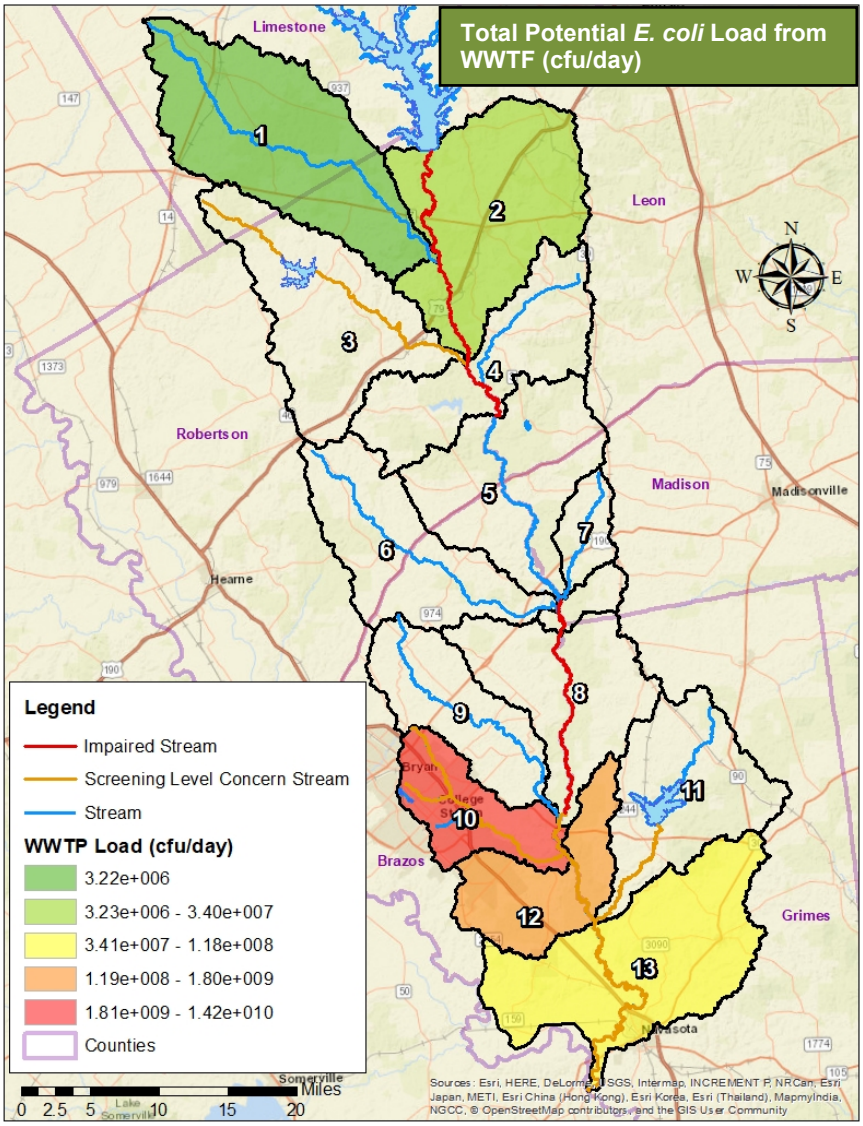

Figure 8. Spatial distribution of potential *E. coli* daily loading from WWTFs

- Clean Water Act Section 319(h) Nonpoint Source Grant Program - USEPA provides funding to the state of Texas to implement NPS pollution projects. TCEQ and TSSWCB administer the grants. TSSWCB administers grants to address agriculture and silvicultural NPS pollution. TCEQ administers grants to address urban and other areas.
- Clean Water State Revolving Fund - This loan program, administered by the Texas Water Development Board (TWDB), provides low-interest loans to local governments and service providers for infrastructure projects that include stormwater BMPs, WWTFs, and collection systems. The loans can spread project costs over a repayment period of up to 20 years. Repayments are cycled back into the fund and used to pay for additional projects.

Estimated Load Reductions

Reduction of SSOs and discharges associated with I&I will result in direct reductions in bacteria loads. However, because the response to education efforts and the development of resources to repair sewage lines is uncertain, load reductions were not calculated. Instead, the number of repairs made to the system and the reduced number of WWTF overloads will indicate progress in reducing pollutant loading.

Measurable Milestones

Contingent upon funding availability, the measurable milestones are as follows.

Years 1-10:

- WWTFs will perform conveyance testing to identify infrastructure failures in need of repairs or replacement and prioritize replacements as funds allow.
- The watershed coordinator will coordinate with local municipalities to deliver educational material as appropriate to inform homeowners about I&I issues and the effect of malfunctions on their utility bills.
- Local homeowners will make conveyance system repairs on their properties as necessary to ensure proper system function and reduce I&I occurrences.

Table 19. Management Measure 5: Address inflow and infiltration (I&I)

Causes and Sources: Fecal bacteria loading from unauthorized discharges and SSOs caused by excess water overloading the sewer systems.

Potential Load Reduction	Technical and Financial Assistance Needed	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Entity
Loads reductions are not estimated for this management measure Reducing I&I in the systems will reduce the number of SSOs and unauthorized discharges. The actual number of repairs and replacements is unknown	Technical: Little to moderate assistance will be needed, as WWTFs have the ability or can hire contractors to conduct smoke testing. Depending on the issue, infrastructure repair or replacement may require contractors Financial: Repair or replacement of infrastructure may be costly: ~$2,000 for equipment to identify failing infrastructure. Costs are estimated to be around $100-$150/foot to repair or replace but can vary greatly depending on system specifics	The watershed coordinator will coordinate with local municipalities to develop and deliver educational materials for homeowners and utility customers	Years 1-10: – Organize, develop, and/or deliver educational materials to utility users – Continue smoke testing to identify failures in the conveyance infrastructure and prioritize repairs and replacements – Repair and replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired Quantity of conveyance system inspections/tests completed Number of utility users reached with education and outreach programs	Number of lines with I&I identified Number of failed lines repaired or replaced Number of education and outreach materials delivered	The watershed coordinator will leverage and track funding resources applied for and received The watershed coordinator will work with WWTFs to track smoke testing and number of lines repaired or replaced The watershed coordinator will track education and outreach resource delivery	Watershed coordinator Local municipalities Private property owners

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-Plan. Stakeholders evaluate several factors, such as the pace of implementation, BMP effectiveness, load reductions, and progress toward meeting water quality standards. The TCEQ and stakeholders 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 effect an improvement in water quality.

Water Quality Indicators

The Brazos River Authority, through the Clean Rivers Program, will monitor water quality status during implementation as funding allows. Additional funding will be sought to conduct supplemental monitoring in the watershed. The indicator bacteria that will be used to measure improvement in water quality are *E. coli*.

Implementation Milestones

Implementation tracking provides information that can be used to determine if progress is being made toward meeting TMDL goals. Tracking also allows stakeholders to evaluate actions taken, identify those which may not be working, and make necessary changes to improve implementation effectiveness.

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 ten-year implementation 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

AVMA. 2012. U.S. Pet Ownership Calculator. [Internet]. American Veterinary Medical Association; [2015 Oct 20]. Available from: <https://www.avma.org/KB/Resources/Statistics/Pages/US-pet-ownership-calculator.aspx>.

Gregory, L.F., Blumenthal, B., Wagner, K.L., Borel, K.E., & Karthikeyan, R. 2013. Estimating on-site sewage facility density and distribution using geo-spatial analyses. Journal of Natural and Environmental Science 4(1):14-21.

Larkin, T. J., & Bomar, G. W. 1983. *Climatic Atlas of Texas.* Retrieved May 23, 2013, from Texas Water Development Board. Available from: <http://www.twdb.texas.gov/publications/reports/limited_printing/doc/LP192.pdf >.

NEIWPCC. 2003. Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities. [Internet]; [cited 2016 Sept 16]. Available from: <http://www.neiwpcc.org/neiwpcc_docs/iddmanual.pdf>.

NLCD. 2011. Multi-resolution land characteristics consortium: national land cover database 2011. [Internet]. USGS; [cited 2014 Nov 17]. Available from: <http://www.mrlc.gov/nlcd2011.php>.

NRCS. 2015. Web soil survey: soil data explorer: suitabilities and limitations for use. [Internet]; [cited 2015 Sept 9]. Available at: <http://websoilsurvey.sc.egov.usda. gov/>.

Reed, Stowe, and Yanke, LLC. 2001. Study to determine the magnitude of, and reasons for, chronically malfunctioning on-site sewage facility systems in Texas. Available from: <https://www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/StudyToDetermine.pdf>.

Rattan, J.M., Higginbotham, B.J., Long, D.B., & Campbell, T.A. 2010. Exclusion fencing for feral hogs at White-tailed deer feeders. Texas Journal of Agriculture and Natural Resource. 23:83-89.

TCEQ. 2012a. Three total maximum daily loads for indicator bacteria in the Carters Creek Watershed. Available from: <https://www.tceq.texas.gov/assets/public/waterquality/tmdl/85carters/85-CartersCreekTMDL-Adopted.pdf>.

TCEQ. 2012b. Implementation plan for three total maximum daily loads for indicator bacteria in the Carters Creek Watershed. Available from: <https://www.tceq.texas.gov/assets/public/waterquality/tmdl/85carters/85A-Car-tersCreekIPlan-Approved.pdf>.

TCEQ. 2014. SWQMIS. [Internet]. Texas Commission on Environmental Quality; [cited 2014 Sept 12]. Available from: <https://www80.tceq.texas.gov/SwqmisPublic/public/default.htm>.

TCEQ. 2015a. Municipal & industrial wastewater outfalls. [Internet GIS layer]. Texas Commission on Environmental Quality; [Retrieved 2015 Oct 21]. Available from: <https://www.tceq.texas.gov/gis/download-tceq-gis-data>.

TCEQ. 2015b. 2014 Guidance for assessing and reporting surface water quality in Texas. [Internet]. Texas Commission on Environmental Quality; [cited 2015 June 17]. Retrieved from: <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_guidance.pdf>.

TCEQ. 2015d. 2014 Texas integrated report - Texas 303(d) list (category 5). [Internet]. Texas Commission on Environmental Quality; [cited 2016 July 28]. Available from: <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_303d.pdf>.

TCEQ. 2015e. 2014 Texas Integrated Report, index of water quality impairments. [Internet]. Texas Commission on Environmental Quality; [cited 2016 July 28]. Available from: <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_imp_index.pdf>.

TSSWCB. 2015a. Water quality management plan data. [cited 2015 Apr 4]. Obtained from TSSWCB via personal communication.

TSSWCB. 2015b. Water quality management plan program. [Internet]. Texas State Soil and Water Conservation Board; [cited 2015 Oct 27]. Available from: <https://www.tsswcb.texas.gov/en/wqmp>.

TSSWCB. 2010. Reference guide for a water quality management program to address agricultural and silvicultural nonpoint source pollution. [Internet]. Texas State Soil and Water Conservation Board; [cited 2015 Oct 28]. Available from: <https://www.tsswcb.texas.gov/sites/default/files/files/programs/agency-reports/WQMP%20Program%20Reference%20Guide.pdf >.

TWDB. 2014. 2016 Regional water plan: population & water demand projections. [Internet]. Texas Water Database; [cited 2014 Nov 19]. Available from: <https://www.twdb.texas.gov/waterplanning/data/projections/>.

TWDB. 2016a. Lake Limestone (Brazos River Basin). [Internet]. Texas Water Development Board; [cited 2016 June 15]. Available from: <http://www.twdb.texas.gov/surfacewater/rivers/reservoirs/limestone/index.asp>.

U.S. Census Bureau. 2010. 2010 TIGER/line shapefiles. Retrieved December 10, 2014, from TIGER/Line® Shapefiles and TIGER/Line® Files. Available from: <http://www.census.gov/geo/maps-data/data/tiger-line.html>.

U.S. Census Bureau. 2010. Data generated by Katelyn Lazar; using American FactFinder. [Internet]. U.S. Department of Commerce; [cited 2015 Oct 20]. Available from: <http://factfinder2.census.gov>.

USDA. 2012. 2012 Census Volume 1, Chapter 2: County Level Data. [Internet]. United States Department of Agriculture; [cited 2015 Oct 21]. Available from: <http:// www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/>.

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

USEPA. 1991. Guidance for water quality based decisions: the TMDL process. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water; EPA 440/4- 91-001.

USEPA. 2001. Protocol for developing pathogen TMDLs. [Internet]. 1st ed. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water; EPA 841-R- 00-002. Available from: <https://nepis.epa.gov/Exe/ZyPDF.cgi/20004QSZ.PDF?Dockey=20004QSZ.PDF>.

USEPA. 2003. Onsite wastewater treatment systems manual. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water. EPA 625/R-00/008.

USEPA. 2008. Handbook for developing watershed plans to restore and protect our waters. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water. EPA 841-B-08-002.

USEPA. 2010. Implementing best management practices improves water quality. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water. EPA 841-F-10-001F.

USEPA. 2012. Recreational water quality criteria. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water. EPA 820-F-12-058.

USEPA. 2015. Enforcement and compliance history online. [Internet]. United States Environmental Protection Agency; [cited 2015 Oct 20]. Available from: <http://echo.epa.gov>.

USGS. 2014. National land cover database 2011 (NLCD2011). Retrieved March 30, 2015, from Multi-resolution Land Characteristics Consortium (MRLC).

Available from:
<https://gdg.sc.egov.usda.gov/GDGOrder.aspx?order=QuickState>.

Weikel, P., Howes, B., & Heufelder, G. 1996. Coliform contamination of coastal embayment: sources and transport pathways. Environmental Science and Technology, 30, 1872-188.

30 TAC Section 307.7. 2014. Texas Administrative Code on environmental quality of Texas surface water quality standards: site-specific uses and criteria. [Internet]. Texas State Legislature; [cited 2015 Jun 22]. Available from:
<https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=307&rl=7>.

30 TAC Section 307.9. 2014. Texas Administrative Code on environmental quality of Texas surface water quality standards: determination of standards attainment. [Internet] Texas State Legislature; [cited 2015 Jun 22]. Available from:
<https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=307&rl=9>.

33 USC Section 1251 et seq. 2002. Clean Water Act of 1972. [Internet]. United States Senate; [cited 2015 Jan 22]. Retrieved from:
<http://www.epw.senate.gov/water.pdf>.

40 CFR Section 130.7. 2013. Code of Federal Regulations. [Internet]. United States Congress; [cited 2015 Jan 22]. Retrieved from:
<http://www.gpo.gov/fdsys/pkg/CFR-2013- title40-vol23/pdf/CFR-2013-title40-vol23-sec130-7.pdf>.

Appendix A.
I-Plan Matrix

Table A-1. Promote feral hog management through technical and operational assistance to landowners — Implementation Schedule and Tasks

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
1	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
	Watershed coordinator AgriLife Extension	Deliver feral hog educational management workshop	Number of people attending workshop
2	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
3	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
4	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
	Watershed coordinator AgriLife Extension	Deliver feral hog educational management workshop	Number of people attending workshop
5	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
6	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
7	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
8	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
	Watershed coordinator AgriLife Extension	Deliver feral hog educational management workshop	Number of people attending workshop
9	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed
10	Local stakeholders	Install deer feeder excluders Trap, hunt, and/or remove feral hogs from the watershed	Number of excluders built Number of hogs trapped, killed, or removed

Table A-2. Develop property-specific conservation plans and Water Quality Management Plans— Implementation Schedule and Tasks

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
1	TSSWCB SWCDs NRCS Local stakeholders Watershed coordinator	Secure funding for regional or watershed field technician conservation plans and WQMPs	One technician hired
	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
2	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
3	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	Watershed coordinator AgriLife Extension	Deliver education program	Deliver 1 Lone Star Health Streams
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
4	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
5	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
6	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
7	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
8	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	Watershed coordinator AgriLife Extension	Deliver education program	Deliver 1 Lone Star Health Streams

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
8, cont.	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
9	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually
10	TSSWCB SWCDs NRCS Local stakeholders	Develop and implement WQMPs and conservation plans	13 WQMPs and conservation plans developed and implemented
	AgriLife Extension	Deliver annual agricultural management practice field day	Field day hosted annually

Table A-3. Identify, inspect, and repair or replace failing OSSFs and provide education and outreach to OSSF landowners — Implementation Schedule and Tasks

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
1	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 7 failing OSSFs
	Watershed coordinator AgriLife Extension	Deliver education program to installers and maintenance providers	Number of attendees at the workshop Number of workshops held
2	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 8 additional failing OSSFs
3	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 10 additional failing OSSFs
	Watershed coordinator AgriLife Extension	Deliver education program to homeowners and landowners	Number of attendees at the workshop Number of workshops held

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
4	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 10 additional failing OSSFs
5	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 15 additional failing OSSFs
	Watershed coordinator AgriLife Extension	Deliver education program to homeowners and landowners	Number of attendees at the workshop Number of workshops held
6	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 20 additional failing OSSFs
7	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 20 additional failing OSSFs

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
7, cont.	Watershed coordinator AgriLife Extension	Deliver education program to installers and maintenance providers	Number of attendees at the workshop Number of workshops held
8	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 20 additional failing OSSFs
9	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 20 additional failing OSSFs
10	Watershed coordinator Counties Local stakeholders Post Oak RC&D	Leverage funding to develop and repair and replacement program	Programs and funding leveraged
	Counties Local stakeholders	Identify, inspect, repair or replace failing OSSFs	Repair/Replace 20 additional failing OSSFs
	Watershed coordinator AgriLife Extension	Deliver education program to homeowners and landowners	Number of attendees at the workshop Number of workshops held

Table A-4. Promote proper pet waste management — Implementation Schedule and Tasks

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
1	Watershed coordinator /AgriLife Extension Local public works and/or parks dept.	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations
2	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations
3	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
4	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations
5	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations
6	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
7	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations
8	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations
9	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks dept., HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
10	Watershed coordinator /AgriLife Extension Local public works and/or parks departments	Develop and deliver educational materials to residents and pet owners across the watershed	Number of educational materials created and delivered
	Local public works/parks departments, HOAs	Maintain pet waste stations across the watershed	Number of pet waste stations maintained
	Developers	Install pet waste stations during development	Number of new pet waste stations

Table A-5. Address inflow and infiltration (I&I) — Implementation Schedule and Tasks

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
1	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
2	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
3	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
4	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
4, cont.	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
5	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
6	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
7	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
8	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered

Plan Year	Responsible Parties	Implementation Tasks	Implementation Milestones
8, cont.	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
9	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed
10	Watershed coordinator Local municipalities	Develop and distribute educational material to homeowners regarding inflow and infiltration	Funding leveraged Number of materials delivered
	Local municipalities	Perform conveyance testing to identify infrastructure failures	Quantity of lines tested
	Local municipalities	Repair or replace WWTF conveyance infrastructure as funds allow	Quantity of lines repaired/replaced
	Private property owners	Maintain and repair wastewater conveyance on private property	As needed

Appendix B.
Load Reduction Estimates

Load Reduction Estimates

Expected *E. coli* load reductions from recommended BMPs included in the I-Plan are based on best available information regarding practice effectiveness reported in literature, the anticipated number of treatments to be implemented, and the presumed *E. coli* loading from the managed species. Median practice efficiency values were used in loading reduction calculations developed to reflect expected per-unit loading reductions. This approach allows quick assessment of expected loading reductions at various levels of implementation.

Management Measure 1: Promote feral hog management through technical and operational assistance to landowners

The feral hog population in the watershed is estimated to be 36,827 animals as determined by watershed stakeholders. This estimate is based on the assumption that feral hogs primarily inhabit wetland and forested areas at a presumed density of eight ac/hog and 13 ac/hog respectively. Stakeholders acknowledge that hogs use almost the entire watershed, but that their primary habitat is in these more secluded areas.

The estimated loading reduction expected from feral hog management was calculated by combining the daily fecal loading rate per hog, estimated number of hogs removed, and number of days annually that the practice will be implemented. Feral hogs also have an affinity for dense riparian cover, thus a 25 percent riparian stream impact factor is also incorporated. The goal established is to remove 15 percent of the total feral hog population annually. By removing the hogs from the watershed completely, the potential *E. coli* load from feral hogs is assumed to decrease by 15 percent as well.

Load reductions for feral hogs were calculated based on the following:

$$LR_{fh} = N_{fh} \times FC_{fh} \times \text{Conversion} \times \text{Proximity Factor} \times 365 \text{ days/year}$$

Where:

LR_{fh} = Potential *E. coli* load reduction from feral hog removal

N_{fh} = Number of feral hogs removed

FC_{fh} = 1.1×10^{10}; fecal coliform production in cfu/day/feral hog (USEPA, 2001)

Conversion = 0.63; fecal coliform to *E. coli* conversion factor (Wagner & Moench, 2009)

Proximity Factor = a percentage-based impact factor that accounts for an assumed stream impact factor to be applied based on feral hog affinity for riparian habitats = 25%

The estimate for feral hog loading reduction across the Navasota River below Lake Limestone watershed is determined by reducing the feral hog population by 3.49×10^{15} cfu/*E. coli* annually.

Management Measure 2: Develop property-specific conservation plans and Water Quality Management Plans

Estimating *E. coli* loading reductions from livestock involves multiple management recommendations and a variety of animal species. However, cattle are by far the dominant livestock animal present in the watershed and make up approximately 93 percent of the total livestock population. Therefore, cattle were presumed to be the species managed through livestock focused management. Using county level data, average farm/ranch size is estimated at 280 acres each. Using this information, livestock population data, and the area of the watershed suitable for livestock grazing, approximately 51 animal units are estimated to be housed on each farm/ranch. For evaluation purposes, it is presumed that each WQMP developed will cover 280 acres, which houses 51 animal units. In reality, each WQMP will vary in size and animal numbers.

Efficiency values for applicable BMPs are used to estimate the amount of *E. coli* reduction expected from implementing each practice. Reported literature values for the three BMPs most likely to be used were aggregated, and median values were identified and utilized in this assessment (Table B-1).

Table B-1. Livestock BMP bacteria median removal efficiencies

Management Practice	*E. coli* Removal Efficiency		
	Low	High	Median
Fencing[1]	37%	46%	42%
Prescribed Grazing[2]	66%	72%	69%
Watering Facility[3]	85%	85%	85%

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

[2] Tate et al. 2004, USEPA 2010

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

A generic equation consisting of the number of animal units, average daily cattle *E. coli* production, and the selected BMPs' median effectiveness values (Table B-1) was used to calculate potential load reductions for each of the three BMPs. This generic equation allows post implementation assessment to be easily performed after WQMPs have been developed, the practices implemented are known, and number of animal units planned are known.

Total potential load reductions from WQMPs and conservation plans were calculated with the following equation:

$$LR_{cattle} = N_{WQMP} \times N_{Cattle/WQMP} \times EC_{cattle} \times \text{Effectiveness Rate} \times \text{Proximity Factor} \times \text{days}$$

Where:

LR_{cattle} = Load reduction in *E. coli* from cattle

N_{WQMP} = Number of water quality management plans

$N_{cattle/WMQP}$ = Number of cattle per water quality management plan

EC_{cattle} = 5.39×10^9 cfu/day; *E. coli* production from cattle (Wagner & Moench, 2009)

Effectiveness Rate = median effectiveness rate from Table B-1

Proximity Factory = a percentage-based impact factor that accounts for an assumed stream impact factor to be applied based on the location of the BMP (riparian areas = 25% and upland areas = 5%)

Days = 365 days/year

Specific load reduction estimates will depend on the number of participating ranchers, specific practices implemented, property location, and the number of cattle managed by a specific BMP. Properties with riparian access are the primary implementation focus, regardless of subwatershed. Upland areas in subwatersheds 1, 2, 3, 5, 6, 8, 11, and 13 will also receive WQMP implementation focus. Combined, the goal is for 130 conservation plans and WQMPs to be developed watershed-wide with 50 being focused near riparian areas and 80 in upland areas. It is assumed each WQMP will include prescribed grazing and fencing. Watering facilities are only presumed for riparian access pastures. Annual load reduction calculations also assume a number of days per year that the practice will be used by the management target.

Table B-2 shows the annual load reduction estimate for each BMP used and the variable used. The total load reduction estimate for Management Measure 2 is 1.83×10^{15} cfu/year.

Table B-2. Annual load reduction estimates for each best management practice

Management Practice	Number of WQMPs	Number of Cattle/WQMP	Efficiency Rate	Days of the Years	Load Reduction Estimate per Year (cfu):
Riparian Pasture Prescribed Grazing	50	51	.69	73	3.12×10^{14}
Upland Pasture Prescribed Grazing	80	51	.69	292	2.77×10^{14}
Watering Facility	50	51	.85	73	2.13×10^{14}
Riparian Area Cross Fencing	50	51	.42	73	1.90×10^{14}
Upland Area Cross Fencing	80	51	.42	292	8.43×10^{14}
Total WQMP Loading Reduction Estimate					**1.83×10^{15}**

Management Measure 3: Identify, inspect, and repair or replace failing OSSFs and provide education and outreach to OSSF landowners

OSSFs are common in the Navasota River below Lake Limestone watershed, with 17,149 estimated to be in use. Presumed failure rates range from 5 to 20 percent depending on the county. System age, lack of maintenance, and soil suitability are the primary factors leading to failures. This information yields an estimate of 1,749 failing OSSFs across the watershed. To estimate expected loading reductions, the influence of a failing OSSF was evaluated based on the suitability of soils for receiving effluent. NRCS defines soil suitability for OSSF drain fields as not limited, somewhat limited, and very limited. These ratings relate to the ability of the soil to absorb effluent which is based on soil texture, infiltration capacity, slope, and other factors. A reasonable goal of repairing or replacing 150 failing OSSFs was established in this I-Plan. The equation used to calculate load reduction from OSSF repair and replacement is as follows:

$$LR_{OSSF} = N_{OSSF} \times FC_S \times Conversion_{FC} \times Production \times Conversion_{mL} \times N_{hh} \times SSF$$

Where:

LR_{OSSF} = Potential annual load reduction of *E. coli* attributed to OSSF repair/replacement

N_{OSSF} = Number of OSSFs repaired/replaced

$FC_S = 1\times10^{7}$ cfu/100mL; fecal coliform concentration in OSSF effluent (Horsley and Witten, 1996)

$Conversion_{FC}$ = 0.63; fecal coliform to *E. coli* conversion factor (Wagner & Moench, 2009)

Production = 70 gallons per person per day effluent production (Horsley and Witten, 1996)

$Conversion_{mL}$ = 3785.2 mL/gallon; number of milliliters in a gallon

N_{hh} = 2.65 persons per household average in watershed (U.S. Census Bureau, 2010)

SSF = Soil Suitability Factor; a percentage based impact factor that accounts for an assumed stream impact factor applied based on soil type (very limited soils = 50%; somewhat limited soils = 30%; not limited = 10%)

The annual OSSF load reduction for very limited soils load reduction is 8.07×10^{12} cfu per OSSF replaced (100 systems addressed). The annual load reduction for somewhat limited soils is 4.84×10^{12} cfu per system per year (50 systems addressed). The total OSSF loading reduction is 1.05×10^{15} cfu for all 150 repairments or replacements.

Management Measure 4: Promote proper pet waste management

E. coli loading from dogs is based on the assumption that not all dog waste is currently disposed of properly. The watershed is estimated to contain 35,341 dogs and improved waste management is recommended for 20 percent of this total. Collecting and disposing of their waste in the trash will remove the majority of *E. coli* present in fecal matter from the watershed and prevent it from washing into area streams during runoff events. It is assumed that 75 percent of the waste can be removed by collection and proper disposal. The equation used to calculate load reductions from proper pet waste management is shown below:

$$LR_d = N_d \times EF \times Production_d \times \text{days per year}$$

Where:

N_d = Number of dogs managed

EF = 0.75; presumed practice efficiency

Days per year = 365 days/year

$Production_d = 2.5\times10^{9}$ cfu *E. coli*/dog/day (Teague et al., 2009)

The annual load reduction from proper pet waste management is 4.84×10^{15} cfu/year.

Appendix B References

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, pp. 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.

Hagedorn, C., Robinson, S.L., Filtz, 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.

Horsley and Witten, Inc. 1996. Identification and evaluation of nutrient and bacterial loadings to Maquoit Bay, New Brunswick and Freeport, Maine. Barnstable, Ma: Horsley and Witten, Inc. Environmental Services. Final Report. Submitted to Casco Bay Estuary Project, Port- land, ME.

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. Raleigh (North Carolina): NCSU Water Quality Group, Biological and Agricultural Engineering Department, NC State University.

Meals, D.W. 2001. Water quality response to riparian restoration in an agricultural watershed in Vermont, USA. Water Science and Technology. 43:175-182.

Meals, D.W. 2004. Water quality improvements following riparian restoration in two Vermont agricultural watersheds. In: Manley TO, Manley PL, Mihuc TB, editors. 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. College Station (Texas): Texas A&M AgriLife Extension Service. ESP-406.

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.

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.

Teague, A., Karthikeyan, R., Babbar-Sebens, M., Srinivasan, R., & Persyn, R.A. 2009. Spatially explicit load enrichment calculation tool to identify potential *E. coli* sources in watersheds. Transactions of the ASABE 52(4): 1109-1120.

U.S. Census Bureau. 2010. Data generated by Katelyn Lazar; using American FactFinder. [Internet]. U.S. Department of Commerce; [Retrieved 2015 Oct 20]. Available from: <http://factfinder2.census.gov>.

USEPA. 2001. Protocol for developing pathogen TMDLs. 1st ed. Washington, D.C.: U.S. Environmental Protection Agency: Office of Water; EPA 841-R-00-002.

USEPA. 2010. Implementing best management practices improves water quality. Washington (D.C.): U.S. Environmental Protection Agency: Office of Water. EPA 841-F-10-001F.

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. Available online at <https://www.tsswcb.texas.gov/sites/default/files/files/programs/nonpoint-source-managment/Completed%20Projects/06-08-Final_Report.pdf>

Weikel, P., Howes, B., & Heufelder, G. 1996. Coliform contamination of coastal embayment: sources and transport pathways. *Environmental Science and Technology, 30*, 1872-1881.