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Two Total Maximum Daily Loads for Indicator Bacteria in the Tidal Segments of the Mission and Aransas Rivers

Segments 2001 and 2003

Assessment Units 2001_01 and 2003_01

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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"Technical Support Document for Total Maximum Daily Loads
for Indicator Bacteria in the Watersheds of the Mission and Aransas Rivers"
prepared by the Texas Institute for Applied Environmental Research.

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Abbreviations and Acronyms

AU	assessment unit
BMP	best management practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
DMR	discharge monitoring report
DSLP	days since last precipitation
ECHO	Enforcement & Compliance History Online
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency (U.S.)
FDA	fractional proportion of drainage area
FDC	flow duration curve
FG	future growth
I/I	inflow and infiltration
I-Plan	implementation plan
LA	load allocation
LDC	load duration curve
MGD	million gallons per day
mL	milliliter
MOS	margin of safety
MPN	most probable number
MSGP	multi-sector general permit
MS4	municipal separate storm sewer system
NDEP	Nevada Division of Environmental Protection
NEIWPCC	New England Interstate Water Pollution Control Commission
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRA	Nueces River Authority
NPS	nonpoint source
ODEQ	Oregon Department of Environmental Quality
OSSF	onsite sewage facility
SNC	significant non-compliance
SSO	sanitary sewer overflow
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TNRIS	Texas Natural Resources Information System

TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
USCB	United States Census Bureau
USGS	United States Geological Survey
WLA	waste load allocation
WQBEL	water quality-based effluent limit
WQMP	Water Quality Management Plan
WSC	Water Supply Corporation
WWTF	wastewater treatment facility

Two TMDLs for Bacteria in the Tidal Segments of the Mission and Aransas Rivers

Executive Summary

This document describes total maximum daily loads (TMDLs) for the tidal segments of the Mission and Aransas Rivers where concentrations of indicator bacteria exceed the criteria used to evaluate attainment of the contact recreation use. The Texas Commission on Environmental Quality (TCEQ) first identified the bacteria impairments within the Mission River Tidal and Aransas River Tidal segments in 2004. The segments have been identified as impaired in each subsequent edition of the Texas Integrated Report of Surface Water Quality (formerly called the Texas Water Quality Inventory and 303(d) List) through 2014. The impaired segments and their identifying assessment units (AUs) are:

- Mission River Tidal 2001_01;
- Aransas River Tidal 2003_01;

The Mission and Aransas Rivers are located in the Texas coastal plain, southeast of the city of San Antonio. Both rivers flow into Copano Bay, which is located on the mid-Texas Gulf Coast between San Antonio Bay and Corpus Christi Bay. Segments 2001 and 2003 are the portions of the Mission and Aransas Rivers, respectively, that are influenced by tidal action and, in addition to freshwater flow from their respective watersheds, also receive regular inflows of saline water from Copano Bay.

Twelve facilities in the Mission and Aransas watersheds treat domestic wastewater; three are in the Mission River watershed and nine are within the more populated Aransas River watershed. None of the wastewater treatment facilities (WWTFs) in the watersheds discharge directly into either the impaired Mission River Tidal or Aransas River Tidal segments.

No municipal separate storm sewer system (MS4) permits are held in the watersheds of the Mission and Aransas Rivers. A review of active stormwater general permits coverage (TCEQ, 2008) in the Mission River watershed, as of March 26, 2013, found four active industrial multi-sector general permit (MSGP) facilities and three active construction sites. A review of active stormwater general permits coverage in the Aransas River watershed, as of March 26, 2013, found seven active industrial MSGP facilities, eight active construction sites, and one active concrete production facility. Regulated stormwater comprises only a very

small portion of the areas of the subject watersheds - 0.06% for Mission River watershed and 0.04% for Aransas River watershed.

The discharges authorized by the industrial MSGP and construction stormwater permits are considered intermittent and variable (subject to precipitation and runoff), and no flow limit is specified in the permit authorizations. Given the circumstances of the permits, these outfalls are treated as part of the regulated stormwater discharge in the waste load allocations (WLAs).

Escherichia coli (*E. coli*) are widely used as an indicator bacteria to assess attainment of the contact recreation use in freshwater bodies, while Enterococci are used as the indicator bacteria in salt waters. Enterococci are the relevant indicator for the Mission River Tidal and Aransas River Tidal. The criteria for assessing attainment of the contact recreation use are expressed as the number (or "counts") of Enterococci bacteria, typically given as the most probable number (MPN). The primary contact recreation use is not supported when the geometric mean of all Enterococci samples exceeds 35 MPN per 100 milliliters (mL).

Recent environmental monitoring within the Mission and Aransas Tidal segments has occurred at three TCEQ monitoring stations. Enterococci data collected at these stations over the seven-year period of December 1, 2003 through November 30, 2010 were used in assessing attainment of the primary contact recreation use as reported in the 2012 Texas Integrated Report (TCEQ, 2013). The 2012 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criterion of 35 MPN/100 mL for Mission River Tidal (66.70 MPN/ 100 mL) and Aransas River Tidal (60.40 MPN/ 100 mL).

A modified load duration curve (LDC) analysis was used to quantify allowable pollutant loads and specific TMDL allocations for point and nonpoint sources of indicator bacteria. The WLA for WWTFs was established as the full permitted discharge flow rate multiplied by the instream geometric criterion and also reduced to account for the required margin of safety (MOS). Future growth of existing or new domestic point sources was determined using population projections.

The TMDL calculations in this report will guide determination of the assimilative capacity of each stream under changing conditions, including future growth. Wastewater discharge facilities will be evaluated case by case.

The endpoint for the TMDLs in this report is to maintain concentrations of Enterococci below the geometric mean criterion of 35 MPN/100 mL. This endpoint was applied to both AUs addressed by the TMDL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2014 Texas Surface Water Quality Standards (TSOS, 2014).

Introduction

Section 303(d) of the federal Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a TMDL for each pollutant that contributes to the impairment of a listed water body. The TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

A TMDL is like a budget—it determines the amount of a particular pollutant that a water body can receive and still meet its applicable water quality standards. TMDLs are the best possible estimates of the assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load with units of mass per period of time, but may be expressed in other ways.

The TMDL Program is a major component of Texas' overall process for managing the quality of its surface waters. The program addresses impaired or threatened streams, reservoirs, lakes, bays, and estuaries (water bodies) in, or bordering on, the state of Texas. The primary objective of the TMDL Program is to restore and maintain the beneficial uses—such as drinking water supply, recreation, support of aquatic life, or fishing—of impaired or threatened water bodies.

This TMDL addresses impairments to the contact recreation use due to indicator bacteria in the Mission River Tidal and Aransas River Tidal segments. This TMDL takes a watershed approach to addressing indicator bacteria impairments. While TMDL allocations were developed only for the impaired AUs identified in this report, the entire project watershed and all WWTFs that discharge within it are included within the scope of this TMDL.

Section 303(d) of the Clean Water Act and the implementing regulations of the U.S. Environmental Protection Agency (EPA) in Title 40 of the Code of Federal Regulations (CFR), Part 130 (40 CFR 130) describe the statutory and regulatory requirements for acceptable TMDLs. The EPA provides further direction in its *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA, 1991). This TMDL document has been prepared in accordance with those regulations and guidelines.

The TCEQ must consider certain elements in developing a TMDL. They are described in the following sections of this report:

- Problem Definition
- Endpoint Identification
- Source Analysis
- Linkage Analysis
- Margin of Safety
- Pollutant Load Allocation

- Seasonal Variation
- Public Participation
- Implementation and Reasonable Assurance

Upon adoption of the TMDL report by the TCEQ and subsequent EPA approval, these TMDLs will become an update to the state's Water Quality Management Plan (WQMP).

Problem Definition

The TCEQ first identified the bacteria impairments to the Mission River Tidal and Aransas River Tidal segments in 2004. The segments have been identified as impaired in each subsequent edition of the Texas Integrated Report of Surface Water Quality (formerly called the Texas Water Quality Inventory and 303(d) List) through 2014.

This TMDL document will consider bacteria impairments in the two tidal segments, each of which has a single AU (Figure 1). The complete list of water bodies and their identifying AU numbers is shown below:

- Mission River Tidal 2001_01;
- Aransas River Tidal 2003_01

Because the two impaired segments each comprise only one AU, the AU descriptor (_01) is unnecessarily cumbersome. From this point forward, AU and segment may be used interchangeably. For example, the Mission River Tidal may be referred to as AU 2001_01 or Segment 2001, with each term referring to the same geographic unit.

Ambient Indicator Bacteria Concentrations

Recent environmental monitoring within the Mission River Tidal and Aransas River Tidal segments has occurred at three TCEQ monitoring stations (Figure 1). Enterococci data collected at these stations over the seven-year period of December 1, 2003 through November 30, 2010 were used in assessing attainment of the primary contact recreation use as reported in the 2012 Texas Integrated Report (TCEQ, 2013) and as summarized in Table 1. The 2012 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations of indicator bacteria exceed the geometric mean criterion of 35 MPN/100 mL for the Mission River Tidal (2001) and Aransas River Tidal (2003).

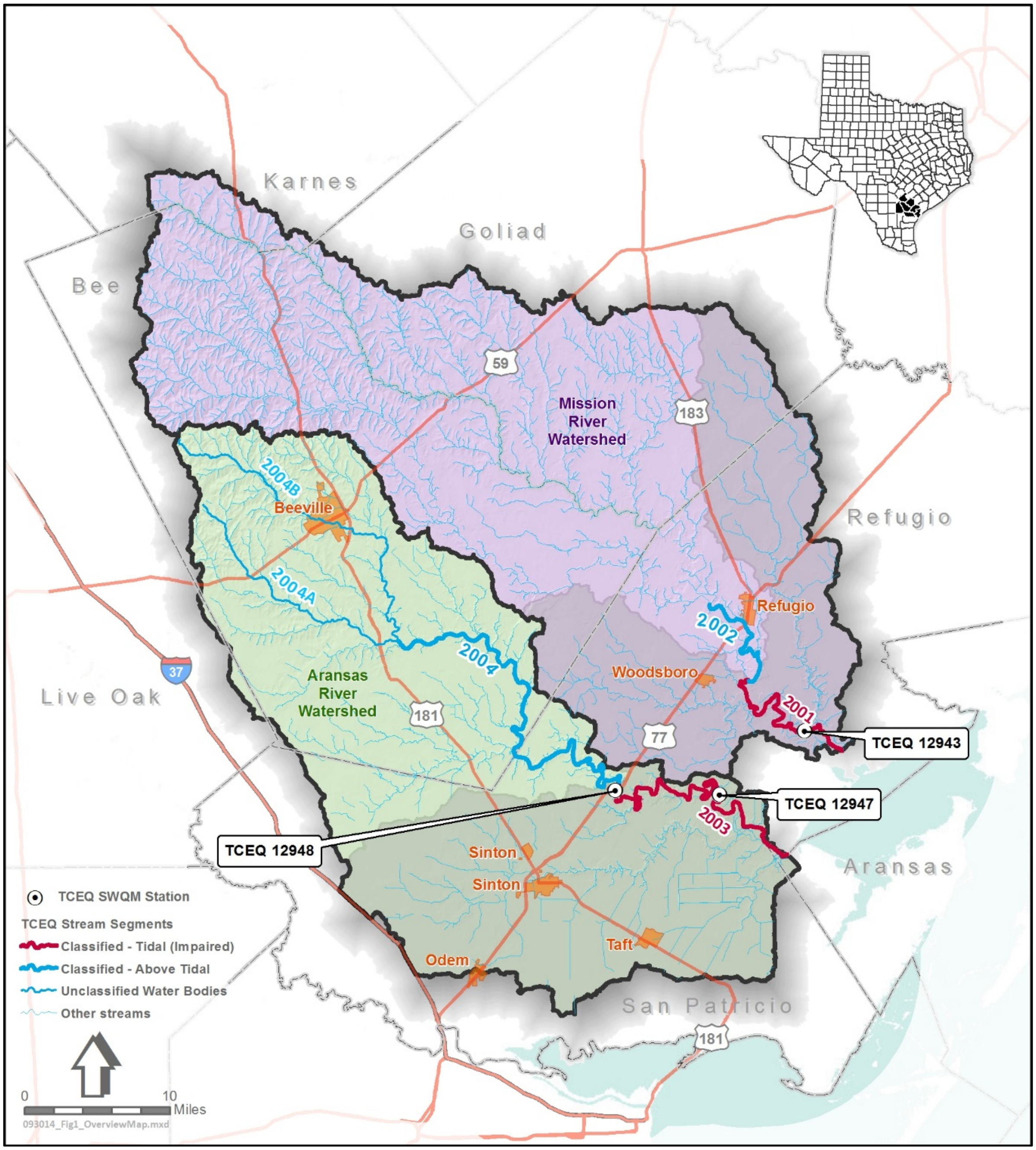

Figure 1. Overview map showing the total contributing drainage area for the study, including Segments 2001, 2002, 2003, and 2004, and TCEQ surface water quality monitoring stations.

Table 1. 2012 Integrated Report Summary for the Mission River Tidal and Aransas River Tidal.

Source: TCEQ (2013)

Water Body	Segment Number	AU	Parameter	Station	No. of Samples	Data Date Range	Station Geometric Mean (MPN/100 mL)
Mission River Tidal	2001	2001_01	Enterococci	12943	28	2003-2010	66.70
Aransas River Tidal	2003	2003_01	Enterococci	12948/ 12947	46	2003-2010	60.40

Watershed Overview

The Mission and Aransas Rivers, located adjacent to each other along the Texas Gulf Coast, are both comprised of two segments – the upstream segment of each river, designated as "Above Tidal," and the downstream segment designated simply as "Tidal." The above tidal portions of both the Mission and Aransas Rivers are perennial freshwater streams, while the downstream tidal portions are influenced by seawater from Mission and Copano Bays. This study incorporates a watershed approach where the entire drainage area of each river is considered (Figure 1).

The Mission River Above Tidal (Segment 2002) begins at the confluence of the Blanco and Medio Creeks in Refugio County and is approximately 11 miles in length. Mission River Tidal (Segment 2001) begins downstream of US 77 in Refugio County and flows approximately 16 miles into Mission Bay. Because of the contiguousness of these segments and the upstream position of Segment 2002 to the bacterially impaired Segment 2001, both water bodies are considered in this report. The TMDL development, however, will only be for Segment 2001. At its mouth, the Mission River drains an area of approximately 1,029 square miles in Bee (36% of the watershed), Refugio (31%), Goliad (30%), and Karnes (3%) counties (Figure 1).

The Aransas River above Tidal (Segment 2004) begins at the confluence of Poesta and Aransas Creeks in Bee County and is approximately 35 miles in length. The Aransas River Tidal (Segment 2003) begins upstream of US 77 on the Refugio/San Patricio County line, and flows approximately 28 miles into Copano Bay. At its mouth, the Aransas River drains an area of approximately 843 square miles in Bee (48% of the watershed), San Patricio (47%), Refugio (4%), Live Oak (0.6%) and Aransas (0.2%) counties (Figure 1). For the same reason as for the Mission River, both Segments 2003 and 2004 are described in this report, but the TMDL development is only for Segment 2003.

The 2012 Texas Integrated Report of Surface Water Quality (TCEQ, 2013) provides the following segment and AU descriptions for the water bodies considered in this document:

- Segment 2001 (AU 2001_01) (Mission River Tidal) - From the confluence with Mission Bay in Refugio County to a point 7.4 kilometers (4.6 miles) downstream of US 77 in Refugio County.
- Segment 2002 (AU 2002_01) (Mission River Above Tidal) - From a point 7.4 km (4.6 miles) downstream of US 77 in Refugio County to the confluence of Blanco Creek and Medio Creek in Refugio County.
- Segment 2003 (AU 2003_01) (Aransas River Tidal) - From the confluence with Copano Bay in Aransas/Refugio County to a point 1.6 kilometers (1.0 mile) upstream of US 77 in Refugio/San Patricio County.
- Segment 2004 (AUs 2004_01 and 02)(Aransas River Above Tidal) - From a point 1.6 kilometers (1.0 mile) upstream of US 77 in Refugio/San Patricio County to the confluence of Poesta Creek and Aransas Creek in Bee County.
- Segment 2004A (AU 2004A_01) (Aransas Creek [unclassified water body]) - From confluence with the Aransas River to the headwaters of the stream about 10 km upstream of US Highway 59.
- Segment 2004B (AUs 2004B_01 and 02) (Poesta Creek [unclassified water body]) - From the confluence with the Aransas River to the headwaters of the stream about 7.5 km upstream of FM 673.

Watershed Climate and Hydrology

The watersheds of the Mission and Aransas Rivers (henceforth collectively referred to as the Mission and Aransas watersheds) are in the approximate boundary area between climate regions (Larkin & Bomar, 1983). The region's subtropical climate is caused by the "predominant onshore flow of tropical maritime air from the Gulf of Mexico," while the increasing moisture content (from west to east) reflects variations in "intermittent seasonal intrusions of continental air" (Larkin & Bomar, 1983). For the period from 1981 – 2010, average annual precipitation in the Mission River watershed was 33.2 inches, slightly higher than the average annual total precipitation for the Aransas River watershed of 32.3 inches (Figure 2; PRISM, 2012). In Beeville, the location of the meteorological station most representative of the Aransas River watershed, the wettest month is normally September (3.8 in), and the driest month is normally February (1.6 inches), although some rainfall typically occurs year-round (NOAA, 2012).

In Beeville, average high temperatures generally reach their peak of 95° F in August, but highs above 100°F have occurred from April through September. Fair skies generally accompany the highest temperatures of summer when nightly average lows drop to about 72°F. During winter, the average low temperature is 43°F in January, although below freezing temperatures have occurred from September through April. The frost-free period in Beeville generally lasts for about

287 days, with the average last frost occurring February 23 and the average first frost occurring on December 7 (Welsh, 2007).

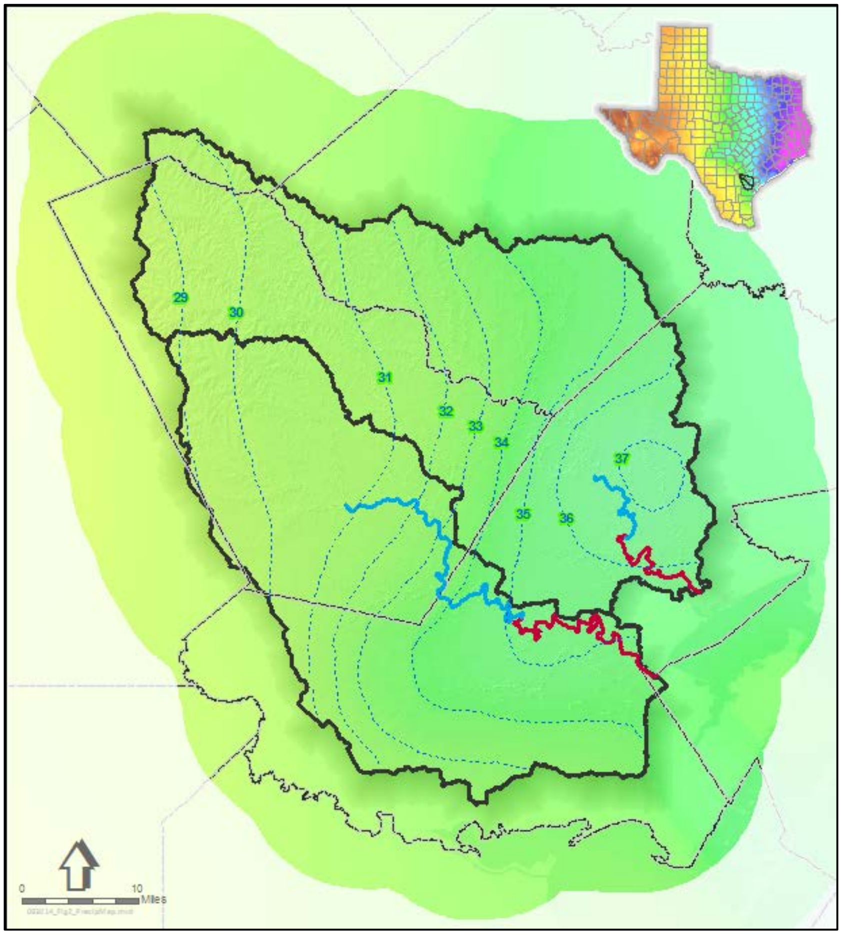

Figure 2. Annual average precipitation isohyets (in inches) in the Mission and Aransas Rivers watersheds (1981-2010).

Source: PRISM Climate Group at Oregon State University (2012)

Watershed Population and Population Projections

According to the 2010 Census (USCB, 2012), population throughout the Mission River watershed is generally rural and dispersed outside of the cities of Refugio (population 2,890) and Woodsboro (1,512). The total population of the Mission River watershed was approximately 8,882, indicating a population density of about 9 people per square mile. The largest municipalities within the more populous Aransas River watershed are the cities of Beeville (population 12,863), Sinton (5,665), Taft (3,048), and Odem (2,389). The total population of the Aransas watershed was approximately 45,689, indicating a population density of about 54 people per square mile, more than six times that of the Mission River watershed (Figure 3).

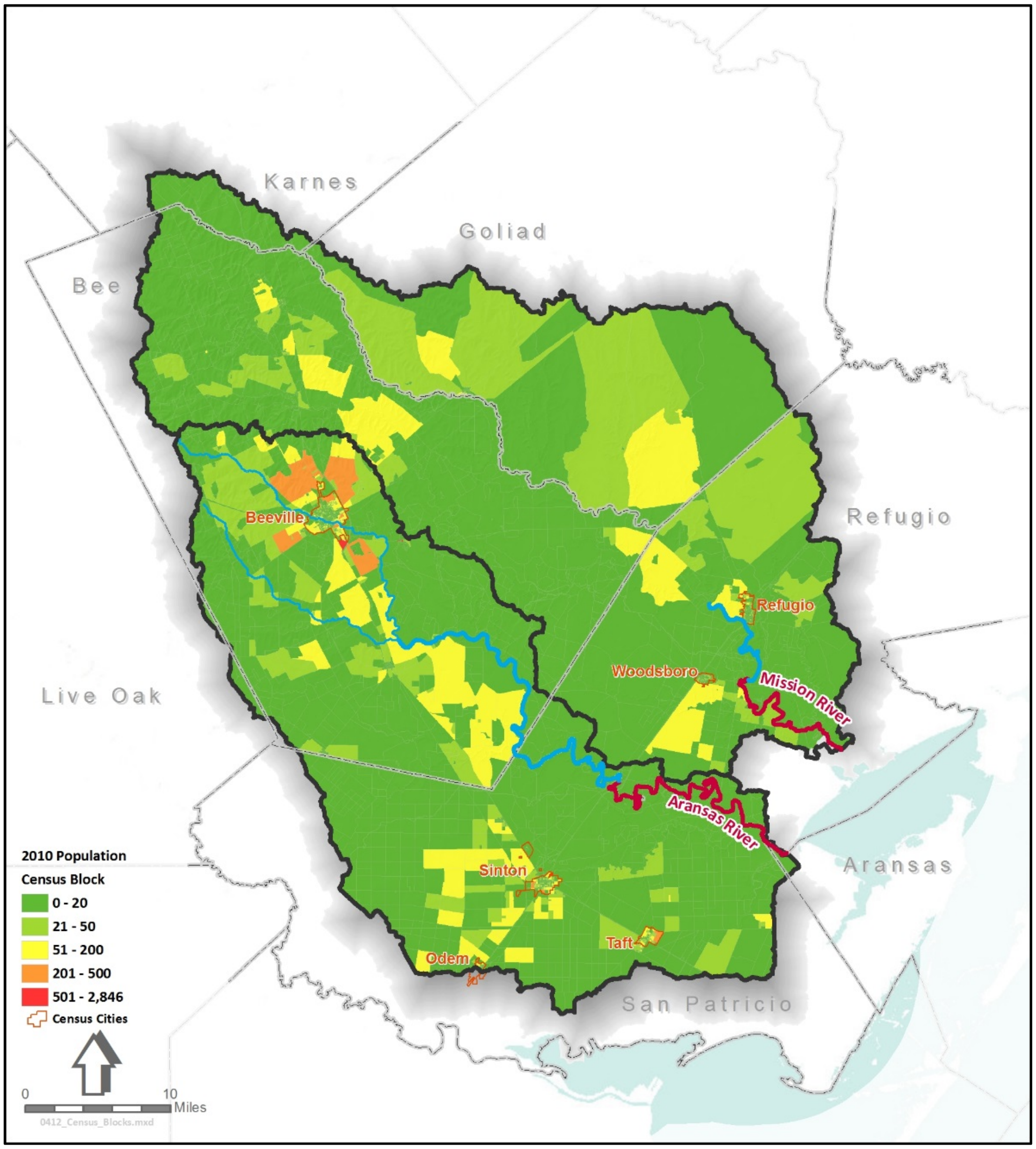

Figure 3. 2010 Population by Census Block.

Sources: Census information obtained from TNRIS (2012) & USCB (2010)

Population projections developed by the Office of the State Demographer and the Texas Water Development Board (TWDB, 2013) indicate that the populations of the seven counties that are included within the Mission River and Aransas River watersheds (Aransas, Bee, Goliad, Karnes, Live Oak, Refugio, and San Patricio) are expected to increase by an average of 14.5% between 2010 and 2050. For the cities within the watershed, including Beeville, Odem, Refugio, Sinton, Taft, and Woodsboro, the populations are projected to increase by an average of 13.5% between 2010 and 2050 (Table 2). The cities of Odem, Sinton, and Taft, all located within the Aransas River Tidal watershed, are expected to have the most significant growth (Table 2).

Table 2. 2010 Population and 2020 – 2050 Population Projections for cities in the Mission and Aransas River watersheds.

Source: TWDB (2013)

City	Watershed	2010 U.S. Census	2020 Population Projection	2030 Population Projection	2040 Population Projection	2050 Population Projection	Percent Increase (2010 - 2050)
Refugio	Mission	2,890	3,009	3,104	3,126	3,179	10.00%
Woodsboro	Mission	1,512	1,575	1,624	1,636	1,663	10.00%
Beeville	Aransas	12,863	13,516	14,082	14,327	14,351	11.60%
Odem	Aransas	2,389	2,535	2,659	2,730	2,782	16.50%
Sinton	Aransas	5,665	6,011	6,305	6,473	6,596	16.40%
Taft	Aransas	3,048	3,235	3,392	3,483	3,549	16.40%

Land Use

The land use/land cover data for the watersheds of the Aransas and Mission Rivers were obtained from the 2006 National Land Cover Database (NCDC - U.S. Geological Survey) and are displayed in Figure 4. The land use/land cover is represented by the following categories and definitions:

Scrub/Grassland - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. *Grassland*: Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

Pasture - 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% 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% of total vegetation. This class also includes all land being actively tilled.

Developed - Includes areas of constructed materials (residential/commercial), impervious surfaces, parks, and golf courses. Impervious surfaces account for 20 to 100% of total cover.

Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Includes deciduous and evergreen species.

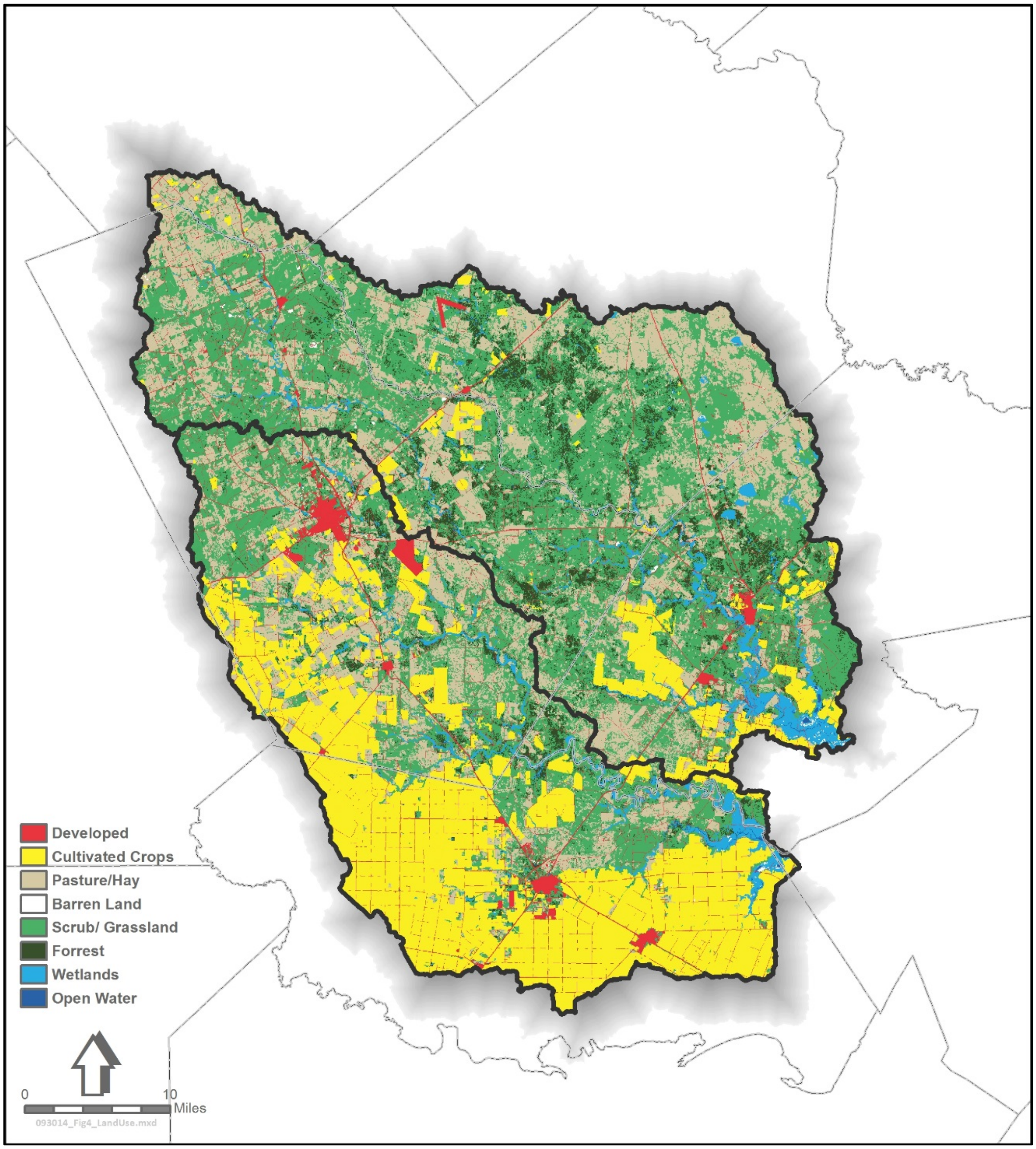

Figure 4. 2006 land use/land cover within the watersheds of the Mission and Aransas Rivers.

Source: USGS (2011)

Wetlands - Areas where forest, shrubland vegetation and/or perennial herbaceous vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Barren Land (Rock/Sand/Clay) - Barren 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% of total cover.

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

As displayed in Table 3, the watershed area encompassing Segments 2001 and 2002 (Mission River watershed) is 658,581 acres. Dominant land uses in the Mission River watershed include Scrub/Grassland (47.3%) and Pasture (31.5%). The watershed area encompassing Segments 2003 and 2004 (Aransas River watershed) is 539,714 acres, and is dominated by Cultivated Crops (44.7%) and Scrub/Grassland (24.3%). Both watersheds are mostly rural, with only about 5% of the combined area classified as Developed.

Table 3. Land Use/Land Cover within the Mission and Aransas watersheds.

Source: USGS (2011)

2006 NLCD	Mission Tidal (2001_01)		Mission Above Tidal (2002_01)		Mission River Grand Total	
Classification	**Acres**	**% of Total**	**Acres**	**% of Total**	**Acres**	**% of Grand Total**
Barren land	560	0.3%	1,152	0.3%	1,713	0.3%
Cultivated Crops	26,955	13.3%	11,532	2.5%	38,487	5.8%
Developed	7,476	3.7%	18,207	4.0%	25,683	3.9%
Forest	10,143	5.0%	38,424	8.4%	48,567	7.4%
Open Water	632	0.3%	211	0.0%	843	0.1%
Pasture	62,182	30.7%	145,204	31.8%	207,386	31.5%
Scrub/ Grassland	81,994	40.5%	229,593	50.3%	311,586	47.3%
Wetlands	12,593	6.2%	11,723	2.6%	24,316	3.7%
Total	202,535 acres		456,046 acres		658,581 acres	
2006 NLCD	**Aransas Tidal (2003_01)**		**Aransas Above Tidal (2004_01)**		**Aransas River Grand Total**	
Classification	**Acres**	**% of Total**	**Acres**	**% of Total**	**Acres**	**% of Grand Total**
Barren land	398	0.2%	265	0.1%	663	0.1%
Cultivated Crops	152,145	66.3%	89,111	28.7%	241,256	44.7%
Developed	13,024	5.7%	19,605	6.3%	32,629	6.0%
Forest	2,486	1.1%	11,974	3.9%	14,460	2.7%
Open Water	1,195	0.5%	27	0.0%	1,222	0.3%
Pasture	17,105	7.5%	83,805	27.0%	100,910	18.7%
Scrub/ Grassland	33,808	14.7%	97,542	31.5%	131,350	24.3%
Wetlands	9,406	4.1%	7,818	2.5%	17,224	3.2%
Total	229,567 acres		310,147 acres		539,714 acres	

Note: NLCD is the National Land Cover Database.

Endpoint Identification

All TMDLs must identify a quantifiable water quality target that indicates the desired water quality condition and provides a measurable goal for the TMDL. The TMDL endpoint also serves to focus the technical work to be accomplished and as a criterion against which to evaluate future conditions.

The endpoint for the TMDLs in this report is to maintain concentrations of Enterococci below the geometric mean criterion of 35 MPN/100 mL. This endpoint was applied to both AUs addressed by the TMDL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2010 Surface Water Quality Standards (TCEQ, 2010).

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). WWTF and storm water discharges from industries, construction, and the MS4s of cities are considered point sources of pollution.

Unregulated sources are typically nonpoint source in origin, meaning the pollutants originate from multiple locations and rainfall runoff washes them into to surface waters. Nonpoint sources are not regulated by permit.

With the exception of WWTFs, which receive individual WLAs (see the “Waste Load Allocation” section), the regulated and unregulated sources in this section are presented to give a general account of the different sources of bacteria expected in the watershed. These are not meant to be used for allocating bacteria loads or interpreted as precise inventories and loadings.

Regulated Sources

Regulated sources are controlled by permit under the TPDES and the NPDES programs. The permitted sources in the TMDL watersheds include WWTF outfalls and stormwater discharges from industry and construction.

Domestic Wastewater Treatment Facilities

Twelve facilities in the Mission River and Aransas River watersheds treat domestic wastewater; three are in the Mission River watershed and nine are within the more populated Aransas River watershed (Table 4; Figure 5). None of the WWTFs in the watersheds discharge directly into either the Mission River Tidal or Aransas River Tidal segments, which are the subjects of this TMDL document. The only WWTF that discharges directly into a main stem river is the Chase Field WWTF operated by the City of Beeville, which discharges into the Aransas River Above Tidal (Segment 2004). All other WWTFs discharge into tributaries of the impaired rivers or to ditches that eventually flow into the impaired rivers or Copano Bay.

Review of Compliance Information on Permitted Sources

A review of the EPA Enforcement & Compliance History Online (ECHO) database (EPA, 2013a), conducted April 17, 2013, revealed non-compliance issues regarding *E. coli* permit limits for four WWTFs in the Mission River and Aransas River watersheds (See Table 5).

Table 4. Permitted domestic wastewater treatment facilities in the Aransas and Mission River watersheds.

Source: Individual TPDES Permits

TPDES Permit No.	NPDES Permit No.	Facility	AU	Receiving Waters	Final Permitted Discharge[a] (MGD)	Recent Discharge [b] (MGD)
WQ0010124004	TX0113859	City of Beeville - Chase Field WWTF	2004_01	Aransas River Above Tidal	2.5	0.4155
WQ0010124002	TX0047007	City of Beeville - Moore Street WWTF	2004_01	Poesta Creek to Aransas River Above Tidal	3.0	0.0707
WQ0010055001	TX0024562	City of Sinton-Main WWTF	2003_01	Chiltipin Creek to Aransas River Tidal	0.80	0.3901
WQ0013641001	TX0110361	City of Sinton - Rod and Bessie Welder WWTF	2003_01	San Patricio County Drainage District ditch to Unnamed Tributary to Chiltipin Creek to Aransas River Tidal	0.015	0.0078
WQ0010705001	TX0027472	City of Taft WWTF	2003_01	Taft Drainage Ditch to Mud Flats to Copano Bay	0.90	0.3967
WQ0010748001	TX0054780	Pettus MUD WWTF	2002_01	Medio Creek to Mission Creek Above Tidal	0.105	0.0388

TPDES Permit No.	NPDES Permit No.	Facility	AU	Receiving Waters	Final Permitted Discharge[a] (MGD)	Recent Discharge [b] (MGD)
WQ0014112001	TX0119407	Skidmore Water Supply Corporation(WSC) WWTF	2004_01	Unnamed Tributary to Aransas River Above Tidal	0.131	0.0457
WQ0014119001	TX0119563	St. Paul WSC WWTF	2003_01	Unnamed Tributary to Chiltipin Creek to Aransas River Tidal	0.05	0.0261
WQ0013412001	TX0102920	Texas Department of Transportation (TxDOT) - Sinton Engineering Building WWTF	2003_01	Oliver Drainage Ditch to Unnamed Tributary to Chiltipin Creek to Aransas River Tidal	0.00038	0.0005
WQ0010255001	TX0032492	Town of Refugio WWTF	2002_01	Dry Creek to Mission River Above Tidal	0.576	0.2790
WQ0010156001	TX0032638	Town of Woodsboro WWTF	2001_01	Ditch to Willow Creek to Sous Creek to Mission River Tidal	0.25	0.0967
WQ0014123001	TX0119601	Tynan WSC WWTF	2004_01	Papalote Creek to Aransas River Above Tidal	0.045	0.0338

Note: MGD denotes million gallons per day

[a] Significant figures reflect MGDs presented in TPDES permits.

[b] Average measured discharge from Nov. 2007 through Oct. 2012, as available from EPA's ECHO database and/or the EPA's Integrated Compliance Information System.

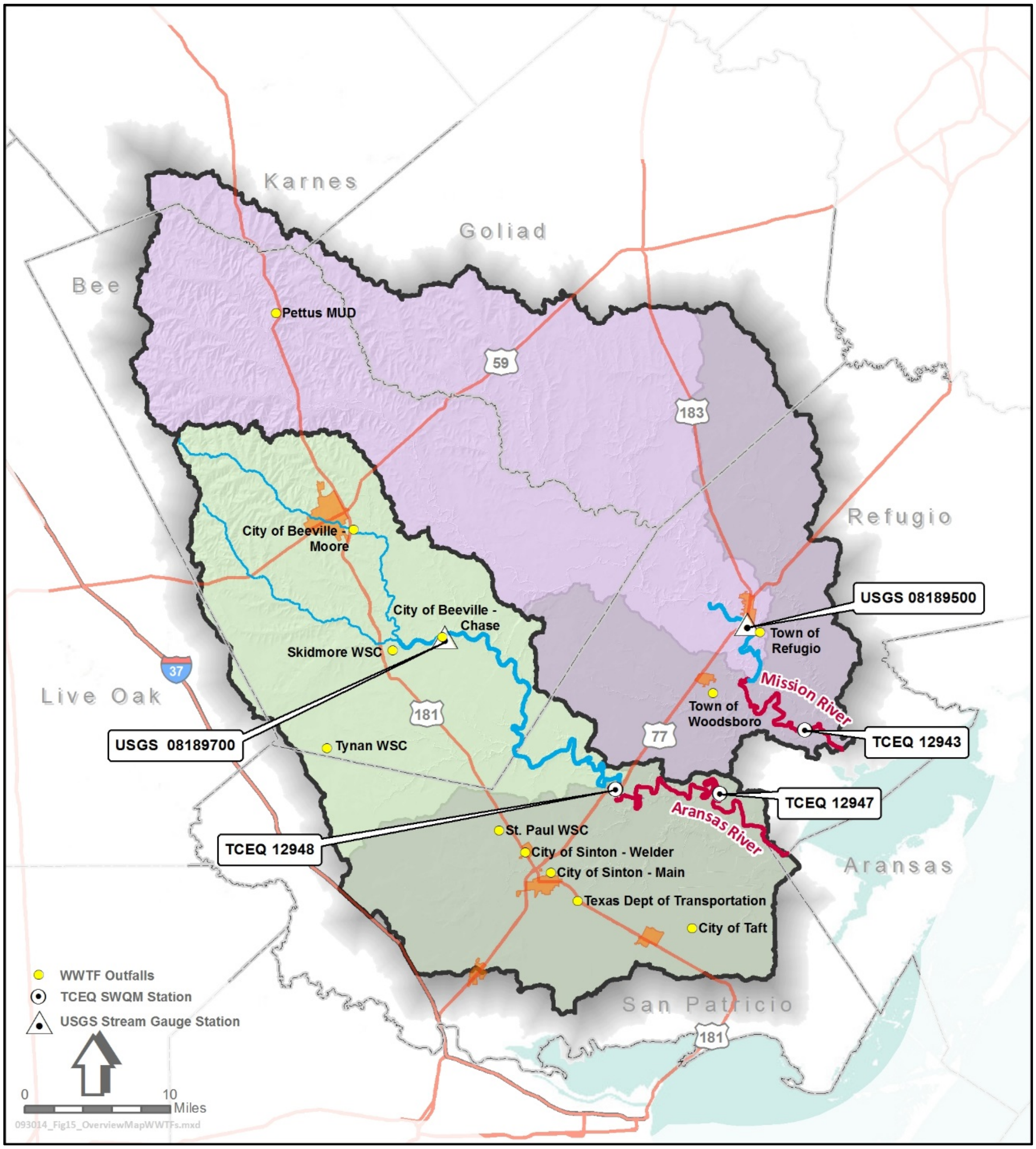

Figure 5. Mission and Aransas watersheds showing WWTFs, TCEQ surface water quality monitoring stations, and USGS stream gage stations.

Source: Permitted outfalls from TCEQ (2012a); TCEQ stations from TCEQ (2012b); USGS stream gage stations from USGS (2013)

Table 5. Bacteria monitoring requirements and compliance status for WWTFs in the watersheds of the Mission and Aransas Rivers.

Compliance status based on the period of record available through the EPA's ECHO database. Periods of record vary, but all fall within the Jul. 2009 – Dec. 2012 timeframe. "% Monthly Exceedances" were calculated based on reported monthly records.

TPDES Permit No.	NPDES Permit No.	Facility	Bacteria Monitoring Requirement	Min. Self-Monitoring Requirement Frequency	Daily Average (Geometric Mean) Limitation	Single Grab (or Daily Max) Limitation	% Monthly Exceedances Daily Average	% Monthly Exceedances Single Grab
WQ0010124004*	TX0113859	City of Beeville - Chase Field WWTF	*E. coli*	Two/month	126	394	not available	not available
WQ0010124002	TX0047007	City of Beeville - Moore Street WWTF	*E. coli*	One/week	126	394	9%	16%
WQ0010055001	TX0024562	City of Sinton-Main WWTF	n/a	n/a	n/a	n/a	n/a	n/a
WQ0013641001	TX0110361	City of Sinton - Rod and Bessie Welder WWTF	*E. coli*	Five/week	126	394	6%	56%
WQ0010705001	TX0027472	City of Taft WWTF	Enterococci	Two/month	35	89	0%	0%
WQ0010748001	TX0054780	Pettus MUD WWTF	*E. coli*	One/month	126	394	0%	0%
WQ0014112001	TX0119407	Skidmore WSC WWTF	n/a	n/a	n/a	n/a	n/a	n/a
WQ0014119001	TX0119563	St. Paul WSC WWTF	*E. coli*	One/quarter	126	394	0%	0%
WQ0013412001	TX0102920	TxDOT- Sinton Engineering Building WWTF	*E. coli*	One/week	126	394	3%	6%
WQ0010255001	TX0032492	Town of Refugio WWTF	*E. coli*	Twice/month	126	394	0%	0%
WQ0010156001	TX0032638	Town of Woodsboro WWTF	*E. coli*	One/month	126	394	0%	6%
WQ0014123001	TX0119601	Tynan WSC WWTF	*E. coli*	One/quarter	126	394	0%	0%

* No compliance data was available through ECHO for Chase Field WWTF.

For the period from July 2009 through December 2012, the following four facilities reported exceedances in bacteria concentration discharge limits:

- City of Beeville - Moore Street WWTF,
- City of Sinton - Rod and Bessie Welder WWTF,
- TxDOT- Sinton Engineering Building WWTF, and
- Town of Woodsboro WWTF.

None of the bacteria effluent violations were reported as Significant Non-compliance (SNC) effluent violations, but unresolved SNC violations for bacteria were indicated for the following three facilities:

- City of Sinton - Rod and Bessie Welder WWTF,
- TxDOT- Sinton Engineering Building WWTF, and
- Town of Woodsboro WWTF.

Two of the 12 permits do not require monitoring bacteria concentrations in effluent; those are the City of Sinton- Main WWTF and the Skidmore Water Supply Corporation (WSC) WWTF. For the City of Beeville - Chase Field WWTF, *E. coli* monitoring is a permit requirement, but no *E. coli* data were available through ECHO when that database was searched.

Bacteria data were collected under a special study by the Nueces River Authority (NRA) (Nueces River Authority, 2011). The NRA sampled the effluent from 12 WWTFs over a period from October 2007 to January 2011. A summary of bacteria sampling data collected at the ten WWTF outfalls that were located within the Mission River and Aransas River watersheds is presented in Table 6. (The City of Odem outfall and the City of Bayside are both outside of the subject watersheds, and therefore were not included in the following table.) The data indicate that most WWTFs were providing disinfected effluent with indicator bacteria levels below state instream indicator bacteria criteria, though the data indicate that two facilities (City of Sinton - Main and St. Paul WSC) exceeded the criteria for one or both indicator bacteria more than 50% of the time.

TPDES General Wastewater Permits

In addition to the individual wastewater discharge permits listed in Table 4, 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
- TXG670000 – hydrostatic test water discharges
- TXG830000 – water contaminated by petroleum fuel or petroleum substances

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

Table 6. Summary of Enterococci and *E. coli* WWTF effluent data collected by NRA from October 2007 to January 2011.

Source: (Nueces River Authority, 2011).

TPDES Permit No.	Facility	Enterococci			*E. coli*		
		N*	Percent Exceeding Geometric Mean Criterion (35 MPN/ 100 mL)	Geo-metric Mean (MPN/ 100 mL)	N*	Percent Exceeding Geometric Mean Criterion (126 MPN/ 100 mL)	Geo-metric Mean (MPN/ 100 mL)
WQ0010124004	City of Beeville - Chase Field WWTF	28	18%	8	28	0%	6
WQ0010124002	City of Beeville - Moore Street WWTF	27	0%	4	27	0%	5
WQ0010055001	City of Sinton-Main WWTF	31	61%	163	34	15%	65
WQ0010705001	City of Taft WWTF	32	6%	2	35	9%	2
WQ0010748001	Pettus MUD WWTF	27	22%	7	27	22%	6
WQ0014112001	Skidmore WSC WWTF	27	7%	2	28	0%	2
WQ0014119001	St. Paul WSC WWTF	31	68%	439	34	74%	419
WQ0010255001	Town of Refugio WWTF	31	23%	8	34	15%	6
WQ0010156001	Town of Woodsboro WWTF	28	0%	2	31	0%	2
WQ0014123001	Tynan WSC WWTF	24	29%	29	24	21%	31

*Number of Samples

A review of active general permit coverage (TCEQ, 2008) in the Mission River watershed as of 26 March 2013 found no operations or facilities of the types listed. A review of active general permit coverage (TCEQ, 2008) in the Aransas River watershed as of 26 March 2013 found one concrete production facility covered by the general permit. This facility is located in Segment 2004, above the impaired AU watershed. No other active general wastewater permit facilities or operations were found. There were no facilities covered under the general permits for aquaculture production, petroleum bulk stations and terminals, hydrostatic test water discharges, water contaminated by petroleum fuel or petroleum substances, concentrated animal feeding operations, or livestock manure compost operations. No attempt was made to allocate bacteria loads to the concrete production facility in Segment 2004, Aransas River Above Tidal, because (1) flows are intermittent and variable and (2) the flows are not anticipated to contain high bacteria loadings.

Sanitary Sewer Overflows

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. Inflow and infiltration (I/I) are typical causes of SSOs under conditions of high flow 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.

The TCEQ Region 14 Office maintains a database of SSO data reported by municipalities. These SSO data typically contain estimates of the total gallons spilled, responsible entity, and a general location of the spill. The reports of SSO events that occurred within the watersheds of the Mission and Aransas Rivers between August 2009 and January 2013 are shown in Table 7. Ten separate incidences were reported for four different facilities. The reported data indicate that the SSOs occurred at various times of the year and, of the incidences in which duration and volume were reported, the durations lasted from one minute to almost 44 hours, and overflow volumes ranged from less than one gallon to 28,200 gallons.

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-regulated MS4s, industrial facilities, and regulated construction activities.
2) Stormwater runoff not subject to regulation.

Discharges of stormwater from a Phase II urbanized area, industrial facility, construction site, or other facility involved in certain activities are required to be covered under the following TPDES general permits:

- TXR040000 – stormwater Phase II MS4 general permit for urbanized areas

- TXR050000 – stormwater MSGP for industrial facilities
- TXR150000 – stormwater from construction activities disturbing more than one acre
- TXG110000 – concrete production facilities
- TXG340000 – petroleum bulk stations and terminals

Table 7. SSO incidences reported in the watersheds of the Mission and Aransas Rivers watersheds from Aug. 2009 – Jan. 2013.

Source: Modified, TCEQ Region 14

Facility Name	Discharge Date(s)	Duration (hours-minutes)	Volume (Gallons)	Cause	Segment
Pettus MUD WWTF	intermittent from at least 01/5/2011 thru 03/07/2011	unknown	unknown	clogged rags/grease	2002
	5/16/2012	unknown	unknown	power outage	2002
Town of Refugio WWTF	6/29/2009; 07/02/2009 and 07/08/2009	unknown	unknown	concrete obstruction in the main line	2002
	4/16/2012	0-1	less than 1	I/I	2002
	8/23/2009	unknown	unknown	unknown	2002
City of Sinton Main WWTF	9/11/2009	43-45	28,200	I/I	2003
City of Taft WWTF	9/16/2009	0-20	5,000 -8,000	Line Break	2003
	11/20/2009	8-45	unknown	I/I	2003
	4/10/2010	unknown	500	Line Break	2003
	9/21/2010	unknown	unknown	I/I	2003

Three of these permits (MS4, MSGP, and construction) pertain solely to stormwater discharges. The other two – concrete production facilities and petroleum bulk stations and terminals – also authorize the discharge of process wastewater as discussed under “TPDES General Wastewater Permits.”

A review of active stormwater general permits coverage (TCEQ, 2008) in the Mission River watershed, as of March 26, 2013, found four active industrial (MSGP) facilities and three active construction sites. A review of active stormwater general permits coverage in the Aransas River watershed, as of March 26, 2013, found seven active industrial (MSGP) facilities, eight active construction sites, and one active concrete production facility. There are currently no Phase II MS4s or petroleum bulk station and terminal facilities in either watershed. Regulated stormwater comprises only a very small portion of the areas of the subject watersheds — 0.06% for Mission River watershed and 0.04% for Aransas River watershed.

Illicit Discharges

Pollutant loads can enter streams from outfalls that are authorized by law, for example under the provisions of a permit granted by the appropriate regulatory entity, but they can also enter streams from unauthorized sources. The term "illicit discharge" refers to an unauthorized release of pollutants either because it is not allowed by law or because the release requires authorization from a permitting entity. Illicit discharges can be categorized as either direct or indirect. Examples of illicit discharges can be found in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003) and include the following:

Examples of 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.

Examples of 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 indicator bacteria are generally nonpoint sources. Nonpoint source (NPS) loading enters the impaired segment through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities, agricultural animals, land application fields, failing on-site sewage facilities (OSSFs), unmanaged and feral animals, and domestic pets.

Wildlife and Unmanaged Animal Contributions

Enterococci 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 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. An estimate of deer and feral hog populations for the watersheds of the Mission and Aransas Rivers were made by Borel & Karthikeyan (2013) and are reported in Table 8.

Table 8. Estimated distributed deer and feral hog populations.

Source: Adapted from Table 5 in Borel & Karthikeyan (2013)

Watershed	Deer Population	Feral Hog Population
Aransas Above Tidal	21,982	8,712
Aransas Tidal	18,527	6,248
Mission Above Tidal	33,313	13,088
Mission Tidal	15,009	5,536
Totals	88,831	33,584

On-Site Sewage Facilities

For each of the four major watersheds (Aransas River Above Tidal, Aransas River Tidal, Mission River Above Tidal, and Mission River Tidal), the number of OSSFs was estimated from information in Borel & Karthikeyan (2013) and personal communications with Borel in April 2014. Table 9 shows the estimated total numbers of OSSFs by the four major watersheds and the estimated total number of failing OSSFs based on soil limitation class and failure rates. More detail on the soil limitation class and failure rates is provided in Borel & Karthikeyan (2013).

Table 9. Number of OSSFs and soil conditions for the watersheds of the Mission and Aransas Rivers.

Source: Adapted from Borel & Karthikeyan (2013), Table 3 and personal communication with Borel, April 2014.

Soil Condition	Failure Rate	Total OSSFs by Watershed				Total OSSFs by Soil Condition	Estimated Total Failing OSSFs
		Aransas Above Tidal	Aransas Tidal	Mission Above Tidal	Mission Tidal		
Very Limited	15%	3,515	3,815	2,112	617	10,059	1,509
Somewhat Limited	10%	1,364	11	916	-	2,291	229
Not Limited	5%	-	-	-	-	-	-
Not Rated	15%	4	-	6	-	10	2
Totals		4,883	3,826	3,034	617	12,360	1,738

Non-Permitted Agricultural Activities and Domesticated Animals

Domesticated animal populations for goats, horses, sheep, and cattle in the Mission River and Aransas River watersheds were estimated based on Borel & Karthikeyan (2013). The animal numbers distributed to the four watersheds are presented in Table 10. Activities, such as livestock grazing close to water bodies and the use of manure as fertilizer, can contribute fecal indicator bacteria such as Enterococci to nearby water bodies. The livestock numbers in Table 10 are provided to demonstrate that livestock are a potential source of bacteria in the watershed. These livestock numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock. The estimated livestock populations were verified by the Texas State Soil and Water Conservation Board.

Table 10. Estimated distributed domesticated animal populations.

Source: Adapted from Tables 5 and 6 in Borel & Karthikeyan (2013)

Watershed	Goat Population	Horse Population	Sheep Population	Total Cattle Population
Aransas Above Tidal	1,165	650	170	15,022
Aransas Tidal	200	321	155	3,658
Mission Above Tidal	1,653	857	205	29,090
Mission Tidal	300	390	20	11,736
Totals	3,318	2,218	550	59,506

Pets can also be sources of Enterococci, because storm runoff carries the animal wastes into streams (EPA, 2013b). The estimated number of domestic dogs in the Mission River and Aransas River watersheds was estimated by Borel & Karthikeyan (2013), and is shown in Table 11.

Table 11. Estimated distributed dog population.

Source: Adapted from Table 4 in Borel & Karthikeyan (2013).

Watershed	Distributed Dog Population
Aransas Above Tidal	4,254
Aransas Tidal	2,940
Mission Above Tidal	2,444
Mission Tidal	427
Totals	10,065

Bacteria Survival and Die-off

Bacteria are living organisms that survive and die in the environment. Certain enteric bacteria can survive and replicate in organic materials if appropriate conditions prevail (e.g., warm temperature and moist conditions). Fecal organisms from improperly treated effluent can survive and replicate during their transport in pipe networks, and they can survive and replicate in organic rich materials such as compost and sludge. While the die-off of indicator bacteria has been demonstrated in natural water systems due to the presence of sunlight and predators, the potential for their re-growth is less well understood. Both processes (replication and die-off) are instream processes and are not considered in the bacteria source loading estimates of each water body in the TMDL watersheds.

Linkage Analysis

Establishing the relationship between instream water quality and the source of loadings is an important component in developing a TMDL. It allows for the evaluation of management options that will achieve the desired endpoint. The relationship may be established through a variety of techniques.

Generally, if high bacteria concentrations are measured in a water body at low to median flow in the absence of runoff events, the main contributing sources are likely to be point sources. During ambient flows, these constant inputs to the system will increase pollutant concentrations depending on the magnitude and concentration of the sources. As flows increase in magnitude, the impact of point sources is typically diluted, and would therefore be a smaller part of the overall concentrations.

Bacteria load contributions from regulated and unregulated stormwater sources are greatest during runoff events. Rainfall runoff, depending upon the severity of the storm, has the capacity to carry indicator bacteria from the land surface into the receiving stream. Generally, this loading follows a pattern of lower concentrations in the water body just before the rain event, followed by a rapid increase in bacteria concentrations in the water body as the first flush of storm runoff enters the receiving stream. Over time, the concentrations decline because the sources of indicator bacteria are attenuated as runoff washes them from the land surface and the volume of runoff decreases following the rain event.

Modified Load Duration Curve Analysis

A modified LDC method was used to examine the relationship between instream water quality and the source of indicator bacteria loads. LDCs are graphs of the frequency distribution of loads of pollutants in a stream. In the case of these TMDLs, the loads shown are of Enterococci bacteria in MPN/day. LDCs are derived from Flow Duration Curves (FDCs), which are graphs of the frequency distribution of flow in a stream. The LDCs shown in the following figures represent the maximum acceptable load in the stream that will result in achievement of the TMDL water quality target.

LDCs are a simple statistical method that provides a basic description of the water quality problem. The strength of this tool is that it is easily developed and explained to stakeholders, and uses available water quality and flow data. The LDC method does not require any assumptions regarding loading rates, stream hydrology, land use conditions, and other conditions in the watershed.

Inherent to the use of LDCs as the mechanism of linkage analysis is the assumption of a one to one relationship between instream loadings and loadings originating from point sources and the landscape as regulated and unregulated sources. Further, this one to one relationship was also inherently assumed when using LDCs to define the TMDL pollutant load allocation (LA). That is, the allocation of pollutant loads was based on apportioning the loadings based on flows assigned to WWTFs, a fractional proportioning of the remaining flow based on the area of the watershed under stormwater regulation, and assigning the remaining portion to unregulated stormwater.

The State of Oregon Department of Environmental Quality (ODEQ) developed the modification of the LDC method (or modified LDC method) for tidal streams of the Umpqua River Basin (ODEQ, 2006) that was applied to the Mission River Tidal (Segment 2001) and Aransas River Tidal (Segment 2003).

The modified LDC method is based on the assumption that combining of river water with seawater increases the loading capacity in the tidal river because seawater typically contains lower concentrations of indicator bacteria, such as Enterococci, than river water. The assumption of decreasing concentrations of Enterococci with distance from the tidal segments of the Mission and Aransas River into Copano Bay are borne out in the historical data.

The weaknesses of the LDC method include the limited information it provides regarding the magnitude or specific origin of the various sources. Only limited information is gathered regarding point and nonpoint sources in the watershed. The general difficulty in analyzing and characterizing Enterococci in the environment is also a weakness of this method.

The modified LDC method allows for estimation of existing pollutant loads and TMDLs by utilizing the cumulative frequency distribution of stream flow with diluting seawater and measured pollutant concentration data (ODEQ, 2006). In addition to estimating instream loads, this method (1) allows for the determination of the hydrologic conditions under which impairments are typically occurring, (2) can give indications of the broad origins of the bacteria (*i.e.*, point source and stormwater), and (3) provides a means to allocate allowable loadings.

Data requirements for the modified LDC method are minimal, consisting of continuous daily stream flow records and both historical bacteria and salinity data. A 15-year period of record from January 1, 1998 through December 31, 2012 was selected for LDC development, and this period included all available Enterococci data at the time of the study. A 15-year period is of sufficient duration to contain a reasonable variation from dry months and years to wet months and years and at the same time is short enough in duration to contain a hydrology that is responding to recent and current conditions in the watershed.

For this report, LDCs were constructed for the most downstream monitoring station within the Mission River Tidal (Station 12943) and the Aransas River Tidal (Station 12947). The most downstream surface water quality monitoring (SWQM) stations were selected because these locations encompass more of the drainage area of each watershed and are representative of conditions in a greater area of each watershed than stations located farther upstream.

On numerous creeks and rivers in Texas, U.S. Geological Survey (USGS) streamflow gauging stations have been in operation for a sufficient period to provide long-term streamflow records. The USGS streamflow gauges used for LDC development and the area of application are:

- USGS gauging station 08189500 (Mission River at Refugio, TX) applied to develop the freshwater flows for Mission River Tidal Station 12943; and
- USGS gauging station 08189700 (Aransas River near Skidmore, TX) applied to develop the freshwater flows for the Aransas River Tidal Stations 12947.

The required daily streamflow record for each LDC was estimated based on application of a drainage area ratio computed as the drainage area above the LDC location divided by the drainage area of the appropriate USGS gauge. Prior to application of the drainage area ratio, the USGS gauge record was corrected by removing (subtracting) upstream WWTF discharges based on discharge monitoring report (DMR) information. After multiplication of the corrected stream flow record by the drainage area ratio, a final adjustment occurred for the purposes of pollutant load computations. The hydrologic records were adjusted to reflect full permitted flows from all upstream WWTFs and future growth flows that account for the probability that additional flows from WWTF discharges may occur as a result of population increases.

Another part of the development of the modified LDC method is to determine a relationship of daily streamflow and measured salinities. The resulting regression is used to determine the daily volume of saltwater present for each daily freshwater flow in the 15-year period of record.

Information on the modified LDC method is provided in Appendix A and additional details are provided in the document titled *Technical Support*

Document for Total Maximum Daily Loads for Indicator Bacteria in the Watersheds of the Mission and Aransas Rivers (Painter and Hauck, 2013).

Each FDC was generated by:

- ranking the daily flow data, including any additional saltwater flow, from highest to lowest,
- calculating the percent of days each flow was exceeded (rank ÷ quantity of the number of data points + 1), and
- plotting each flow value (y-axis) against its exceedance value (x-axis).

Exceedance values along the x-axis represent the percent of days that flow was at or above the associated flow value on the y-axis. Exceedance values near 100% occur during low flow or drought conditions while values approaching 0% occur during periods of high flow or flood conditions.

Bacteria LDCs were developed by multiplying each streamflow value along the flow duration curves by the Enterococci geometric mean criterion (35 MPN/100 mL) and by the conversion factor to convert to loading in colonies per day. Flow was measured in cubic feet per second (cfs). This effectively displays the LDC as the TMDL curve of maximum allowable loading:

TMDL (MPN/day) = Criterion * flow (cfs) * conversion factor

Where:

Criterion = 35 MPN/100 mL (Enterococci)

Conversion factor (to MPN/day) = 283.168 100 mL/ft^3 * 86,400 seconds/day

The resulting curve plots each bacteria load value (y-axis) against its exceedance value (x-axis). Exceedance values along the x-axis represent the percent of days that the bacteria load was at or above the allowable load on the y-axis.

For the LDCs at each of the two TCEQ monitoring stations, historical bacteria data obtained from the TCEQ Surface Water Quality Monitoring Information System (SWQMIS) database were superimposed on the allowable bacteria LDC. Each historical Enterococci measurement was associated with the flow on the day of measurement and converted to a bacteria load. The associated flow for each bacteria loading was compared to the FDC data to determine its value for “percent days flow exceeded,” which becomes the “percent of days load exceeded” value for purposes of plotting the Enterococci loading. Each load was then plotted on the LDC at its percent exceedance. This process was repeated for each Enterococci measurement at each station. Points above the LDC represent exceedances of the bacteria criterion and their associated allowable loadings. As a further refinement, the historical Enterococci points on the LDCs were symbolized according to whether the sampling event was considered to be a wet or non-wet weather event based on antecedent rainfall. A sample was determined to be influenced by a wet weather event based on the reported "days since last precipitation" (DSLP). Wet weather events were determined by DSLP of 0-3.

The flow exceedance frequency can be subdivided into hydrologic condition classes to facilitate the diagnostic and analytical uses of FDCs and LDCs. The hydrologic classification scheme utilized for the TMDL watersheds is as follows: high flow regime (0 – 10%), mid-range flow regime (10 – 60%), and low flow regime (60 – 100%). Additional information explaining the LDC method and the modified LDC method may be found in Cleland (2003), Nevada Department of Environmental Protection (NDEP 2003), and ODEQ (2006).

The median loading of the high flow regime (0-10% exceedance) is used for the TMDL calculations. The median loading of the high flow regime is represented by the 5% exceedance and is used for the TMDL calculations, because it represents a reasonable yet high value for the allowable pollutant load allocation.

An important observation is that under the high flow regime used for the TMDL calculations, there was no seawater volume computed as being present at the two locations where LDCs were developed. Saltwater has been effectively pushed out of the rivers by the freshwater inflows present under the high flow regime. With an absence of seawater at these high flows, the modified LDC results effectively simplified to those of the LDC method without any adjustments to accommodate tidal influences.

Load Duration Curve Results

For developing the TMDL allocation, LDCs were constructed for the most downstream monitoring station within the Mission River Tidal and Aransas River Tidal (Figures 6 and 7). Geometric mean loadings for the data points within each flow regime have also been distinguished on each figure to aid interpretation. The LDCs for the two monitoring stations provide a means of identifying the stream flow conditions under which exceedances in Enterococci concentrations have occurred. The LDCs depict the allowable loadings at the stations under the geometric mean criterion (35 MPN/100 mL) and show that existing loadings often exceed the criterion. For purposes of the pollutant load computations, the hydrologic records for the FDCs and subsequent allowable loads from the LDCs are adjusted to reflect future capacity estimates that account for the probability that additional flows from WWTF discharges may occur as a result of future population increases in the TMDL watersheds.

Based on these LDCs with historical Enterococci data added to the graphs (Mission River Tidal Station 12943, Figure 6 and Aransas River Tidal Station 12947, Figure 7), the following broad linkage statements can be made. For both the Mission River and Aransas River watersheds, the historical Enterococci data indicate that elevated bacteria loadings occur under all flow conditions, but become most elevated under the highest flows and are often below the geometric mean criterion under the lowest flows. Regulated stormwater comprises only a very small portion of the watershed (0.06% for the Mission River watershed and 0.04% for the Aransas River watershed) and must be considered only a minor contributor. Unregulated stormwater most likely comprises the majority of high-flow related loadings. The elevated Enterococci loadings under the lower flow conditions cannot be reasonably attributed exclusively to WWTFs due to the fact that the outfalls are typically located at significant distances from the SWQM stations. Also, most of the WWTFs in the TMDL watersheds show a relatively good compliance record. Therefore, other sources of bacteria loadings under lower flows and in the absence of overland flow contributions (i.e., without stormwater contribution) are most likely contributing bacteria directly to surface water. Bacteria loading under lower flows could occur through direct deposition of fecal material from wildlife, feral hogs, and livestock. The actual contribution of bacteria loadings attributable to these direct sources of fecal material deposition cannot be determined using LDCs.

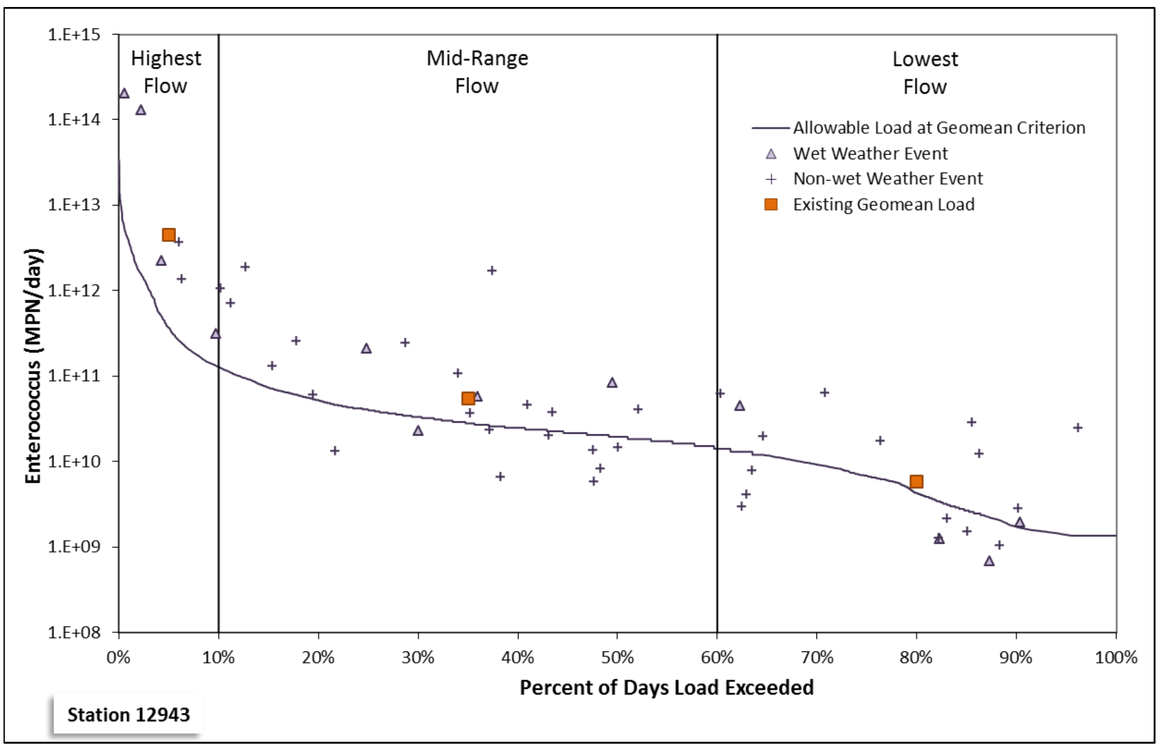

Figure 6. Load duration curve for Station 12943, Mission River Tidal.

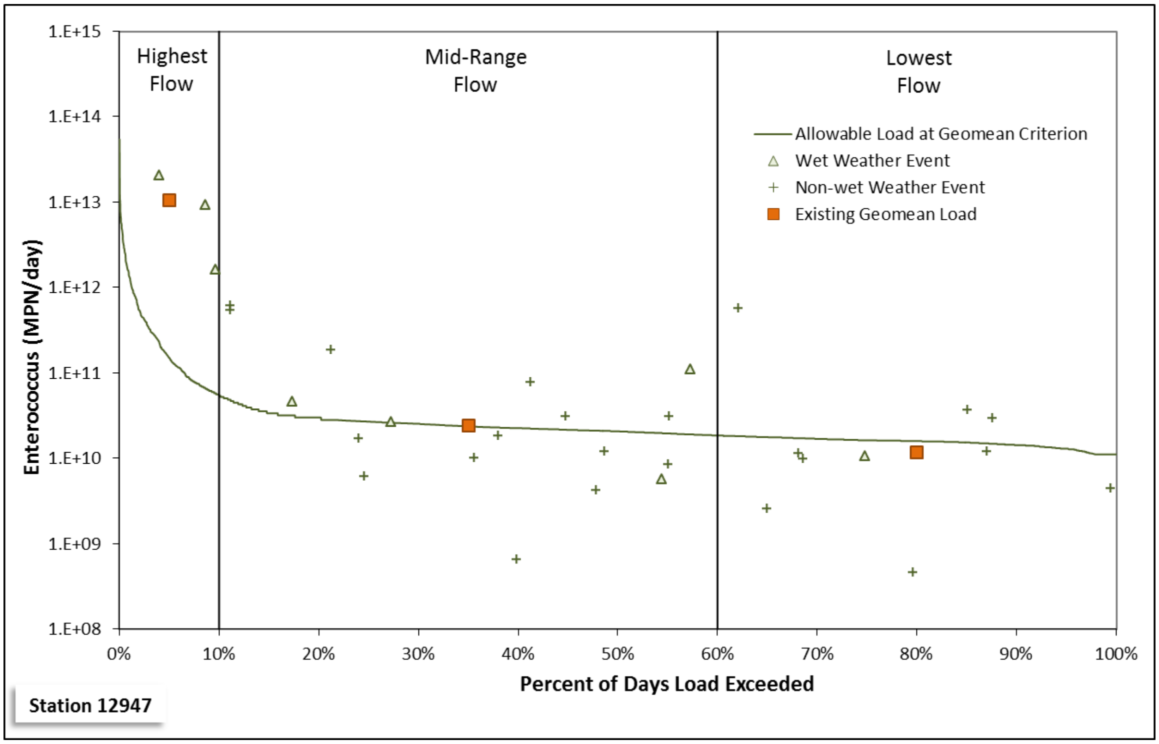

Figure 7. Load duration curve for Station 12947, Aransas River Tidal.

Margin of Safety

The MOS is used to account for uncertainty in the analysis used to develop the TMDL and thus provide a higher level of assurance that the goal of the TMDL will be met. According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using two methods:

1) Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
2) Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning a MOS.

The TMDLs covered by this report incorporate an explicit MOS by setting a target for indicator bacteria loads that is five percent lower than the geometric mean criterion. For primary contact recreation, this equates to a geometric mean target for Enterococci of 33.3 MPN/100 mL. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced.

Pollutant Load Allocation

A TMDL represents the maximum amount of a pollutant that the stream can receive in a single day without exceeding water quality standards. The pollutant load allocations for the selected scenarios were calculated using the following equation:

TMDL = WLA + LA + FG + MOS

Where:

TMDL = total maximum daily load

WLA = waste load allocation, the amount of pollutant allowed by existing regulated or permitted dischargers

LA = load allocation, the amount of pollutant allowed by unregulated or non-permitted sources

FG = loadings associated with future growth from potential permitted facilities

MOS = margin of safety

As stated in 40 CFR, Section 130.2(1), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For Enterococci, TMDLs are expressed as MPN/day, and represent the maximum one-day load the stream can assimilate while still attaining the standards for surface water quality.

The TMDL component for the two impaired AUs covered in this report are derived using the median flow within the high flow regime (or 5% flow) of the LDC developed for the downstream SWQM station in each AU (12943 in the Mission River and 12947 in the Aransas River). The immediately following sections will present an explanation of the TMDL component first, followed by the results of the calculation for that component.

AU-Level TMDL Computations

The bacteria TMDLs for the Mission River Tidal and Aransas River Tidal segments were developed as a pollutant load allocation based on information from the most downstream LDCs (Figures 6 and 7). As discussed in more detail in Appendix A, bacteria LDCs using modifications to include tidal influences were developed by multiplying each flow value along the flow duration curves by the Enterococci criterion (35 MPN/100 mL) and by the conversion factor used to represent maximum loading in MPN/day. Effectively, the “Allowable Load” displayed in the modified LDC at 5% exceedance (the median value of the high-flow regime) is the TMDL:

TMDL (MPN/day) = Criterion * Flow (cfs) * Conversion factor

Where:

Criterion = 35 MPN/100 mL (Enterococci)

Conversion factor (to MPN/day) = 283.168 100 mL/ft^3 * 86,400 sec/day

At 5% load duration exceedance, the TMDL values are provided in Table 12.

Table 12. Summary of allowable loading calculations for AUs within the TMDL watersheds

Watershed	AU	5% Exceedance Flow (cfs)	5% Exceedance Load (Billion MPN/ day)	TMDL (Billion MPN/ day)
Mission	2001_01	432.72	370.543	370.543
Aransas	2003_01	175.55	150.321	150.321

Margin of Safety

The MOS is only applied to the allowable loading for a watershed. Therefore the margin of safety is expressed mathematically as the following:

MOS = 0.05 * TMDL

Where:

MOS = margin of safety load

TMDL = total maximum allowable load

Since the MOS is based solely on the TMDL term, the calculation is straightforward (Table 13).

Table 13. MOS calculations for downstream stations within the Mission and Aransas Rivers.

Watershed	AU	TMDL (Billion MPN/ day)	MOS (Billion MPN/ day)
Mission	2001_01	370.543	18.527
Aransas	2003_01	150.321	7.516

Waste Load Allocation

The WLA consists of two parts – the waste load that is allocated to TPDES-regulated wastewater treatment facilities (WLA_{WWTF}) and the waste load that is allocated to regulated stormwater dischargers (WLA_{SW}).

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

WWTFs

TPDES-permitted wastewater treatment facilities are allocated a daily waste load (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by the instream geometric criterion and also reduced to account for the required MOS. The saline water Enterococci criterion (35 MPN/100mL) is used as the WWTF target. The WLA_{WWTF} term is also calculated for the freshwater *E. coli* primary contract recreation geometric mean criterion of 126 MPN/100 mL, since WWTF bacteria permit limits are often expressed in terms of *E. coli*. This is expressed in the following equation:

WLA_{WWTF} = Criterion * Flow * Conversion Factor * (1 – F_{MOS})

Where:

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

Flow = full permitted flow in millions of gallons per day (MGD)

Conversion Factor (to MPN/day)= 1.54723 cfs/MGD *283.168 100 mL/ft^3 * 86,400 seconds/day

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

Thus the daily allowable loading of Enterococci and *E. coli* assigned to WLA_{WWTF} was determined based on the full permitted flow of each WWTF and summed individually for the watersheds of the Mission and Aransas Rivers. Table 14 presents the WLAs for each individual WWTF located within each of the two TMDL watersheds. The WLA_{WWTF} for each AU includes the sum of the WWTF allocations for all upstream AUs. Since the pollutant load allocation is developed in terms of Enterococci as the indicator bacteria, it is the Enterococci loadings from Table 14 that will be used in subsequent computations.

Table 14. Waste load allocations for TPDES-permitted facilities

AU	TPDES Permit No.	NPDES Permit No.	Facility	Full Permitted Discharge (MGD)	Enterococci WLA_{WWTF} (Billion MPN/ day)	*E. coli* WLA_{WWTF} (Billion MPN/ day)
2001_01	WQ0010156001	TX0032638	Town of Woodsboro WWTF	0.25	0.315	1.133
2002_01	WQ0010748001	TX0054780	Pettus MUD WWTF	0.105	0.132	0.476
2002_01	WQ0010255001	TX0032492	Town of Refugio WWTF	0.576	0.725	2.610
			Mission River Tidal Total	0.931	1.172	4.218
2003_01	WQ0010055001	TX0024562	City of Sinton-Main WWTF	0.80	1.007	3.625
2003_01	WQ0013641001	TX0110361	City of Sinton - Rod and Bessie Welder WWTF	0.015	0.019	0.068
2003_01	WQ0010705001	TX0027472	City of Taft WWTF	0.90	1.133	4.078
2003_01	WQ0014119001	TX0119563	St. Paul WSC WWTF	0.05	0.063	0.227
2003_01	WQ0013412001	TX0102920	Texas Department of Transportation - Sinton Engineering Building WWTF	0.00038	0.0005	0.0017
2004_01	WQ0010124004	TX0113859	City of Beeville - Chase Field WWTF	2.5	3.147	11.328
2004_01	WQ0010124002	TX0047007	City of Beeville - Moore Street WWTF	3.0	3.776	13.593
2004_01	WQ0014112001	TX0119407	Skidmore WSC WWTF	0.131	0.165	0.594
2004_01	WQ0014123001	TX0119601	Tynan WSC WWTF	0.045	0.057	0.204
			Aransas River Tidal Total	7.441	9.366	33.718

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are also considered permitted or regulated point sources. Therefore, the WLA calculations must also include an allocation for permitted stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA for these areas was used in the development of these TMDLs due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of the land area included in each watershed that is under the jurisdiction of stormwater permits is used to estimate the amount of the overall runoff load that should be allocated as the permitted stormwater contribution in the WLA_{SW} component of the TMDL. The LA component of the TMDL corresponds to direct nonpoint runoff and is the difference between the total load from stormwater runoff and the portion allocated to WLA_{SW}.

WLA_{SW} is the sum of loads from regulated stormwater sources and is calculated as follows:

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

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 permitted facilities

MOS = margin of safety load

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

In order to calculate the WLA_{SW} component of the TMDL, the fractional proportion of the drainage area under the jurisdiction of stormwater permits (FDA_{SWP}) must be determined in order to estimate the amount of overall runoff load that should be allocated to WLA_{SW}. The term FDA_{SWP} was calculated based on the combined area under regulated stormwater permits. As described in the Source Analysis section, a search for all five categories of stormwater general permits was performed. The search results are summarized in Table 15.

No MS4 permits are held in the watersheds of the Mission and Aransas Rivers. For the Multi-sector and Concrete Production general permits, only the acreages associated with active permits were tallied. These acreages were calculated by importing the location information associated with the authorizations into a Geographic Information System, and measuring the estimated disturbed area based on the most recently available aerial imagery. For the Construction Activities general permits, the authorization contains an “Area Disturbed” field. Due to the variable and temporary nature of construction projects, it was preferable to average the acreages (on a monthly basis) associated with active permits over the entire available period of record (approximately 5 years). The results of this temporal averaging were used as representative of the average area under Construction Activities stormwater permits.

Table 15. Stormwater General Permit areas and calculation of the FDA_{SWP} term for the Mission and Aransas Rivers.

Watershed	AU	MS4 General Permit(acres)	Multi-sector General Permit (acres)	Construction Activities (acres)	Concrete Production Facilities (acres)	Petroleum Bulk Stations (acres)	Total Area of Permits (acres)	Watershed Area (acres)	FDA_{SWP}
Mission	2001_01	0	343	57	0	0	400	658,817	0.0606%
Aransas	2003_01	0	49	149	5	0	203	539,806	0.0375%

In order to calculate WLA_{SW}, the Future Growth (FG) term must be known. The calculation for the FG term is presented in a later report section, but the results will be included here for continuity. Table 16 provides the information needed to compute WLA_{SW}.

Table 16. Regulated stormwater calculations for Mission River Tidal and Aransas River Tidal.

All loads expressed as billion MPN/day Enterococci

Watershed	AU	TMDL	WLA_{WWTF}	FG	MOS	FDA_{SWP}	WLA_{SW}
Mission	2001_01	370.543	1.172	0.119	18.527	0.0606%	0.213
Aransas	2003_01	150.321	9.366	1.191	7.516	0.0375%	0.050

Once the WLA_{SW} and WLA_{WWTF} terms are known, the WLA term can be calculated as the sum of the two parts, as shown in Table 17.

Table 17. Waste load allocation calculations for the Mission River Tidal and Aransas River Tidal.

All loads expressed as billion MPN/day Enterococci

Watershed	AU	WLA_{WWTF}	WLA_{SW}	WLA
Mission	2001_01	1.172	0.213	1.385
Aransas	2003_01	9.366	0.050	9.416

Implementation of WLAs

The TMDLs in this document will result in protection of existing beneficial uses and conform to Texas's antidegradation policy. The three-tiered antidegradation policy in the State of Texas Surface Water Quality Standards prohibits an increase in loading that would cause or contribute to degradation of an existing use. The antidegradation policy applies to point source pollutant discharges. In general, antidegradation procedures establish a process for reviewing individual proposed actions to determine if the activity will degrade water quality.

The TCEQ intends to implement the individual WLAs through the permitting process as monitoring requirements and/or effluent limitations as required by the amendment of 30 Texas Administrative Code (TAC) Chapter 319 which became effective November 26, 2009. WWTFs discharging to the TMDL segments will be assigned an effluent limit based on the TMDL. Monitoring requirements are based on permitted flow rates and are listed in 30 TAC Section 319.9.

The permit requirements will be implemented during the routine permit renewal process. However, there may be a more economical or technically feasible means of achieving the goal of improved water quality and circumstances may warrant changes in individual WLAs after this TMDL is adopted. Therefore, the individual WLAs, as well as the WLAs for stormwater, are non-binding until implemented via a separate TPDES permitting action, which may involve preparation of an update to the state's WQMP. Regardless, all permitting actions will demonstrate compliance with the TMDL.

The executive director or commission may establish interim effluent limits and/or monitoring-only requirements through a permit amendment or permit renewal. These interim limits will allow a permittee time to modify effluent quality in order to attain the final effluent limits necessary to meet the TCEQ and EPA approved TMDL allocations. The duration of any interim effluent limits may not be any longer than three years from the date of permit re-issuance. New permits will not contain interim effluent limits because compliance schedules are not allowed for a new permit.

Where a TMDL has been approved, domestic WWTF TPDES permits will require conditions consistent with the requirements and assumptions of the WLAs. For NPDES/ TPDES-regulated municipal, construction stormwater discharges, and industrial stormwater discharges, water quality-based effluent limits (WQBELs) that implement the WLA for stormwater may be expressed as "system-wide requirements", rather than as numeric effluent limits pertaining to specific discharge locations (EPA 2014).

Using an iterative adaptive approach to the maximum extent practicable is appropriate to address the stormwater component of this TMDL. Therefore, an iterative, adaptive management approach will be used to address stormwater discharges. This approach encourages the implementation of structural or non-structural controls, implementation of mechanisms to evaluate the performance of the controls, and finally, allowance to make adjustments (e.g., more stringent controls or specific best management practices) as necessary to protect water quality.

Updates to WLAs

This TMDL is, by definition, the total of the sum of the WLA, the sum of the LA, and the MOS. Changes to individual WLAs may be necessary in the future in order to accommodate growth or other changing conditions. These changes to individual WLAs do not ordinarily require a revision of the TMDL document; instead, changes will be made through updates to the TCEQ's WQMP. Any future changes to effluent limitations will be addressed through the permitting process and by updating the WQMP.

Allowance for Future Growth

The FG component of the TMDL equation addresses the requirement to account for future loadings that may occur due to population growth, changes in community infrastructure, and development. Specifically, this TMDL component takes into account the probability that new flows from WWTF discharges may occur in the future. The assimilative capacity of streams increases as the amount of flow increases. Increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the contact recreation standard.

The allowance for FG will result in protection of existing beneficial uses and conform to Texas's antidegradation policy.

Currently 12 facilities that treat domestic wastewater are located within the watersheds of the Mission and Aransas Rivers; three in the Mission River watershed and nine in the Aransas River watershed (Table 18). To account for the FG component of the impaired segments, the loadings from all WWTFs are included in the FG computation, which is based on the WLA_{WWTF} formula. The FG equation contains an additional term to account for projected population growth within the WWTF service areas between 2010 and 2050, based on data obtained from the TWDB 2017 State Water Plan Projections Data website (TWDB, 2013)

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

Where:

Criterion = 35 MPN/100 mL (Enterococci)

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

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

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

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

The calculation results are shown in Table 18.

Compliance with these TMDLs is based on keeping the bacteria concentrations in the selected waters below the limits that were set as criteria for the individual sites. Future growth of existing or new point sources is not limited by these TMDLs as long as the sources do not cause bacteria to exceed the limits. The assimilative capacity of streams increases as the amount of flow increases. Consequently, increases in flow allow for increased loadings. The LDCs and tables in this TMDL will guide determination of the assimilative capacity of the stream under changing conditions, including future growth.

Load Allocation

The LA is the load from unregulated sources, and is calculated as:

LA = TMDL - WLA - FG - MOS

Where:

LA = allowable loads from unregulated sources within the AU

TMDL = total maximum daily load

WLA = sum of all WWTF loads and all regulated stormwater loads

FG = sum of future growth loads from potential permitted facilities

MOS = margin of safety load

The calculation results are shown in Table 19.

Table 18. Future growth calculations for the Mission River Tidal and Aransas River Tidal.

Entries are sorted alphabetically by County and Water User Group.

Water-shed	County	Water User Group (WUG)	% Population Increase (2010 to 2050)*	Facility	AU	Full Permitted Flow (MGD)*	Future Growth (MGD)	FG (Enterococci Billion MPN/ day)
Mission	Bee	County - Other	11.6%	Pettus MUD WWTF	2002_01	0.105	0.012	0.015
Mission	Refugio	Refugio	10.0%	Town of Refugio WWTF	2002_01	0.576	0.058	0.072
Mission	Refugio	Woodsboro	10.0%	Town of Woodsboro WWTF	2001_01	0.25	0.025	0.032
Mission Total						0.931	0.095	0.119
Aransas	Bee	Beeville	11.6%	City of Beeville - Moore Street WWTF	2004_01	3.0	0.35	0.437
Aransas	Bee	County - Other	11.6%	City of Beeville - Chase Field WWTF	2004_01	2.5	0.29	0.364
Aransas	Bee	County - Other	11.6%	Skidmore WSC WWTF	2004_01	0.131	0.015	0.019
Aransas	Bee	County - Other	11.6%	Tynan WSC WWTF	2004_01	0.045	0.005	0.007
Aransas	San Patricio	County - Other	16.4%	St. Paul WSC WWTF	2003_01	0.05	0.008	0.010
Aransas	San Patricio	County - Other	16.4%	Texas Dept. of Trans-portation - Sinton Engineering Building WWTF	2003_01	0.00038	0.0001	0.00008
Aransas	San Patricio	Sinton	16.4%	City of Sinton-Main WWTF	2003_01	0.80	0.131	0.165
Aransas	San Patricio	Sinton	16.4%	City of Sinton-Rod and Bessie Welder WWTF	2003_01	0.015	0.0025	0.0031
Aransas	San Patricio	Taft	16.4%	City of Taft WWTF	2003_01	0.90	0.148	0.186
Aransas Total						7.441	0.949	1.191

*Significant figures reflect MGD figures presented in TPDES permits.

Table 19. Load allocation calculations for the Mission River Tidal and Aransas River Tidal.

Units expressed as billion MPN/ day Enterococci

Watershed	AU	TMDL	WLA	FG	MOS	LA
Mission	2001_01	370.543	1.385	0.119	18.527	350.512
Aransas	2003_01	150.321	9.416	1.191	7.516	132.197

Summary of TMDL Calculations

Table 20 summarizes the TMDL calculations for the Mission River Tidal and Aransas River Tidal. Each of the TMDLs was calculated based on the median flow in the 0-10 percentile range (5% exceedance, high flow regime) for flow exceedance from the LDC developed for the downstream SWQM station within each watershed. Allocations are based on the current geometric mean criterion for Enterococci of 35 MPN/100 mL for each component of the TMDL.

Table 20. TMDL allocation summary for the Mission River Tidal and Aransas River Tidal watersheds.

Units expressed as billion MPN/ day Enterococci

AU	Stream Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA[e]	Future Growth[f]
2001_01	Mission River Tidal	370.543	18.527	1.172	0.213	350.512	0.119
2003_01	Aransas River Tidal	150.321	7.516	9.366	0.050	132.197	1.191

[a] TMDL = Median flow (highest flow regime) * 35 MPN/100 mL * Conversion Factor; where the Conversion Factor = 283.168 100 mL/ft^3 * 86,400 sec/day; Median Flow from Table 12

[b] MOS = 0.05 * TMDL

[c] WLA_{WWTF} = 35 MPN/day * Flows (MGD) * Conversion Factor * (1 – F_{MOS}); where Flow is the full permitted flow from regulated discharging facilities (Table 14); Conversion Factor = 1.54723 cfs/MGD * 283.168 100 mL/ft^3; F_{MOS} = 5% or 0.05

[d] WLA_{SW} = (TMDL - $\sum WLA_{WWTF}$ - $\sum$FG - MOS) * FDA_{SWP}; (see Table 16)

[e] LA = TMDL - $\sum WLA_{WWTF}$ - $\sum WLA_{SW}$ - $\sum$FG - MOS; (see Table 19)

[f] Future Growth = 35 MPN/100 mL * [$\%POP_{2010-2050}$ * $WWTF_{FP}$] * Conversion Factor * (1 – F_{MOS}); Conversion Factor = 1.54723 cfs/MGD * 283.168 100 mL/ft^3; $WWTF_{FP}$ is full permitted flows and $\%POP_{2010-2050}$ is from Table 18

The final TMDL allocations (Table 21) needed to comply with the requirements of 40 CFR 130.7 include the future growth component within the WLA_{WWTF}.

In the event that the criterion changes due to future revisions in the state's surface water quality standards, Appendix B provides guidance for recalculating the allocations in Table 21. Figures B-1 and B-2 of Appendix B were developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant load allocations change in relation to a number of proposed water quality criteria for Enterococci. The equations provided, along with Figures B-1 and B-2, allow calculation of new TMDLs and pollutant load allocations based on any potential new water quality criterion for Enterococci.

Table 21. Final TMDL allocations for the Mission River Tidal and Aransas River Tidal.

Units expressed as billion MPN/ day Enterococci

AU	TMDL	WLA_{WWTF}*	WLA_{SW}	LA	MOS
2001_01	370.543	1.291	0.213	350.512	18.527
2003_01	150.321	10.558	0.050	132.197	7.516

* WLA_{WWTF} includes the future potential allocation to wastewater treatment facilities

Seasonal Variation

Seasonal variations or seasonality occur(s) when there is a cyclic pattern in stream flow and, more importantly, in water quality constituents. Federal regulations (40 CFR 130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading.

Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing Enterococci concentrations obtained from routine monitoring collected in the warmer months (May – September) against those collected during the cooler months (November – March). The months of April and October were considered transitional between the warm and cool seasons and were excluded from the seasonal analysis. Differences in Enterococci concentrations obtained in warmer versus cooler months were then evaluated by performing a Wilcoxon Rank Sum test on the original dataset. The nonparametric Wilcoxon Rank Sum test was selected because even with logarithmic transformation, the bacteria data were non-normally distributed. This analysis of Enterococci data indicated that there was a significant difference (α=0.05, p=0.0090) in indicator bacteria between cool and warm weather seasons only for the upstream station of the Aransas River Tidal (Station 12948, Segment 2003), where cool season concentrations were determined to be less than the warm season concentrations. Seasonality was not detected at the Aransas River Tidal downstream station (12947, Segment 2003), nor at the Mission River Tidal station (12943, Segment 2001).

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the investigation, the project team sought to ensure that stakeholders were informed and involved. Communication and comments from the stakeholders in the watershed strengthen TMDL projects and their implementation.

The TCEQ and Texas Water Resources Institute (TWRI) are jointly providing coordination for public participation in this project for development of the TMDL and the TMDL Implementation Plan (I-Plan). A series of public meetings were held over recent years to keep the public aware of the TMDL and to engage public participation in development of the I-Plan.

Public meetings were held in Refugio on January 30, 2012, March 28, 2012, May 30, 2012, August 1, 2012, November 29, 2012, February 19, 2013, April 11, 2013, May 21, 2013, July 11, 2013, and August 20, 2013. At many of the meetings, the main focus was development of the I-Plan, but at certain strategic meetings the participants were introduced to the TMDL process and progress on development of the TMDL. Notices of meetings were posted on the project Web page at both TWRI and TCEQ and on the TCEQ's TMDL program's online calendar. At least two weeks prior to scheduled meetings, the TWRI issued direct mailings and media releases and formally invited stakeholders to attend. To ensure that absent or new stakeholders could get information about past meetings and pertinent material, the TWRI project Web page provides meeting summaries, presentations, ground rules, and documents produced for review at <http://copanobay-wq.tamu.edu/meetings/>.

Implementation and Reasonable Assurance

The issuance of TPDES permits consistent with TMDLs provides reasonable assurance that WLAs in this TMDL report will be achieved. Per federal requirements, each TMDL is included in an update to the Texas WQMP as a plan element.

The WQMP coordinates and directs the state's efforts to manage water quality and maintain or restore designated uses throughout Texas. The WQMP is continually updated with new, more specifically focused plan elements, as identified in federal regulations (CFR Section 130.6(c)). Commission adoption of a TMDL is the state's certification of the associated WQMP update.

Because the TMDL does not reflect or direct specific implementation by any single pollutant discharger, the TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the commission. Based on the TMDL and I-Plan, the TCEQ will propose and certify WQMP updates to establish required water-quality-based effluent limitations necessary for specific TPDES wastewater discharge permits.

No MS4 permits are held in the watersheds of the Mission and Aransas Rivers as of March 2013. However, population growth in these watersheds may require urbanized areas within them to obtain Phase II MS4 stormwater permits in the future. For MS4 permits, the TCEQ will normally establish best management practices, which are a substitute for effluent limitations, as allowed by federal rules, where numeric effluent limitations are infeasible. When such practices are established in an MS4 permit, the TCEQ will not identify specific implementation requirements applicable to a specific TPDES storm water permit through an effluent limitation update. Rather, the TCEQ might revise a stormwater permit, require a revised Stormwater Management Program or Pollution Prevention Plan, or implement other specific revisions affecting stormwater dischargers in accordance with an adopted I-Plan.

Strategies for achieving pollutant loads in TMDLs from both point and nonpoint sources are reasonably assured by the state's use of an I-Plan. The TCEQ is committed to supporting implementation of all TMDLs adopted by the commission.

I-Plans for Texas TMDLs use an adaptive management approach that allows for refinement or addition of methods to achieve environmental goals. This adaptive approach reasonably assures that the necessary regulatory and voluntary activities to achieve pollutant reductions will be implemented. Periodic, repeated evaluations of the effectiveness of implementation methods ascertain whether progress is occurring, and may show that the original distribution of loading among sources should be modified to increase efficiency. I-Plans will be adapted as necessary to reflect needs identified in evaluations of progress.

Key Elements of an I-Plan

An I-Plan includes a detailed description and schedule of the regulatory and voluntary management measures to implement the WLAs and LAs of particular TMDLs within a reasonable time. I-Plans also identify the organizations responsible for carrying out management measures, and a plan for periodic evaluation of progress.

Strategies to optimize compliance and oversight are identified in an I-Plan when necessary. Such strategies may include additional monitoring and reporting of effluent discharge quality to evaluate and verify loading trends, adjustment of an inspection frequency or a response protocol to public complaints, and escalation of an enforcement remedy to require corrective action of a regulated entity contributing to an impairment.

The TCEQ works with stakeholders and interested governmental agencies to develop and support I-Plans and track their progress. Work on the I-Plan begins during development of TMDLs. Because these TMDLs include potential agricultural sources of pollution, the TCEQ will also work in close partnership with the Texas State Soil and Water Conservation Board (TSSWCB) when developing the I-Plan. The TSSWCB is the lead agency in Texas responsible for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural nonpoint sources of water pollution. The cooperation required to develop an I-Plan will become a cornerstone for the shared responsibility necessary to carry it out.

Ultimately, the I-Plan will identify the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the I-Plan that is approved may not approximate the predicted loadings identified category-by-category in the TMDL and its underlying assessment. The I-Plan is adaptive for this very reason; it allows for continuous update and improvement.

In most cases, it is not practical or feasible to approach all TMDL implementation as a one-time, short-term restoration effort. This is particularly true when a challenging wasteload reduction or load reduction is required by the TMDL, there is high uncertainty with the TMDL analysis, there is a need to reconsider or revise the established water quality standard, or the pollutant load reduction would require costly infrastructure and capital improvements.

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Appendix A.
Modified Load Duration Curve

Traditionally, the LDC approach has been restricted in TMDL development to freshwater, non-tidally influenced streams and rivers. The reason for excluding application of LDCs in TMDL development for tidally influenced stream and river systems is the presence of seawater in these river systems, i.e., an additional flow that has a loading. An assumption behind the LDC approach is that the loadings of bacteria are derived exclusively from the sources of the stream flows. These sources and their associated loadings may be varied, but it is inherently assumed that they may be computationally determined based on the stream flow at the selected exceedance frequency on the LDC used for the load allocation. But in a tidal system there is other water (i.e., seawater) that is a source with an associated loading that must be considered.

If the LDC approach is to be adapted to tidally influenced streams and rivers, some means of addressing the additional water and loadings from the seawater that mixes with freshwater in tidal rivers is needed. Oregon's Umpqua Basin Bacteria TMDL provides a modification of the LDC approach that accounts for the seawater component (ODEQ, 2006).

Their approach is based on determining the volume of seawater that must be mixed with the volume of freshwater going down the river to arrive at the "observed" salinity using a simple mass balance approach as provided in the following:

$$(V_r + V_s) * S_t = V_r * S_r + V_s * S_s \qquad \text{(A-1)}$$

Where

V_r = volume daily river flow (m^3) = Q (cfs)*86,400 (sec/day); where Q = river flow (cfs)

V_s = volume of seawater

S_t = salinity in river (parts per thousand or ppt)

S_r = background salinity of river water (ppt); assumed to be close to 0 ppt

S_s = salinity of seawater (35 ppt)

As noted in the computation of V_r, the volumes are actually time-associated using a day as the temporal measure, thus providing the proper association for the daily pollutant load computation. Through algebraic manipulation this mass balance equation can be solved for the daily volume of seawater required to be mixed with freshwater (again, freshwater having an assumed salinity = 0) giving the equation found in the ODEQ (2006) technical information:

$$V_s = V_r \,/\, (S_s/S_t - 1);$$

for S_t > than background salinity; otherwise $V_s = 0$ (A-2)

For the Umpqua Basin tidal streams (e.g., Figure A-1), as well as the present application to the Mission River Tidal and the Aransas River Tidal (Figures 6 and 7 in this report), regressions were developed of S_t to Q using measured salinity data (S_t) with freshwater flows (Q). These regressions all had some stream flow above which S_t = zero. The daily Q and regression-developed S_t were then used to compute V_s. As S_t approaches zero, V_s likewise approaches a value of zero in Equation A-2, meaning the only flow present is the river flow (Q or V_r).

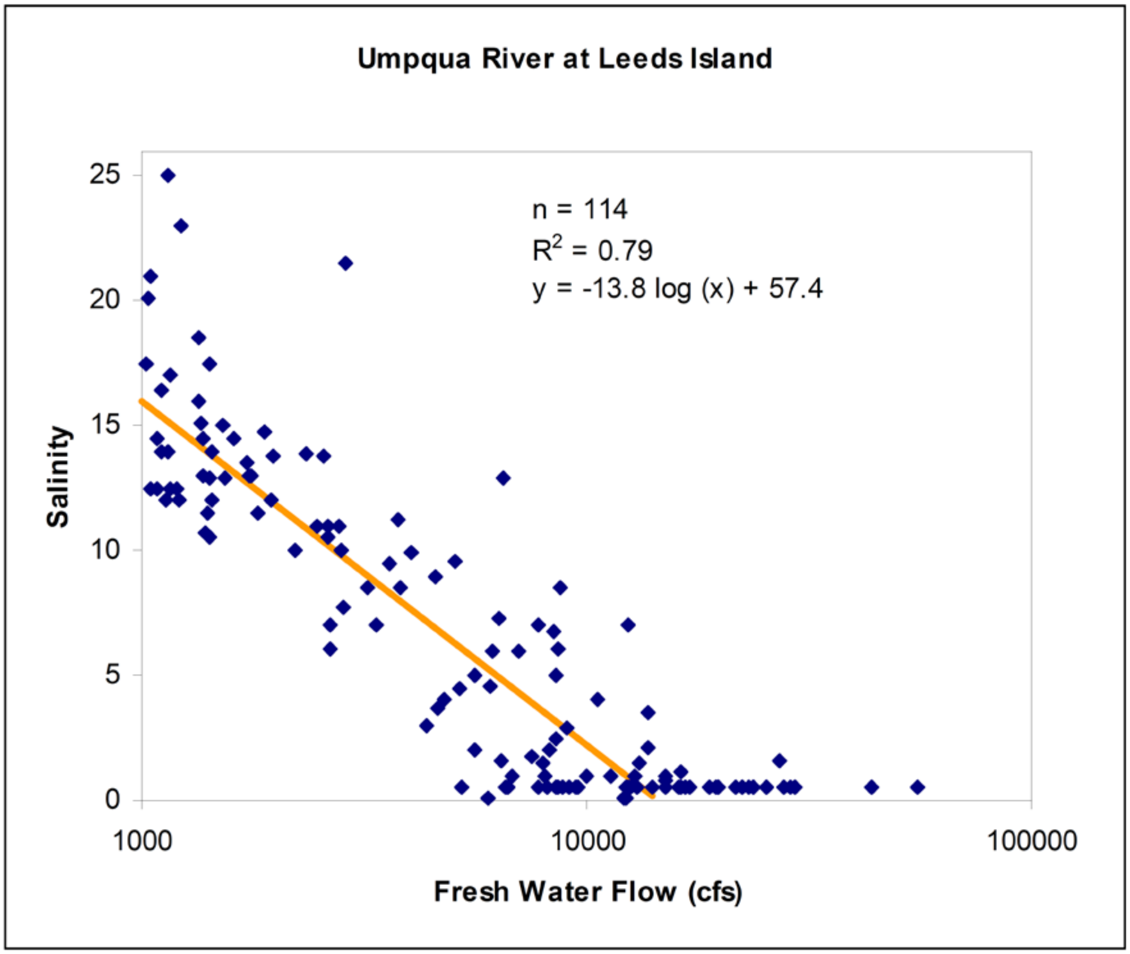

Figure A-1. Example salinity to flow regression from Umpqua Basin Tidal streams (ODEQ, 2006)

It is also relevant to discuss the response of measured salinities at assessment stations to stream flow and the stream flows above which salinities approach background levels (again, assumed to be 0.0) within the context of FDCs for the Mission and Aransas Rivers. These FDCs and the plotted flow exceedance values where salinities approach background should be viewed from the perspective of TCEQ's approach for bacteria TMDLs. Within the TCEQ TMDL approach with indicator bacteria, the highest flow regime is selected for developing the pollutant load allocation. This flow regime is defined as the range of 0-10% for the Mission

River Tidal and Aransas River Tidal. All the flows in the highest flow regime are greater than the amount of stream flow indicated by the regression analysis as needed to result in an absence of seawater.

The significance of the above observation is related to what happens within the modified LDC approach when salinities are at background. As salinity approaches background, V_s in Equation A-2 approaches a value of zero, and in fact would be defined as zero when salinities are at background levels, resulting in the modified LDC flow volume ($V_s + V_r$) defaulting to the flow of the river, i.e., *no modification occurring to that portion of the LDC*. Therefore, regarding the pollutant load allocation process for the Mission River Tidal and Aransas River Tidal, the modified LDC method provides identical allowable loadings in the highest flow regime to those that would be computed using the standard LDC method that does not include tidal influences. The identical results of the modified and standard LDC method for the highest flow regime is the physical reality indicated in the observed salinity data. The data indicate that, at these elevated stream flows, seawater is effectively pushed completely out into Copano Bay. But the other implication, in hindsight, is that for these two tidal rivers, the same pollutant load allocation results would be determined with the LDC method with or without tidal influences being considered due to development of the TMDL for the higher stream flows.

Continuing with the theoretical development of the modified LDC for the Umpqua TMDLs, a total daily volume (V_t) is comprised of V_r computed from Q and the volume of seawater (V_s):

$$V_t = V_r + V_s \qquad \text{(A-3)}$$

Resulting in

$$\text{TMDL (MPN/day)} = \text{Criterion} * V_t * \text{Conversion factor} \qquad \text{(A-4)}$$

The actual FDCs developed for this TMDL using the modified LDC contain both a freshwater riverine flow component and a seawater component. For the Mission River Tidal, one FDC was created for Station 12943 (Figure A-2); for the Aransas River Tidal, the FDC used for the pollutant load allocation was created for Station 12947 (Figure A-3). For both Station 12943 on Mission River Tidal and Station 12947 on Aransas River Tidal, the amount of estimated seawater is provided on the FDC graphs. As expected from the equations, the amount of seawater present increases as both the freshwater flow decreases and the percent of days the flow is exceeded increases. Note that the x-axis direction of increase on the seawater plot is reversed from that on the FDC.

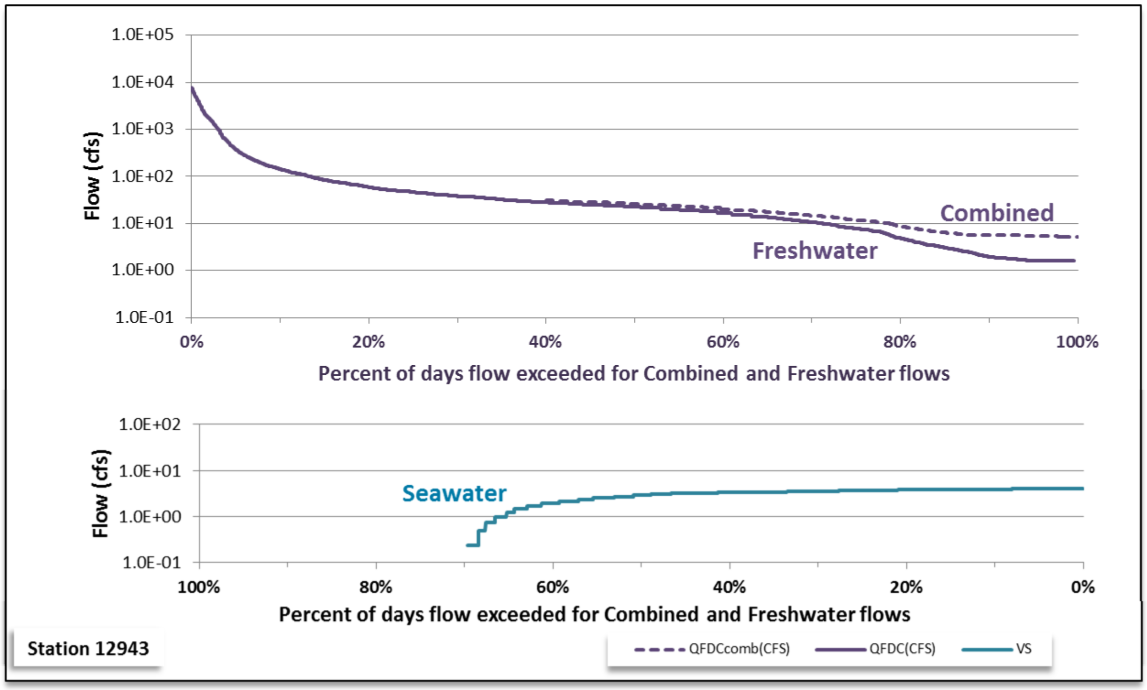

Figure A-3. Flow duration curves for Station 12943, Mission River Tidal.

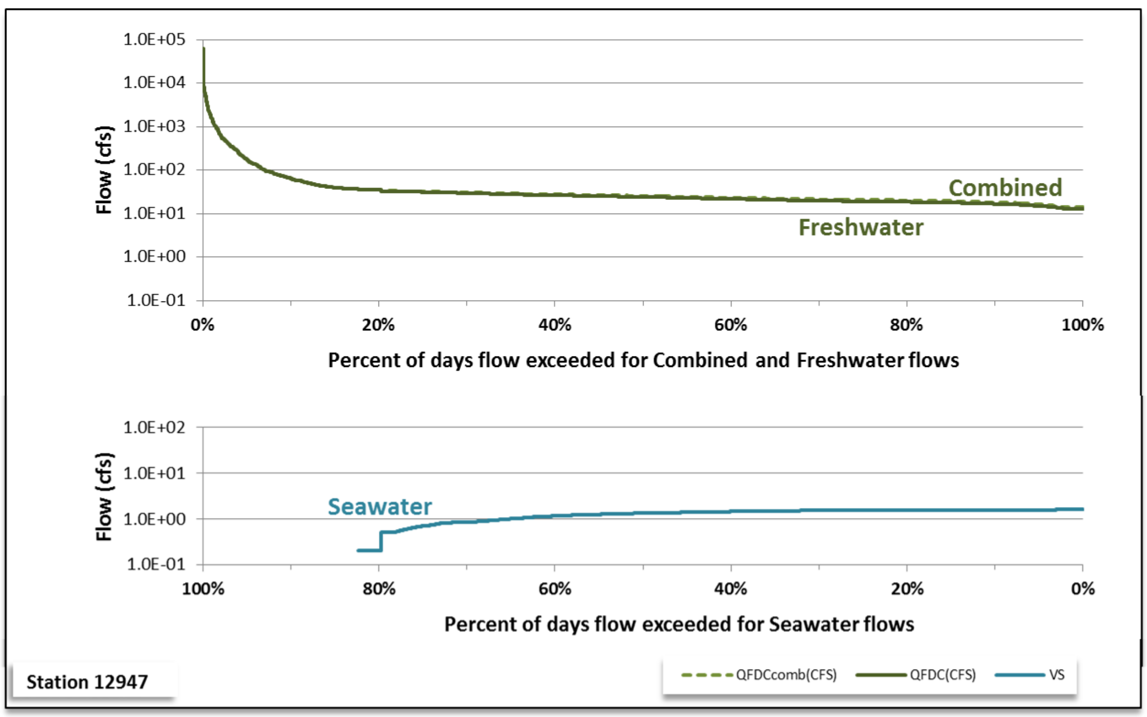

Figure A-4. Flow duration curves for Station 12947, Aransas River Tidal.

Appendix B.
Equations for Calculating TMDL Allocations for Changed Contact Recreation Standard

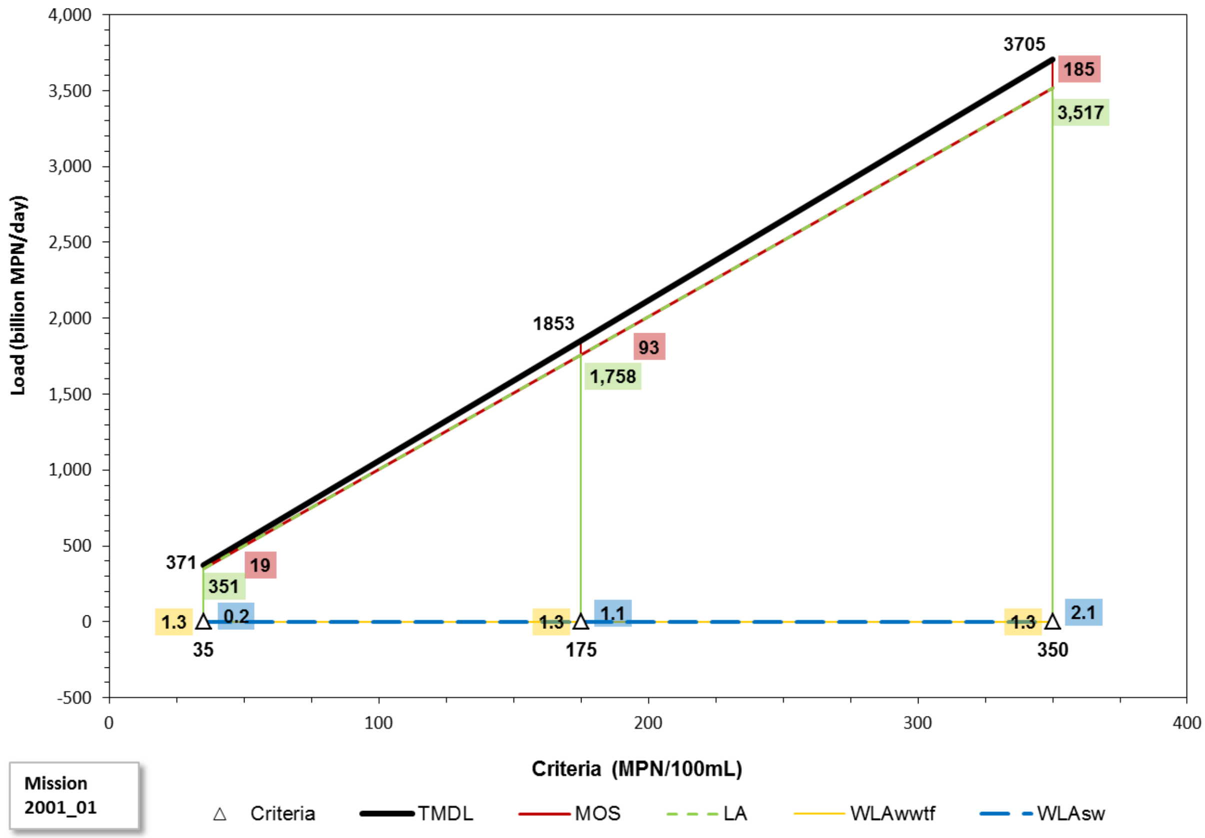

Figure B-1. Allocation loads for the Mission River (2001_01) as a function of water quality criteria

Equations for calculating new TMDL and allocations (in billion MPN/day)

TMDL = 10.5869 * Std

MOS = 0.5293 * Std

LA = 10.0515 * Std - 1.2902

WLA_{WWTF} = 1.2910

WLA_{SW} = 0.0061 * Std - 0.0008

Where:

Std = Revised Contact Recreation Standard

MOS = Margin of Safety

LA = total load allocation (non-permitted source contributions)

WLA_{WWTF} = waste load allocation (permitted WWTF load + future growth)

[Note: WWTF load held at Primary Contact (35 MPN/ 100 mL) criteria]

WLA_{SW} = Waste load allocation (permitted stormwater)

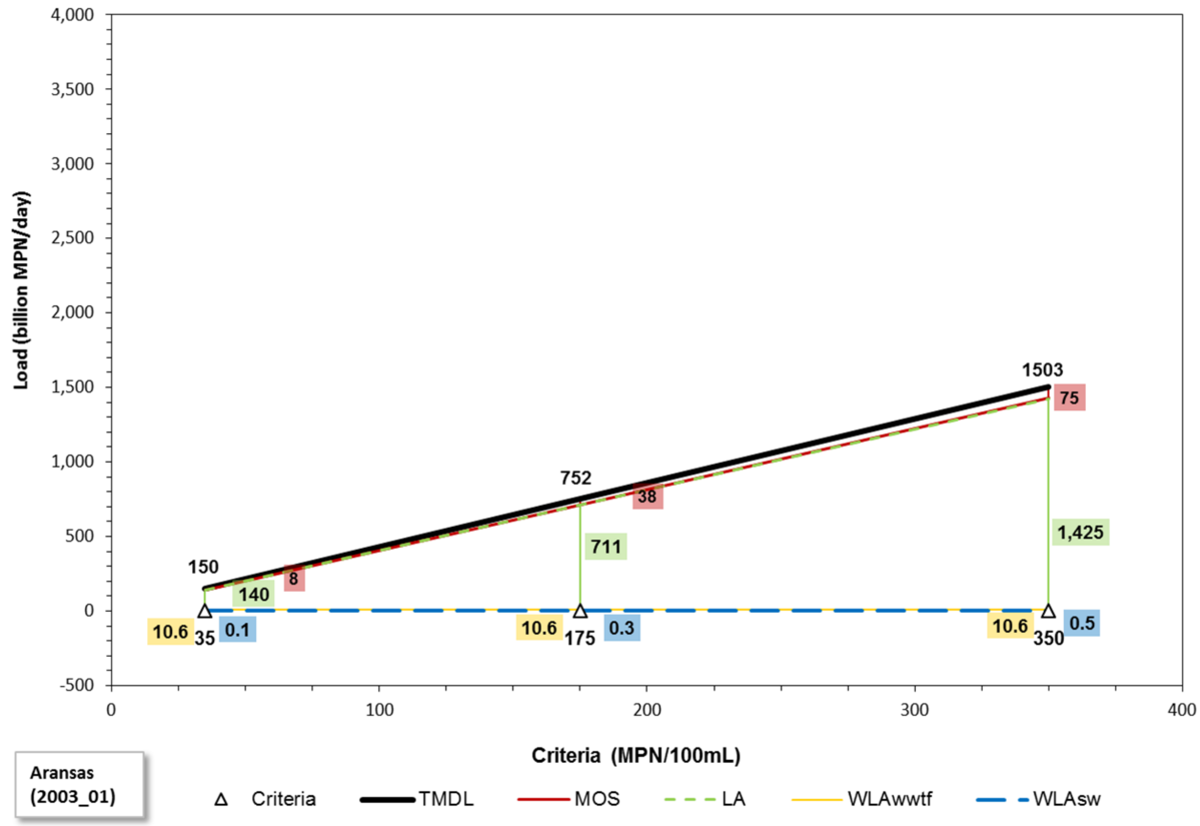

Figure B-2. Allocation loads for the Aransas River (2003_01) as a function of water quality criteria

Equations for calculating new TMDL and allocations (in billion MPN/day)

TMDL = 4.2949 * Std

MOS = 0.2147 * Std

LA = 4.0786 * Std - 10.5536

WLA_{WWTF} = 10.5575

WLA_{SW} = 0.0015 * Std - 0.0040

Where:

Std = Revised Contact Recreation Standard

MOS = Margin of Safety

LA = total load allocation (non-permitted source contributions)

WLA_{WWTF} = waste load allocation (permitted WWTF load + future growth)

[Note: WWTF load held at Primary Contact (35 MPN/ 100 mL) criteria]

WLA_{SW} = Waste load allocation (permitted stormwater)