Dickinson Bayou Watershed: A Community Project to Protect Recreational Uses

Eight TMDLs for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries[1]

Adopted February 8, 2012.

Approved by EPA June 6, 2012.

Three TMDLs for Indicator Bacteria in Dickinson Bayou Added By Addendum I, July 2016[2]

Via the July 2016 Update to the Texas Water Quality Management Plan.

Approved by EPA September 30, 2016.

Two TMDLs for Indicator Bacteria in Dickinson Bayou Added by this Addendum II, April 2022

Via the April 2022 Update to the Texas Water Quality Management Plan (SFR-121/2022-03).

Approved by EPA August 11, 2022 (scroll to view or print this addendum).

[1] https://www.tceq.texas.gov/downloads/water-quality/tmdl/dickinson-bayou-recreational-80/80-dickinson-tmdl-adopted.pdf
[2] https://www.tceq.texas.gov/downloads/water-quality/tmdl/dickinson-bayou-recreational-80/80-dickinson-addendum-01-2016-july.pdf

Appendix VIII. Addendum Two to Eight TMDLs for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries

Adding two Total Maximum Daily Loads (TMDLs) for AUs 1103F_01 and 1103G_01

Two TMDLs for Indicator Bacteria in Dickinson Bayou

Introduction

Texas Commission on Environmental Quality (TCEQ) adopted *Eight TMDLs for Indicator Bacteria in Dickinson Bayou and Three Tidal Tributaries* (TCEQ, 2012) on February 8, 2012. The United States Environmental Protection Agency (EPA) approved the TMDLs on June 6, 2012. An addendum to the original TMDL was submitted to EPA through the July 2016 Water Quality Management Plan (WQMP) update (TCEQ, 2016). That addendum added three additional AU(s). This document is the second addendum to the original TMDL report.

This second addendum includes information specific to two additional assessment units (AUs) for Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 and Unnamed Tributary of Gum Bayou AU 1103G_01 (also referred to in this addendum as the TMDL watersheds). These AUS are located within the watershed of the approved original TMDLs for Dickinson Bayou. The concentrations of indicator bacteria in these additional AUs exceed the criterion used to evaluate support of the primary contact recreation 1 use.

This addendum details the development of the added TMDL allocations for these additional AUs, which were not specifically addressed in the original TMDL report. For background or other explanatory information, please refer to the *Technical Support Document for two Total Maximum Daily Loads for Indicator Bacteria in Unnamed Tributaries of Dickinson Bayou Tidal and Gum Bayou*[3] (Adams and Millican, 2021). Refer to the original, approved TMDL document for details about the overall project watershed as well as methods and assumptions used in developing the original TMDLs.

[3] https://www.tceq.texas.gov/downloads/water-quality/tmdl/dickinson-bayou-recreational-80/80-as-464-unnamed-tribs-dickinson-bayou-tsd-2022-addendum-2.pdf

Problem Definition

TCEQ first identified the bacteria impairments for Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 and Unnamed Tributary of Gum Bayou AU 1103G_01 in the *2018 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (Texas Integrated Report; TCEQ, 2018a) and then in the subsequent 2020 Texas 303(d) List, the latest EPA-approved edition. The impaired AUs are 1103F_01 and 1103G_01. The TMDL watersheds are located entirely within Galveston County. Figure VIII-1 shows the watersheds added in this addendum in relation to the entire watershed of the original TMDLs, and also includes the watersheds from the first addendum.

The Texas Surface Water Quality Standards (TCEQ, 2018b) identify uses for surface waters and numeric and narrative criteria to evaluate attainment of those uses. The basis for the water quality target for the TMDLs developed in this addendum is the numeric criterion for indicator bacteria from the 2018 Texas Surface Water Quality Standards. Enterococci are the indicator bacteria for assessing primary contact recreation 1 use in saltwater.

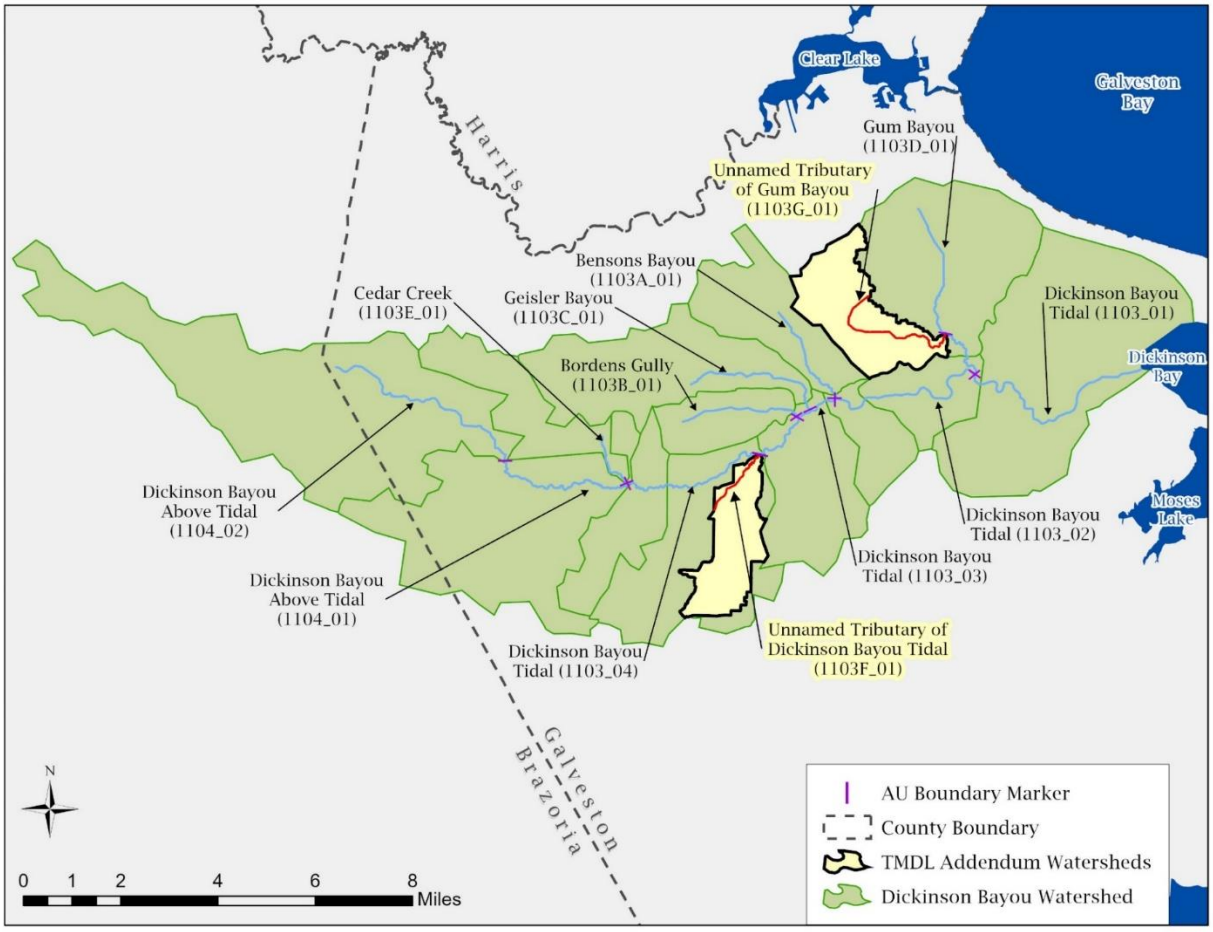

Figure VIII-1. Map showing the previously approved TMDL watersheds and the Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 and Unnamed Tributary of Gum Bayou AU 1103G_01 subwatersheds added by this addendum

Table VIII-1 summarizes the ambient water quality data for the TCEQ surface water quality monitoring (SWQM) stations on the water bodies, as reported in the 2020 Texas Integrated Report (TCEQ, 2020). The data from the assessment indicate nonsupport of the primary contact recreation 1 use for the AUs, because the geometric mean concentration for Enterococci exceeds the saltwater geometric mean criterion of 35 colony forming units per 100 milliliters (cfu/100mL) of water. Figure VIII-2 shows the locations of the TCEQ SWQM stations that were used in evaluating water quality in the 2020 Texas Integrated Report for the water bodies added by this addendum.

Table VIII-1. 2020 Texas Integrated Report summary for the TMDL watersheds

AU	Station	Parameter	Number of Samples	Date Range	Enterococci Geometric Mean (cfu/100 mL)
1103F_01	20477	Enterococci	20	12/01/2011 – 11/30/2018	188
1103G_01	20728	Enterococci	28	12/01/2011 – 11/30/2018	522

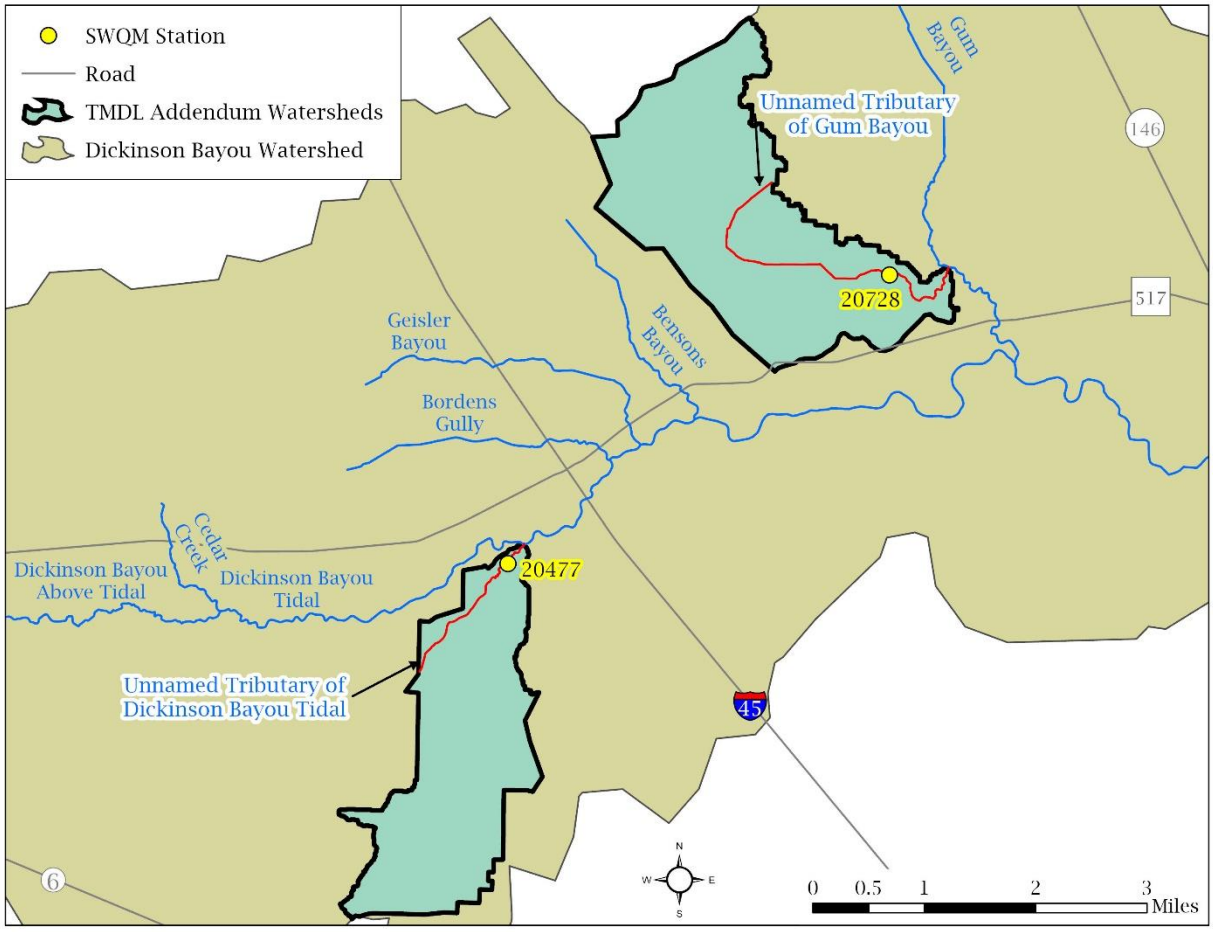

Figure VIII-2. AU 1103F_01 and AU 1103G_01 watersheds showing the TCEQ SWQM stations

Watershed Overview

The Unnamed Tributary of Dickinson Bayou Tidal (AU 1103F_01) is a tributary of Dickinson Bayou (Segment 1103). The Unnamed Tributary of Gum Bayou (AU 1103G_01) is a tributary to Gum Bayou (AU 1103D_01). AU 1103F_01 is approximately 1.71 miles long and drains an area of 3.14 square miles (2,011 acres). AU 1103G_01 is

approximately 3.29 miles long and drains an area of 4.36 square miles (2,788 acres). Both TMDL watersheds are located entirely within Galveston County.

The 2020 Texas Integrated Report (TCEQ, 2020) provides the following description for AU 1103G_01. The description for AU 1103F_01 was revised during development of the TMDLs (TCEQ, 2021a) and the new description shown here will be included in future Integrated Reports:

- 1103F_01 (Unnamed Tributary of Dickinson Bayou Tidal) – From the Dickinson Bayou Tidal confluence to a point 2.75 kilometers (1.7 miles) upstream at Galveston County Drainage Ditch 9.
- 1103G_01 (Unnamed Tributary of Gum Bayou) – From the confluence with Gum Bayou to a point 0.39 miles south of Farm-to-Market 646/Farm-to-Market 1266 intersection between League City and Dickinson.

Watershed Climate

Weather data were obtained for the 15-year period from January 2006 through December 2020 from the National Oceanic and Atmospheric Administration (NOAA) National Center for Environmental Information. The Houston National Weather Service Office weather station (USC00414333) located in League City was used to retrieve the precipitation and temperature data (NOAA, 2021, Figure VIII-3). Data from this 15-year period indicate that the average monthly high temperature typically reaches a maximum of 92.5 ˚F in August, and the average monthly low temperature reaches a minimum of 43 ˚F in January (Figure VIII-3). Annual rainfall averages 60.7 inches. The wettest month is September (7.9 inches) while February (2.6 inches) is the driest month, with rainfall occurring throughout the year.

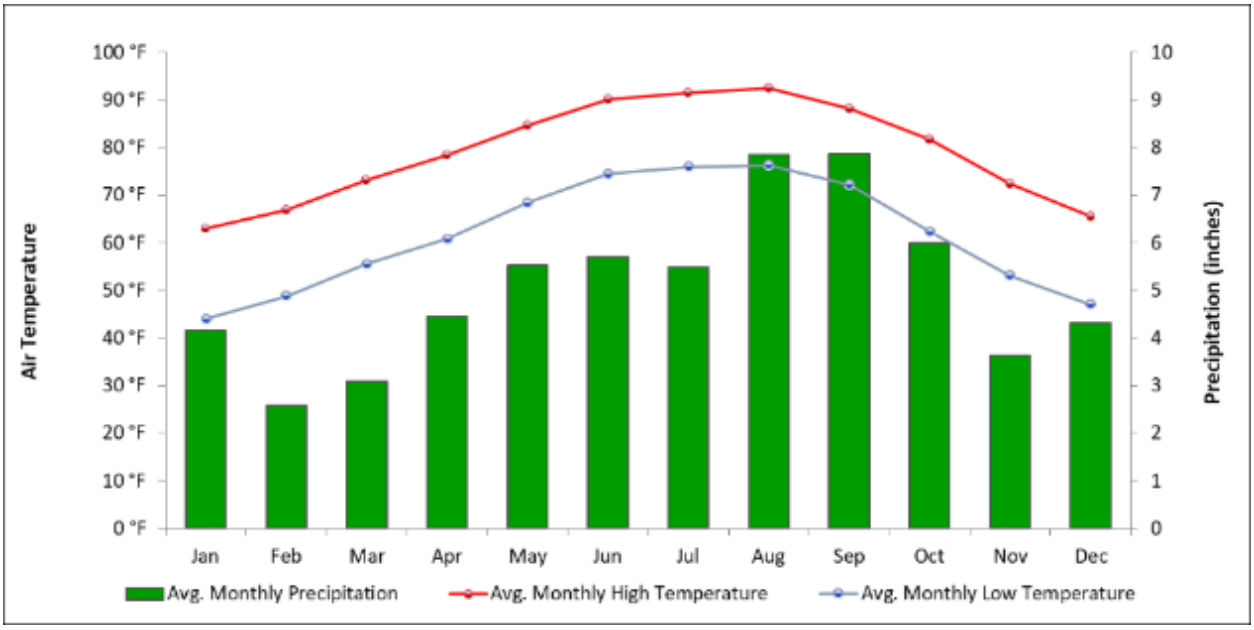

Figure VIII-3. Average monthly temperature and precipitation (2006–2020) at the National Weather Center Office in League City weather station

Watershed Population and Population Projections

The TMDL watersheds are located within Galveston County and include portions of three municipal boundaries (Dickinson, Santa Fe, and League City). According to the United States Census Bureau (USCB) 2010 Census (USCB, 2010), the AU 1103F_01 watershed had an estimated population of 1,608 people in 2010 and the AU 1103G_01 watershed had an estimated population of 10,166 people in 2010.

The population projections in Table VIII-2 are estimated from the H-GAC 2018 Regional Growth Forecast data (H-GAC, 2017). The regional growth forecasts include population projections for transportation analysis zones (TAZ), planning areas used by H-GAC to provide analyses at a local scale. H-GAC updates their regional growth forecast using inputs such as the latest available information on planned and announced developments, population and employment data, and feedback received from forecast users.

Table VIII-2. 2010 population and 2045 population projections for the TMDL watersheds

Area	2010 Estimated Population	2045 Projected Population	Projected Population Increase	Percentage Change
Unnamed Tributary of Dickinson Bayou Tidal (AU 1103F_01) Watershed	1,608	3,120	1,512	94.0%
Unnamed Tributary of Gum Bayou (AU 1103G_01) Watershed	10,166	17,266	7,100	69.8%

The following steps detail the method used to estimate the 2010 and projected 2045 populations in the TMDL watersheds.

1. Obtained 2010 USCB data at the block level.
2. Developed 2010 watershed populations using the block level data for the portion of the census blocks located within the watersheds.
3. For the census blocks that were partially located in the watershed, estimated population by multiplying the block population to the proportion of its area in the watersheds.
4. Obtained the 2018 H-GAC regional growth forecast data and associated TAZs to be used for population projections (H-GAC, 2017).
5. Joined population data for each TAZ with the TAZ polygons in a geographic information system and located the TAZs within the TMDL watersheds.
6. For the TAZs that were partially located in the watersheds, estimated population projections by multiplying the TAZ population to the proportion of its area in the watersheds.
7. Subtracted the 2010 watershed populations from the 2045 population projections to determine the projected population increases. Subsequently, divided the projected population increases by the 2010 watershed populations to determine the percentage population increases for the TMDL watersheds.

Land Cover

The land cover data were obtained from the United States Geological Survey (USGS) 2016 National Land Cover Database (NLCD; USGS, 2019). The land cover for the TMDL watersheds is shown in Figure VIII-4. A summary of the land cover data is provided in Table VIII-3. For the Unnamed Tributary of Dickinson Bayou Tidal (AU 1103F_01) watershed, the predominant land cover is Developed, Open Space comprising 45.41% of the total land cover, followed by Pasture/Hay (11.88%) and Developed, Low Intensity (10.77%). For the Unnamed Tributary of Gum Bayou (AU 1103G_01) watershed, the Developed categories (Low Intensity 30.53%, Open Space 26.76%, Medium Intensity

16.63%, and High Intensity 5.27%) are the dominant land covers comprising 79.19% of the total.

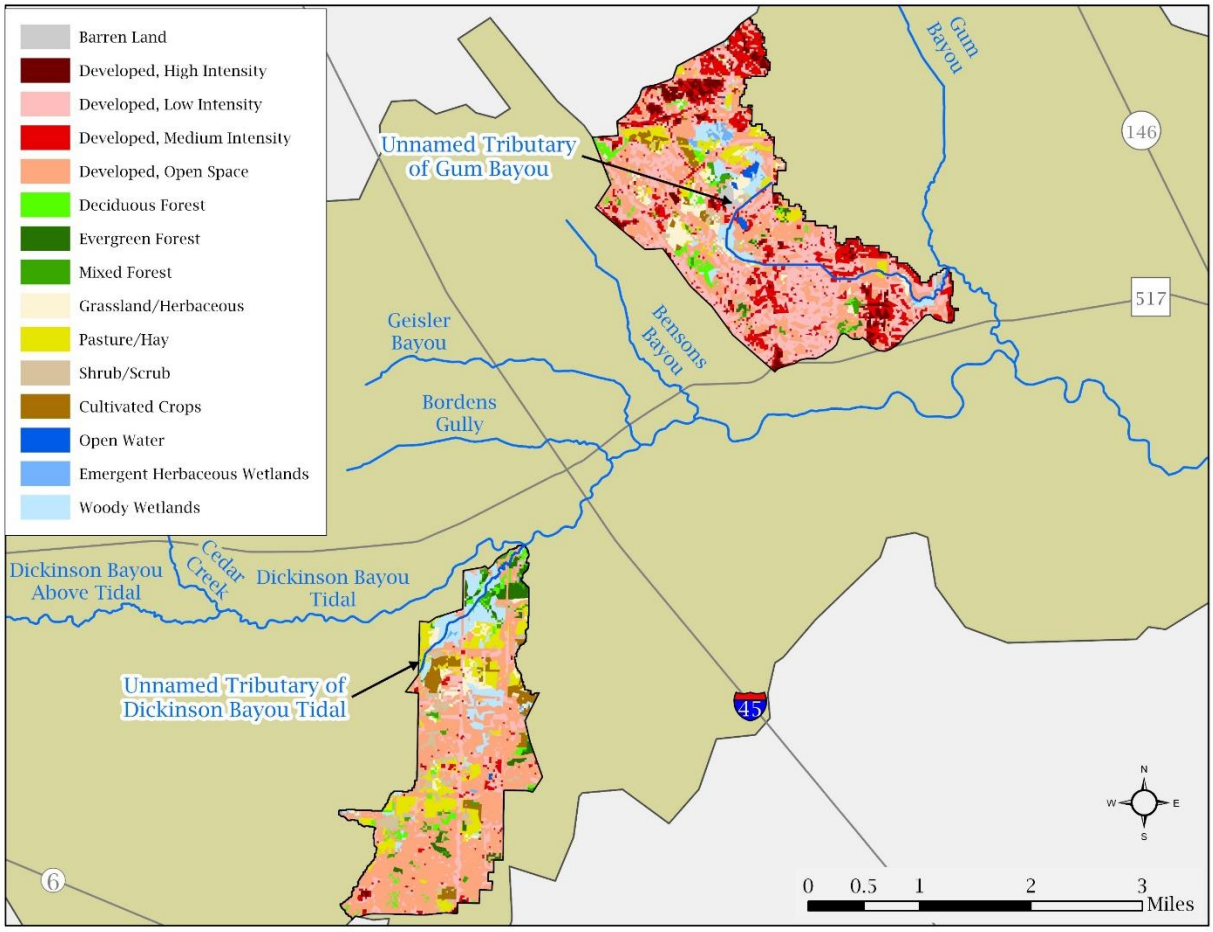

Figure VIII-4. 2016 land cover

Table VIII-3. Land cover summary

2016 NLCD Classification	1103F_01 Area (Acres)	1103F_01 Percentage of Total	1103G_01 Area (Acres)	1103G_01 Percentage of Total
Barren Land	0.45	0.02%	18.23	0.65%
Developed, High Intensity	6.47	0.32%	146.81	5.27%
Developed, Low Intensity	216.61	10.77%	850.94	30.53%
Developed, Medium Intensity	40.26	2.00%	463.65	16.63%
Developed, Open Space	913.25	45.41%	745.97	26.76%
Deciduous Forest	53.73	2.67%	57.05	2.05%
Evergreen Forest	61.31	3.05%	10.55	0.38%

2016 NLCD Classification	1103F_01 Area (Acres)	1103F_01 Percentage of Total	1103G_01 Area (Acres)	1103G_01 Percentage of Total
Mixed Forest	41.06	2.04%	32.11	1.15%
Grassland/Herbaceous	65.11	3.24%	122.32	4.39%
Pasture/Hay	238.89	11.88%	122.45	4.39%
Shrub/Scrub	103.79	5.16%	29.77	1.07%
Cultivated Crops	82.04	4.08%	41.78	1.50%
Open Water	1.88	0.09%	15.33	0.55%
Emergent Herbaceous Wetlands	6.35	0.32%	21.46	0.77%
Woody Wetlands	180.09	8.95%	109.17	3.92%
Total	**2,011.29**	**100%**	**2,787.59**	**100 %**

Endpoint Identification

The endpoint for the TMDLs is to maintain the concentration of Enterococci below the geometric mean criterion of 35 cfu/100 mL, which is protective of the primary contact recreation 1 use in saltwater.

Source Analysis

Pollutants may come from several sources, both regulated and unregulated. Pollutants in regulated discharges, 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) program. Wastewater treatment facilities (WWTFs) and stormwater discharges from industries, construction activities, and the separate storm sewer systems 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 surface waters. Nonpoint sources are not regulated by permit.

Except for WWTFs, which receive individual wasteload allocations (WLAs; see the Wasteload Allocation section), the regulated and unregulated sources in this section are presented to give a general account of the different sources of bacteria expected in the watersheds. 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 program. The regulated sources in the TMDL watersheds include stormwater discharges from industrial and regulated construction sites, and municipal separate storm sewer systems (MS4s).

Domestic and Industrial WWTFs

As of April 5, 2021, there were no WWTFs with TPDES permits within the TMDL watersheds.

TCEQ/TPDES Water Quality General Permits

Certain types of activities are required to be covered by one of several TCEQ/TPDES wastewater general permits:

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production
- TXG340000 – petroleum bulk stations and terminals
- TXG640000 – conventional water treatment plants
- TXG670000 – hydrostatic test water discharges
- TXG830000 – water contaminated by petroleum fuel or petroleum substances
- TXG870000 – pesticides (application only)
- TXG920000 – concentrated animal feeding operations
- WQG100000 – wastewater evaporation
- WQG200000 – livestock manure compost operations (irrigation only)

A review of active general permit coverage (TCEQ, 2021b) in the TMDL watersheds, as of April 5, 2021, found two pesticide permittees were covered by the general permit. The pesticide general permit does not have bacteria reporting requirements or limits. Pesticide application in the pesticide management areas is assumed to contain inconsequential amounts of indicator bacteria; therefore, it was unnecessary to allocate bacteria loads to them. No other active wastewater general permit authorizations were found in the TMDL watersheds.

Sanitary Sewer Overflows

A summary of sanitary sewer overflow (SSO) incidents that occurred during a five-year period from 2016 through 2020 in Galveston County was obtained from TCEQ Central Office in Austin. The summary data indicated no SSO incidents had been reported within the TMDL watersheds.

TPDES-Regulated Stormwater

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

1. Stormwater subject to regulation, which is any stormwater originating from TPDES-regulated MS4 entities, stormwater discharges associated with regulated industrial facilities, and construction activities.
2. Stormwater runoff not subject to regulation.

Discharges of stormwater from a Phase II MS4 area, regulated industrial facility, construction area, or other facility involved in certain activities must be covered under the following TCEQ/TPDES general permits:

- TXR040000 – Phase II MS4 General Permit for MS4s located in urbanized areas
- TXR050000 – Multi-sector General Permit (MSGP) for industrial facilities
- TXR150000 – Construction General Permit (CGP) for construction activities disturbing more than one acre or are part of a common plan of development disturbing more than one acre

A review of active stormwater general permit authorizations (TCEQ, 2021b) in the TMDL watersheds, as of April 5, 2021, found one active MSGP authorization in the Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 watershed. The review also found one active MSGP authorization and one CGP authorization within the Unnamed Tributary of Gum Bayou AU 1103G_01 watershed. Loadings for the areas authorized under the MSGP and CGP were not specifically determined since these areas are already accounted for in the areas covered under MS4s. There are currently five Phase II MS4 authorizations and one combined Phase I/Phase II permit within the TMDL watersheds (Table VIII-4). Figure VIII-5 shows the urbanized area defined by the USCB that accounts for MS4 coverage within the TMDL watersheds.

Table VIII-4. TPDES MS4 permits associated with the TMDL watersheds

AUs	Entity	TPDES Permit	NPDES Permit	Authorization Type
1103F_01, 1103G_01	Texas Department of Transportation	WQ0005011000	TXS002101	Combined Phase I/II
1103F_01, 1103G_01	Galveston County	General Permit (TXR040000)	TXR040364	Phase II
1103F_01, 1103G_01	City of Dickinson	General Permit (TXR040000)	TXR040686	Phase II

AUs	Entity	TPDES Permit	NPDES Permit	Authorization Type
1103F_01	City of Santa Fe	General Permit (TXR040000)	TXR040193	Phase II
1103F_01	Galveston County Drainage District 1	General Permit (TXR040000)	TXR040620	Phase II
1103G_01	City of League City	General Permit (TXR040000)	TXR040249	Phase II

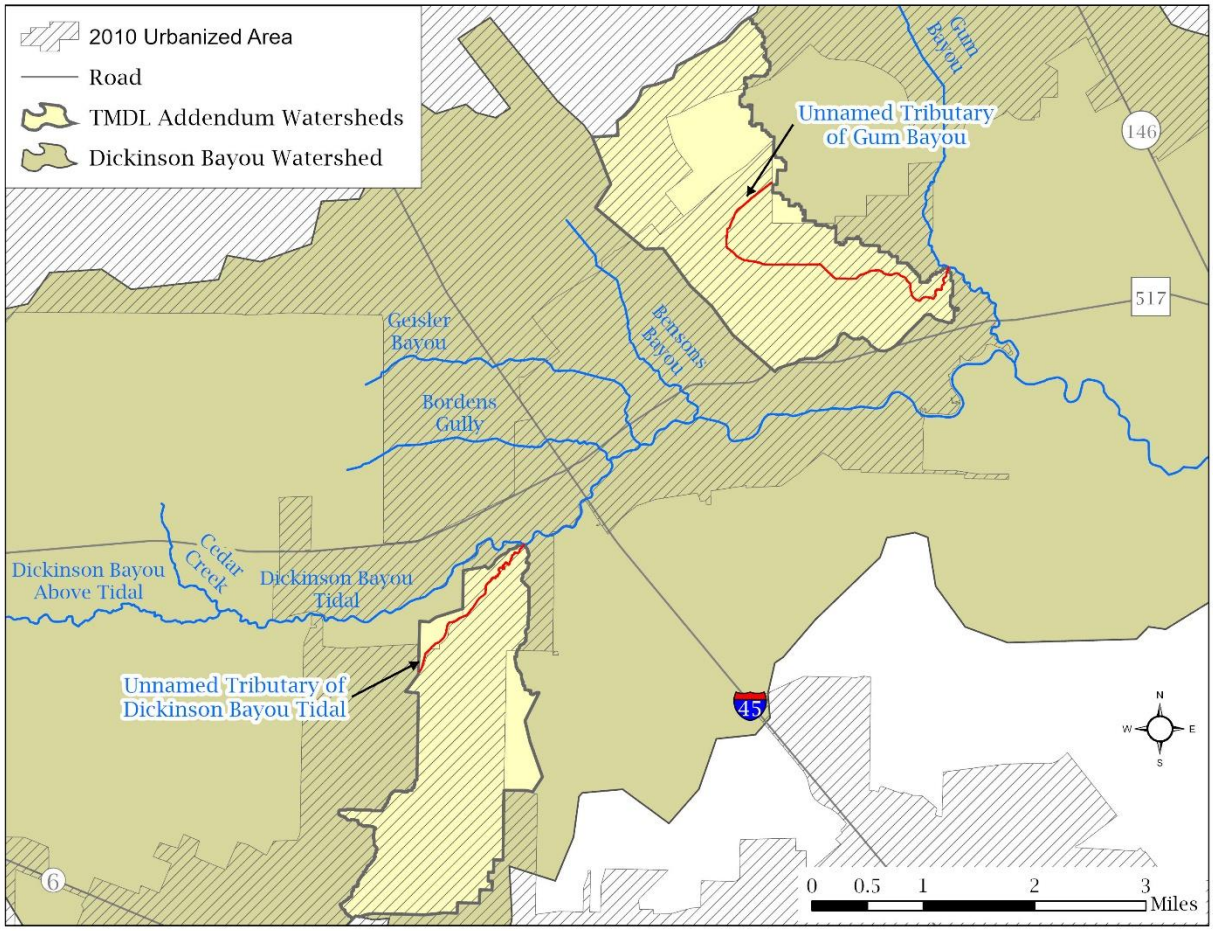

Figure VIII-5. Regulated stormwater area based on urbanized area within the TMDL watersheds

Illicit Discharges

Pollutant loads can enter water bodies from MS4 outfalls that carry authorized sources as well as illicit discharges under both dry- and wet-weather conditions. The term "illicit discharge" is defined in TPDES General Permit TXR040000 for Phase II MS4s as "Any discharge to a municipal separate storm sewer system that is not entirely composed of stormwater, except discharges pursuant to this general permit or a separate

authorization and discharges resulting from emergency firefighting activities." Illicit discharges can be categorized as either direct or indirect contributions.

Unregulated Sources

Unregulated sources of bacteria are nonpoint and can originate from wildlife and feral hogs, various agricultural activities, agricultural animals, land application fields, urban runoff not covered by a permit, failing on-site sewage facilities (OSSFs), and domestic pets.

Unregulated Agricultural Activities and Domesticated Animals

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

Table VIII-5 provides estimated numbers of selected livestock in the TMDL watersheds based on the 2017 Census of Agriculture conducted by U.S. Department of Agriculture (USDA NASS, 2019). The county-level estimated livestock populations were reviewed by Texas State Soil and Water Conservation Board staff and were distributed by dividing the suitable livestock land cover (Hay/Pasture, Grassland/Herbaceous, and Shrub/Scrub) area of each TMDL watershed by the total suitable livestock land cover area within Galveston County. This ratio was then applied to the county-level livestock data. These livestock numbers, however, were not used to develop an allocation of allowable bacteria loading to livestock.

Table VIII-5. Estimated livestock populations

AU	Cattle and Calves	Hogs and Pigs	Sheep and Lambs	Goats	Horses and Ponies	Mules, Burros, and Donkeys
1103F_01	106	7	3	6	11	4
1103G_01	71	4	2	4	7	2

Fecal bacteria from dogs and cats is transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table VIII-6 summarizes the estimated number of dogs and cats within the TMDL watersheds. Pet population estimates were calculated as the estimated number of dogs (0.614) and cats (0.457) per household (AVMA, 2018). The number of households in the TMDL watersheds was estimated using 2010 Census data (USCB, 2010). The actual contribution and significance of bacteria loads from pets reaching the water bodies is unknown.

Table VIII-6. Estimated households and pet population

AU	Estimated Households	Estimated Dog Population	Estimated Cat Population
1103F_01	607	373	277
1103G_01	3,597	2,209	1,644

Wildlife and Unmanaged Animals

Fecal 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 water bodies. 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 water bodies by rainfall runoff.

For feral hogs, a study by Timmons et al. (2012) estimated a range of feral hog densities within suitable habitat in Texas from 8.9 to 16.4 hogs per square mile. The average hog density (12.65 hogs/square mile) was multiplied by the hog-habitat area of 1.17 square miles in the Unnamed Tributary of Dickinson Bayou watershed and 0.79 square miles in the Unnamed Tributary of Gum Bayou watershed. Habitat deemed suitable for hogs includes the following classifications from the 2016 NLCD land cover: Deciduous Forest, Evergreen Forest, Mixed Forest, Emergent Herbaceous Wetlands, Woody Wetlands, Pasture/Hay, Shrub/Scrub, and Grassland/Herbaceous. Using this methodology, the estimated feral hog population is 15 in the Unnamed Tributary of Dickinson Bayou watershed and 10 in the Unnamed Tributary of Gum Bayou watershed.

For deer, the Texas Parks and Wildlife Department (TPWD) has published data showing deer population-density estimates by Deer Management Unit (DMU) and Ecoregion in the state (TPWD, 2021). The TMDL watersheds are located entirely within the DMU Urban Houston, for which there is no deer density data. However, because the TMDL watersheds are close to DMU 10, density data from this DMU was used to estimate deer populations for the TMDL watersheds. For the 2020 TPWD survey year, the estimated deer population density for DMU 10 was 21.52 deer per 1,000 acres and applies to all habitat types within the DMU. Applying this value to the entire area of the TMDL watersheds returns an estimated 43 deer within the Unnamed Tributary of Dickinson Bayou Tidal watershed and 60 deer in the Unnamed Tributary of Gum Bayou watershed. The Enterococci contribution from feral hogs and wildlife in the TMDL watersheds could not be determined based on existing information.

Onsite Sewage Facilities

The estimated number of OSSFs in the TMDL watersheds was determined using data supplied by H-GAC (H-GAC, 2020) and the TCEQ Coastal On-Site Sewage Inventory Database (TCEQ, 2018c). Data from these sources indicate that there are 233 OSSFs located within the Unnamed Tributary of Dickinson Bayou Tidal watershed and 229 OSSFs within the Unnamed Tributary of Gum Bayou watershed (Figure VIII-6). Several pathways of the liquid waste in OSSFs afford opportunities for bacteria to enter ground and surface waters, if the systems are not properly operating. Properly designed and operated, however, OSSFs would be expected to contribute virtually no fecal bacteria to surface waters (Weiskel et al., 1996).

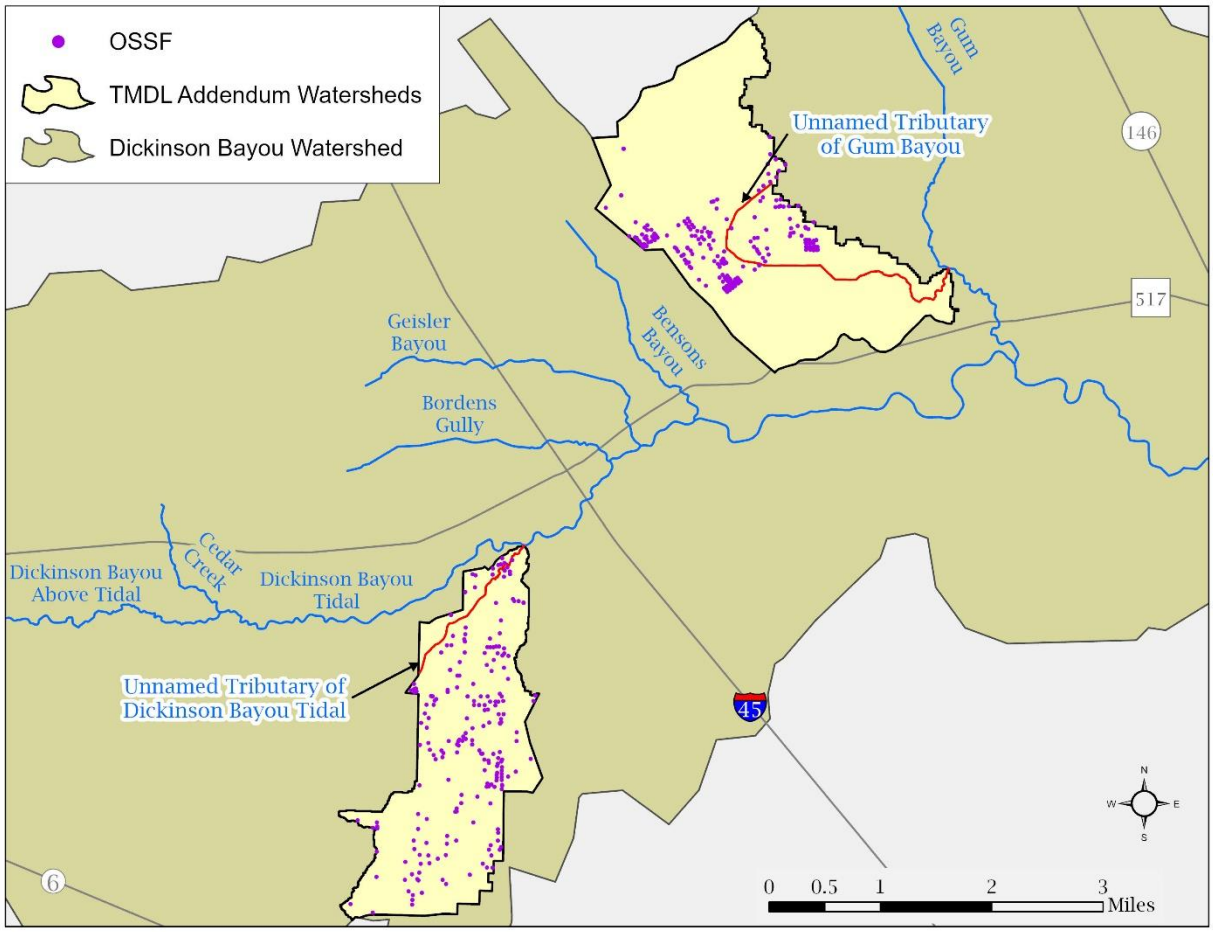

Figure VIII-6. OSSFs located within the TMDL watersheds

Linkage Analysis

An adaptation of the load duration curve (LDC) method was used to examine the relationship between instream water quality and the source of indicator bacteria loads.

In watersheds where there are tidal exchanges along the Texas coast, the flow is adjusted to address tidal influences. The LDC developed through this approach is called a modified LDC (ODEQ, 2006). Modified LDCs are based on the assumption that combining freshwater with seawater increases the loading capacity in the tidal water body.

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 as regulated and from the landscape as unregulated sources. Further, this one-to-one relationship was also inherently assumed when using the modified LDCs to define the TMDL pollutant load allocations. The LDC method allows for estimation of TMDL loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). In addition to estimating stream loads, this method allows for the determination of the hydrologic conditions under which impairments are typically occurring, can give indications of the broad origins of the bacteria (i.e., point or nonpoint source), and provides a means to allocate allowable loadings. The technical support document for this addendum (Adams and Millican, 2021) provides details about the linkage analysis along with the modified LDC method and its application.

The Enterococci data plotted on the modified LDC for the Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 SWQM Station 20477 in Figure VIII-7 show exceedances of the geometric mean criterion have commonly occurred regardless of streamflow conditions. Likewise, Enterococci data plotted on the modified LDC for the Unnamed Tributary of Gum Bayou AU 1103G_01 SWQM Station 20728 show exceedances of the geometric mean criterion have commonly occurred in all flow regimes (Figure VIII-8). The allowable load at the single sample criterion (130 cfu/100 mL) is included on the modified LDCs for comparison with individual Enterococci samples, although it is not used for assessment or allocation purposes.

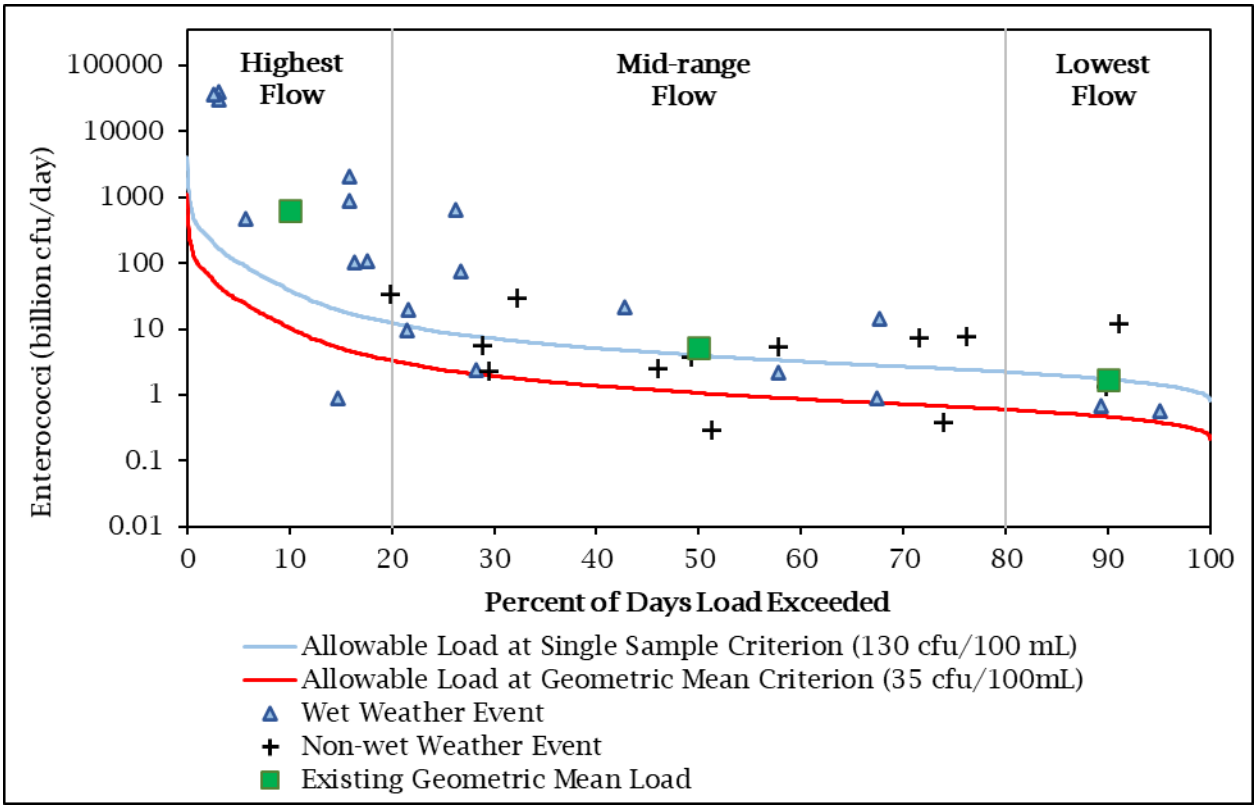

Figure VIII-7. Modified LDC for AU 1103F_01 at SWQM Station 20477

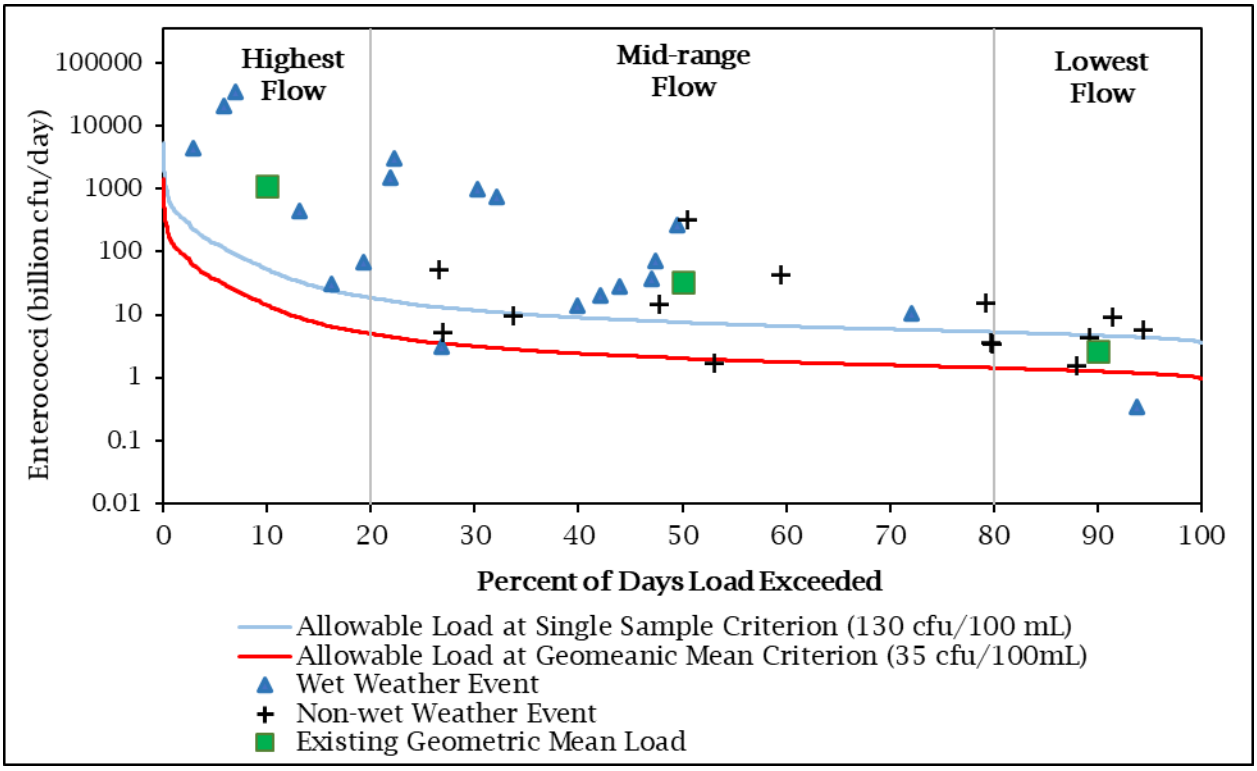

Figure VIII-8. Modified LDC for AU 1103G_01 at SWQM Station 20728

Margin of Safety

The margin of safety (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 an MOS. The TMDLs in this report incorporate an explicit MOS of 5% of the total TMDL allocations.

Pollutant Load Allocation

The 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:

WLA = wasteload allocations, the amount of pollutant allowed by regulated dischargers

LA = load allocations, the amount of pollutant allowed by unregulated sources

FG = loadings associated with future growth from potential regulated facilities

MOS = margin of safety load

AU-Level TMDL Calculation

To be consistent with previously completed TMDLs in the original watershed, the TMDLs for AUs 1103F_01 and 1103G_01 were derived using the median flow in the 0-20 percentile range (or 10% load duration exceedance, "Highest Flow" regime) of the modified LDCs developed for TCEQ SWQM stations 20477 and 20728. These stations represent the locations within AUs 1103F_01 and 1103G_01 where an adequate number of Enterococci samples were collected.

Margin of Safety Calculation

The TMDLs in this report incorporate an explicit MOS of 5%.

Wasteload Allocation

The WLA is the sum of loads from regulated sources, which are WWTFs and regulated stormwater.

Wastewater Treatment Facilities

TPDES-permitted WWTFs are allocated a daily wasteload (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by one-half the instream geometric mean criterion. One-half of the water quality criterion (17.5 cfu/100 mL Enterococci) is used as the WWTF target to provide instream and downstream load capacity and to be consistent with the original TMDL report. Due to the absence of any permitted dischargers in the TMDL watersheds, the WLA_{WWTF} component is zero.

Regulated Stormwater

Stormwater discharges from MS4, industrial, and construction areas are also considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). The percentage of the land area included in the TMDL watersheds 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.

The area under an MS4 permit was calculated for the TMDL watersheds using geographic information system shapefiles. The acreage covered by an MS4 permit for the Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 watershed is 1,779

acres, 88.46% of the watershed, and the acreage for the Unnamed Tributary of Gum Bayou AU 1103G_01 watershed is 2,365 acres, 84.83% of the watershed.

Load Allocation

The load allocation (LA) component of the TMDLs corresponds to runoff or direct deposition from unregulated sources.

Allowance for Future Growth

The future growth (FG) component of the TMDL equation addresses the requirement of TMDLs to account for future loadings that might occur as a result of 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 water bodies increases as the amount of flow increases. The allowance for FG in this TMDL report will result in protection of existing uses and conform to Texas' antidegradation policy.

The FG component of the TMDL watersheds was based on the population projections for the entire TMDL watersheds. A new WWTF must accommodate daily wastewater flow of 75-100 gallons per capita per day (gpcd) as required under Title 30, Texas Administrative Code, Chapter 217, Subchapter B, Section 217.32 (30 TAC 217.32; TCEQ 2015). Conservatively taking the higher daily wastewater flow capacity (100 gpcd), and multiplying it by a potential population change, gives an FG flow. Based on the information in Table VIII-2, the projected population change within the AU 1103F_01 watershed for the time period 2010-2045 is 1,512 and the population change within the AU 1103G_01 watershed is 7,100. Multiplying the projected population growths by the higher daily wastewater flow capacity yields a value of 0.151 million gallons per day (MGD) for AU 1103F_01 and a value of 0.710 MGD for AU 1103G_01. These values would be considered the full permitted discharges of potential future WWTFs.

FG 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 water bodies increases as the amount of flow increases. Consequently, increases in flow allow for increased loadings. The modified LDCs and tables in this TMDL report will guide determination of the assimilative capacity of the water bodies under changing conditions, including FG.

Summary of TMDL Calculations

Table VIII-7 summarizes the TMDL calculations for the TMDL watersheds. The TMDLs were calculated based on the median flow in the 0-20 percentile range (or 10% load duration exceedance, "Highest Flow" regime) from the modified LDCs developed for

TCEQ SWQM stations 20477 and 20728. Allocations are based on the current geometric mean criterion for Enterococci of 35 cfu/100mL for each component of the TMDLs (with the exception of the WLA_{WWTF} and FG terms, which use one-half the criterion).

Table VIII-7. TMDL allocation summary for the TMDL AUs

All loads expressed as billion cfu/day Enterococci

Water Body	AU	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA	FG
Unnamed Tributary of Dickinson Bayou Tidal	1103F_01	10.421	0.521	0	8.669	1.131	0.100
Unnamed Tributary of Gum Bayou	1103G_01	14.176	0.709	0	11.025	1.972	0.470

The final TMDL allocations (Table VIII-8) needed to comply with federal requirements include the FG component within the WLA_{WWTF} (40 CFR Section 103.7).

Table VIII-8. Final TMDL allocations for the TMDL AUs

All loads expressed as billion cfu/day Enterococci

Water Body	AU	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA
Unnamed Tributary of Dickinson Bayou Tidal	1103F_01	10.421	0.521	0.100	8.669	1.131
Unnamed Tributary of Gum Bayou	1103G_01	14.176	0.709	0.470	11.025	1.972

Seasonal Variation

Federal regulations require that TMDLs account for seasonal variation in watershed conditions and pollutant loading [40 CFR Section 130.7(c)(1)]. Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing Enterococci concentrations obtained from 13 years (2008 through 2020) of routine monitoring data collected in the warmer months (May through September) against those collected during the cooler months (November through March). The months of April and October were considered transitional between 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 (also known as the "Mann-Whitney" test). This analysis of Enterococci data indicated that there was a significant difference (α=0.05) in indicator bacteria between cool and

warm weather seasons for the Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 (p=0.0026) with higher Enterococci concentrations during the cool season. For the Unnamed Tributary of Gum Bayou AU 1103G_01 (p=0.0716), there was no indication of significant difference of indicator bacteria between cool and warm weather seasons. Seasonal variation was also addressed by using all available flow and Enterococci records (covering all seasons) from the period of record used in the modified LDC development for this project.

Public Participation

TCEQ maintains an inclusive public participation process. From the inception of TMDL development, 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 technical support document for this TMDL addendum (Adams and Millican, 2021) was published on TCEQ's website on March 31, 2022. Project staff presented information about this addendum at the Galveston Bay Coalition of Watersheds stakeholder meeting (held online) on August 24, 2021. The public had an opportunity to comment on this addendum during the public comment period (May 6 through June 7, 2022) for the WQMP update in which this addendum is included. Notice of the public comment period for this addendum was emailed to stakeholders and posted on the TCEQ's TMDL Program News webpage.[4] Notice of the comment period, along with the document, was also posted on the WQMP Updates webpage.[5] TCEQ accepted public comments on the original TMDL report from September 16, 2011 through October 17, 2011. Of the four comments submitted, none of them referred directly to the AUs in this TMDL addendum.

Implementation and Reasonable Assurance

The water bodies covered by this addendum are within the existing bacteria TMDL watershed for Dickinson Bayou. The TMDL watersheds, including Unnamed Tributary of Dickinson Bayou Tidal AU 1103F_01 and Unnamed Tributary of Gum Bayou AU 1103G_01, are within the area covered by the implementation plan (I-Plan) developed by stakeholders for the TMDL watersheds, which was approved by the Commission on January 15, 2014. The I-Plan outlines an adaptive management approach in which measures are assessed annually by the stakeholders for efficiency and effectiveness. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals and expresses stakeholder commitment to the process.

[4] https://www.tceq.texas.gov/waterquality/tmdl/tmdlnews.html
[5] https://www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html

Please refer to the original TMDL document for additional information regarding implementation and reasonable assurance.

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