Adopted August 11, 2021
Publication AS-207
Approved by EPA February 1, 2022

One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou

Assessment Unit 0704_02

Water Quality Planning Division, Office of Water
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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

Total maximum daily load project reports are available on the TCEQ website at:
www.tceq.texas.gov/waterquality/tmdl

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

This total maximum daily load report is based in large part on the report titled: "Technical Support Document for One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou Watershed" prepared by the Texas Water Resources Institute.

All maps were generated by the Total Maximum Daily Load Program of the Texas Commission on Environmental Quality. These maps are for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. They do not represent an on-the-ground survey and represent only the approximate relative location of property boundaries. For more information concerning these maps, contact the Water Quality Planning Division at 512-239-6682.

Contents

Figures

Tables

Abbreviations

AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CGP	Construction General Permit
cfs	cubic feet per second
cfu	colony forming units
DAR	drainage area ratio
DD6	Drainage District Number 6
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
FDC	flow duration curve
FG	future growth
I/I	inflow and infiltration
I-Plan	implementation plan
LA	load allocation
LDC	load duration curve
MCM	minimum control measure
mL	milliliter
MGD	million gallons per day
MOS	margin of safety
MS4	municipal separate storm sewer system
MSGP	multi-sector general permit
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
PUC	Public Utility Commission of Texas
RMU	Resource Management Unit
SSO	sanitary sewer overflow
SWMP	Stormwater Management Program
SWQM	Surface Water Quality Monitoring
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department

TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
UA	urbanized area
US	United States
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	wasteload allocation
WQBEL	water quality-based effluent limit
WQMP	Water Quality Management Plan
WUG	Water User Group
WWTF	wastewater treatment facility

One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou

Executive Summary

This document describes one total maximum daily load (TMDL) for Hillebrandt Bayou where concentrations of indicator bacteria exceed the criterion used to determine attainment of the primary contact recreation 1 use. The Texas Commission on Environmental Quality (TCEQ) first identified the impairment to Hillebrandt Bayou in the *2010 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d) List* (Texas Integrated Report) (TCEQ, 2011). The bacteria impairment has been identified in each subsequent edition through 2020. The impaired segment and the identifying assessment unit (AU) is:

- Hillebrandt Bayou 0704_02

Hillebrandt Bayou is in Jefferson County near the Gulf Coast in southeast Texas and originates in the city of Beaumont, south to its confluence with Taylor Bayou. Hillebrandt Bayou consists of a single classified segment (0704) and two AUs (0704_01 and 0704_02). This document will consider the impairment of the upstream AU of Hillebrandt Bayou (0704_02). The Hillebrandt Bayou (AU 0704_02) watershed is approximately 36 square miles, located entirely in Jefferson County, with a mostly urbanized drainage.

Escherichia coli (*E. coli*) are widely used as indicator bacteria to determine attainment of the contact recreation use in freshwater. Criteria for determining attainment of the contact recreation use are expressed as the number (or "counts") of *E. coli* bacteria, typically given as colony forming units (cfu). The primary contact recreation 1 use is not supported when the geometric mean of all *E. coli* samples exceeds 126 cfu per 100 milliliters (mL).

There are no active permitted facilities that discharge domestic wastewater within the Hillebrandt Bayou (AU 0704_02) watershed. Two municipal separate storm sewer system (MS4) permits are held in the watershed. These permits cover 97% of the Hillebrandt Bayou (AU 0704_02) watershed.

A load duration curve (LDC) analysis was used to quantify allowable pollutant loads and specific TMDL allocations for point and nonpoint sources of indicator bacteria. No WLA for wastewater treatment facilities (WWTFs) was established because no permitted discharges exist within the TMDL watershed. The Hillebrandt WWTF is located within the TMDL watershed but the final discharge is to Hillebrandt Bayou AU 0704_01 which is downstream of AU 0704_02. A future growth (FG) allowance was allocated to account for future loadings that

might occur as a result of population growth, changes in community infrastructure, and development. The FG allocation was calculated using the projected percent watershed population increase multiplied by the current permitted flow for the Hillebrandt WWTF, with the assumption that future facilities could be built within the TMDL watershed. The TMDL allocations in this report will guide determination of the assimilative capacity of the water body under changing conditions, including FG.

Compliance with this TMDL is based on keeping the indicator bacteria concentrations in Hillebrandt Bayou below the geometric mean criterion of 126 cfu/100 mL.

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 water body included on a state's 303(d) list of impaired waters. 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 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 Program's primary objective is to restore and maintain water quality uses—such as drinking water supply, recreation, support of aquatic life, or fishing—of impaired or threatened water bodies.

This TMDL document addresses the impairment of the primary contact recreation 1 use. due to exceedances of indicator bacteria in Hillebrandt Bayou, AU 0704_02. This TMDL takes a watershed approach to addressing the indicator bacteria impairment. Information in this TMDL document was derived from the *Technical Support Document for One Total Maximum Daily Load for Indicator Bacteria in the Hillebrandt Bayou*[1] (Schramm and Jha, 2020).

Section 303(d) of the Clean Water Act and the implementing regulations of the United States Environmental Protection Agency (EPA) in Title 40 of the Code of

[1] www.tceq.texas.gov/assets/public/waterquality/tmdl/118hillebrandt/118-hillebrandt-tsd-2020june.pdf

Federal Regulations (CFR), Part 130 (40 CFR 130) describe the statutory and regulatory requirements for acceptable TMDLs. 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.

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 TCEQ and subsequent EPA approval, this TMDL will become an update to the state's Water Quality Management Plan (WQMP).

Problem Definition

TCEQ first identified a bacteria impairment within the upstream AU of Hillebrandt Bayou (Segment 0704) in the 2010 Texas Integrated Report (TCEQ, 2011). The bacteria impairment has been identified in each subsequent edition through the most recent EPA-approved 2020 Texas Integrated Report (TCEQ, 2020).

This document will consider one bacteria impairment in one AU of Hillebrandt Bayou. The term Hillebrandt Bayou TMDL watershed, or simply TMDL watershed, will be used to the describe the 0704_02 watershed from this point forward. The impaired water body and identifying AU is:

- Hillebrandt Bayou (AU 0704_02)

Surface water quality has been monitored within the TMDL watershed at a single TCEQ surface water quality monitoring (SWQM) station (Table 1 and Figure 1). *E. coli* data collected at this station from December 1, 2011 through November 30, 2018 were used to determine attainment of the primary contact recreation 1 use as reported in the 2020 Texas Integrated Report (TCEQ, 2020). Hillebrandt Bayou does not attain the primary contact recreation 1 use because the geometric mean concentration of *E. coli* exceeds the criterion of 126 cfu/100 mL (Table 1).

Table 1. 2020 Texas Integrated Report Summary for Hillebrandt Bayou (AU 0704_02)

Water Body	AU	Parameter	Station	Data Range	Number of Samples	Geometric Mean (cfu/100 mL)
Hillebrandt Bayou	0704_02	*E. coli*	10687	12/01/2011 – 11/30/2018	29	455.13

Watershed Overview

Hillebrandt Bayou is in the Neches-Trinity Coastal Basin in the southeast Gulf Coast region. Hillebrandt Bayou begins in the city of Beaumont, approximately 100 meters upstream of State Highway 124 and flows approximately 14.6 miles southeasterly until converging with Taylor Bayou (Figure 1). Hillebrandt Bayou consists of a single classified segment (0704) and two AUs (0704_01 and 0704_02). This document will consider the bacteria impairment in the upstream AU (0704_02). The drainage area for AU 0704_02 is 36.02 square miles (23,053.76 acres) located entirely in Jefferson County. Delineation of the watershed incorporates drainage information provided by Jefferson County Drainage District No. 6 (DD6) (Figure 1).

The 2020 Texas Integrated Report (TCEQ, 2020) provides the following segment and AU descriptions:

- Segment 0704 (Hillebrandt Bayou) – From the confluence of Taylor Bayou in Jefferson County to a point 100 meters (110 yards) upstream of State Highway 124 in Jefferson County.
    - AU 0704_01 - From the confluence with Taylor Bayou Above Tidal (0701) upstream to confluence with Willow Marsh Bayou (0704A).
    - AU 0704_02 - From the confluence with Willow Marsh Bayou (0704A) upstream to a point 100 meters (110 yards) upstream of State Highway 124 in Jefferson County.

Watershed Climate and Hydrology

Regional precipitation and temperature data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center database. The nearest active weather station, Beaumont, Texas Station USC00410611 (Figure 1), reported temperature and precipitation data from 2005 through 2018 (NOAA, 2019). The highest average monthly precipitation occurs in July at 7.8 inches and the lowest average monthly precipitation occurs in October at 3.5 inches (Figure 2). The highest average monthly maximum temperatures occur in August (93.2˚ F) and the lowest average monthly minimum temperatures occur in January (42.9˚ F) (Figure 2). From 2005 through 2018, the average annual precipitation was 62.1 inches, with a low of 34 inches occurring in 2011 and high of 93.4 inches occurring in 2017 (Figure 3).

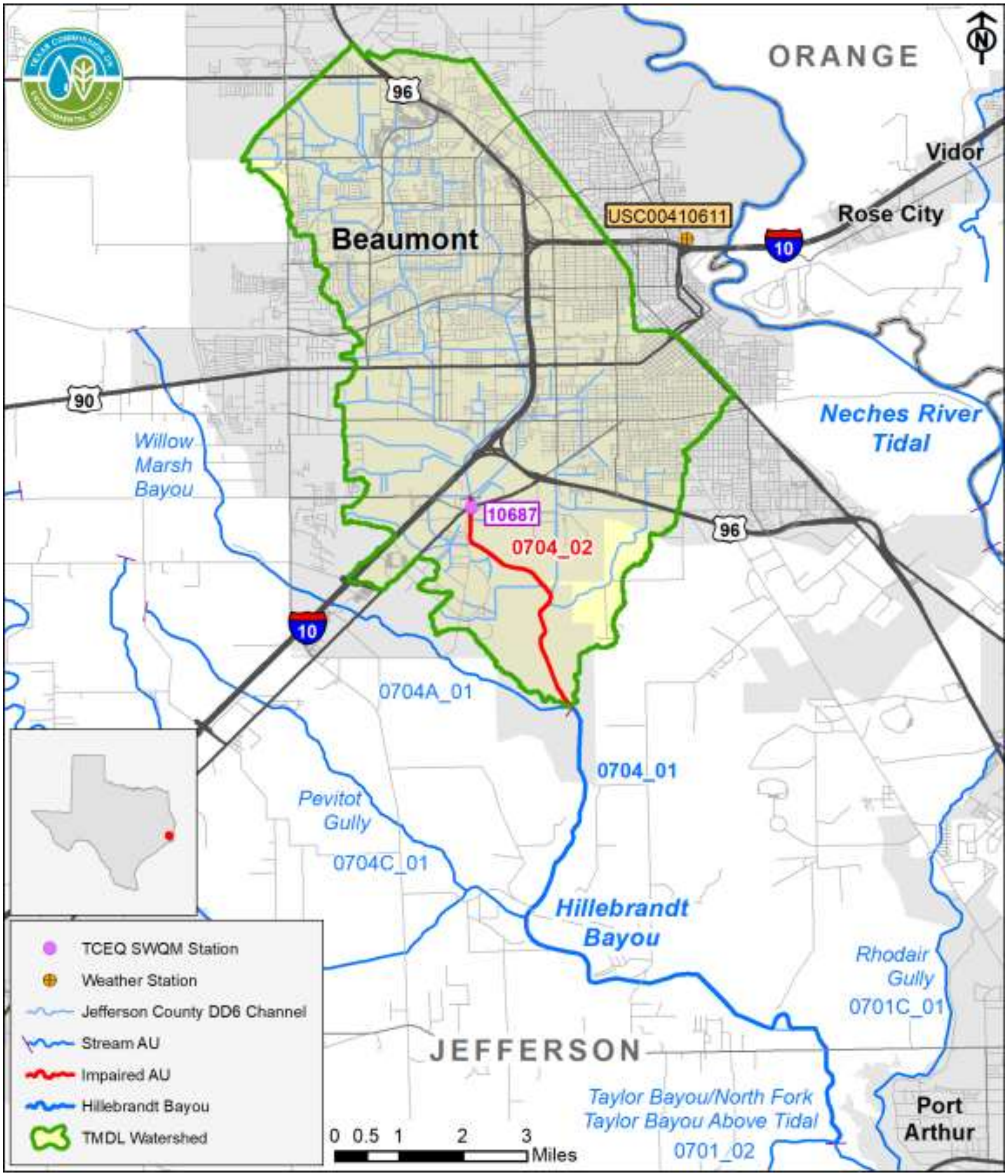

Figure 1. Area map of Hillebrandt Bayou TMDL watershed

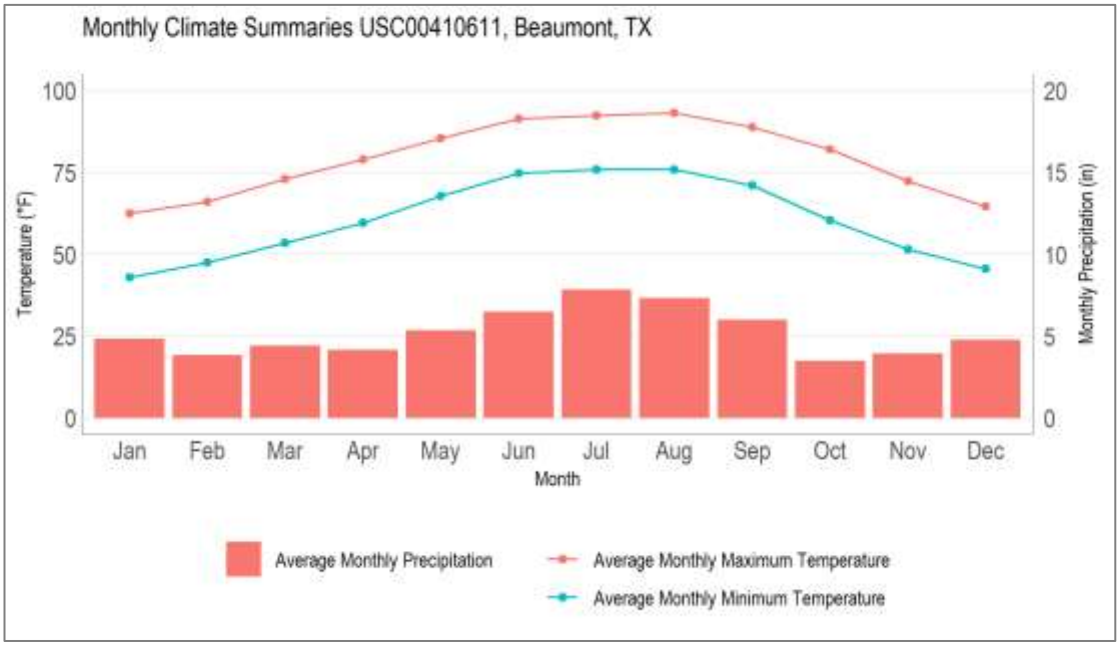

Figure 2. Average monthly temperature and precipitation (2005-2018) at Beaumont, Texas Station USC00410611

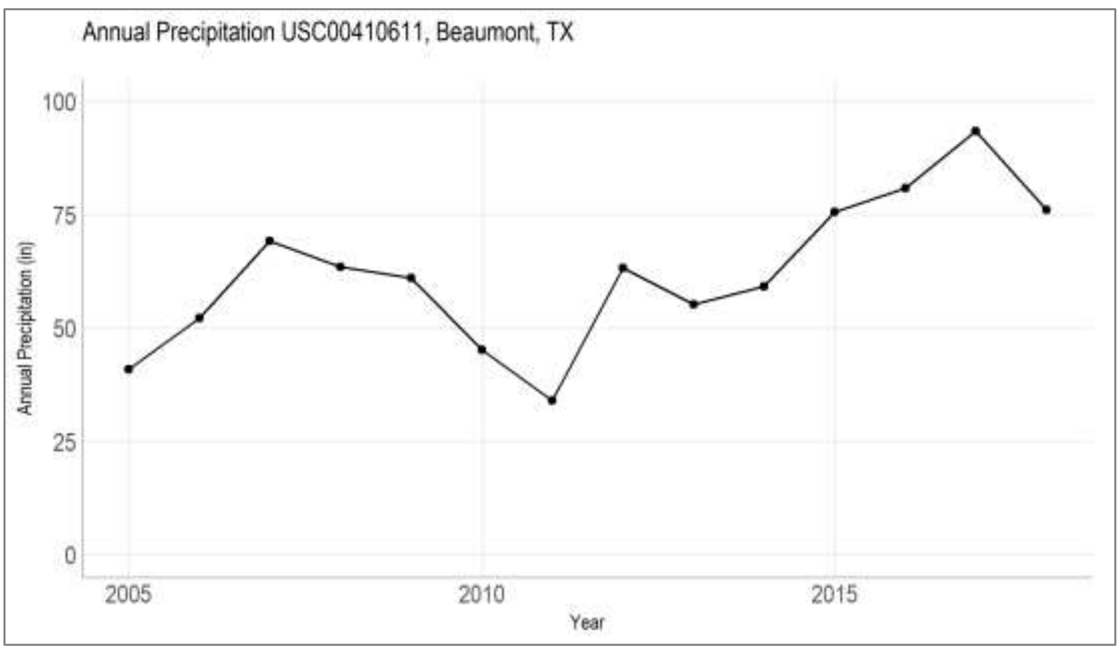

Figure 3. Annual precipitation (2005-2018) at Beaumont, Texas Station USC00410611

Watershed Population and Population Projections

Watershed population estimates were developed using 2010 United States Census Bureau (USCB) census block geographic units and population data (USCB, 2010). Census blocks are the smallest geographic units used by USCB to tabulate population data. Using the methodology outlined in Appendix A, the Hillebrandt Bayou TMDL watershed population is estimated to be 61,273 people (Figure 4).

Texas Water Development Board (TWDB) Regional Water Plan Population Projections by Water User Group (WUG) in Texas (TWDB, 2019) were used to estimate population projections for the TMDL watershed. The population projections, developed by TWDB, indicate a 39.5% population increase for the Beaumont WUG from 2020 through 2070. Future total watershed population (Table 2) was estimated using the methodology outlined in Appendix A.

Table 2. Population projections for Hillebrandt Bayou TMDL watershed

Area	2020	2070	Percent increase (2020-2070)
TMDL watershed	67,348	93,961	39.5%

Land Cover

Land cover for the watershed was obtained from the 2016 National Land Cover Database (NLCD) (USGS, 2019a), and is displayed in Figure 5. The following are the land cover categories and definitions represented in the NLCD found in the Hillebrandt Bayou TMDL watershed:

- **Open Water** – Areas of open water, generally with less than 25% cover of vegetation or soil.
- **Developed, Open Space** – Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- **Developed, Low Intensity** – Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% of total cover. These areas most commonly include single-family housing units.
- **Developed, Medium Intensity** – Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of total cover. These areas most commonly include single-family housing units.

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

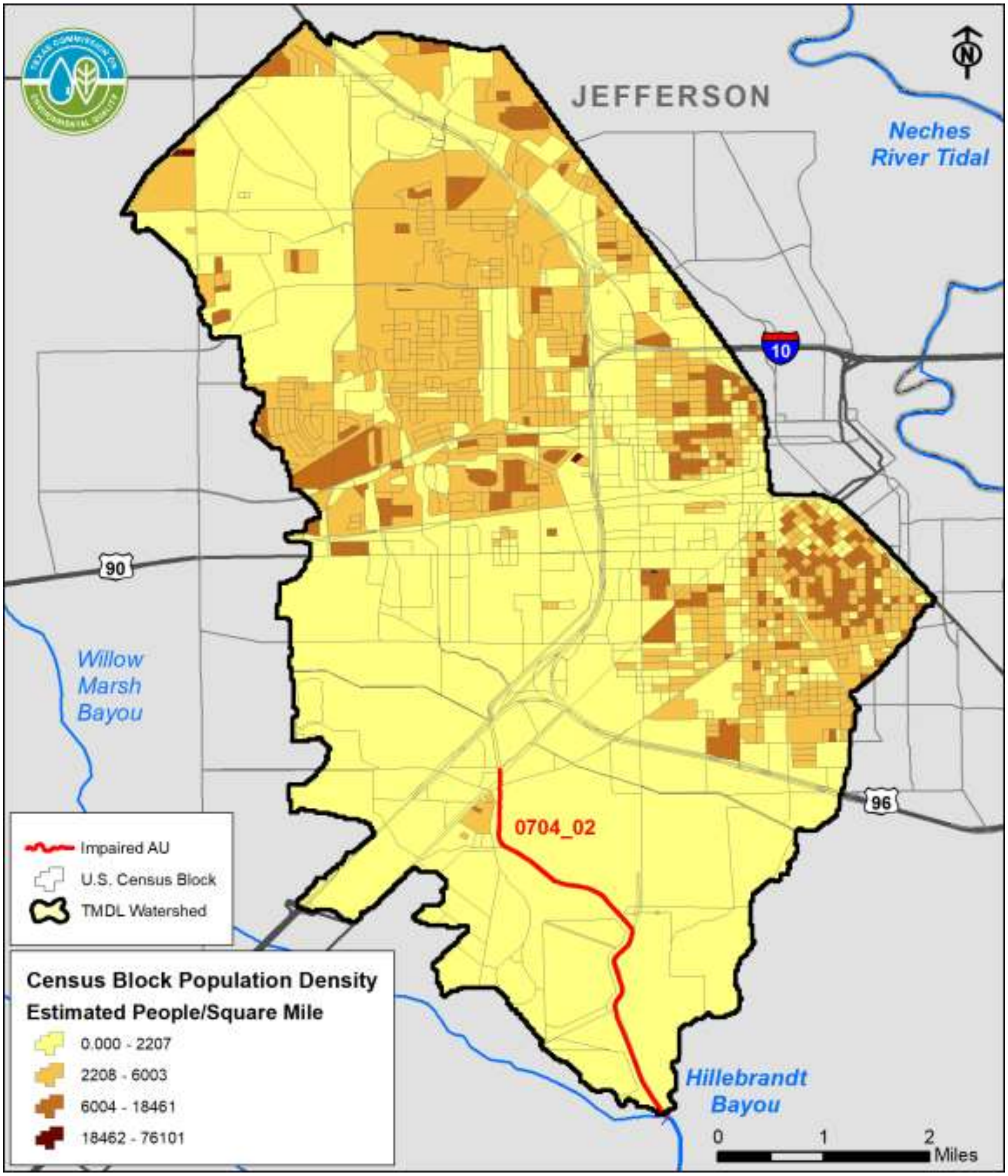

Figure 4. **2010 population density estimates using USCB census block data in Hillebrandt Bayou TMDL watershed**

- **Barren Land (Rock/Sand/Clay)** – Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
- **Deciduous Forest** – Areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
- **Evergreen Forest** – Areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. More than 75% of the species maintain their leaves all year. Canopy is never without green foliage.
- **Mixed Forest** – Areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% total tree cover.
- **Shrub/Scrub** – Areas dominated by shrubs; less than five meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
- **Grassland/Herbaceous** – Areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing.
- **Pasture/Hay** – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/Hay vegetation accounts for greater than 20% of total vegetation.
- **Cultivated Crops** – Areas used to produce annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class includes all land being actively tilled.
- **Woody Wetlands** – Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
- **Emergent Herbaceous Wetlands** – Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil substrate is periodically saturated with or covered with water.

The total Hillebrandt Bayou TMDL watershed is 23,053.76 acres (Table 3). The dominant land use is predominately developed areas (Open Space, Low, Medium, and High Intensity) which comprise 69.56% of the watershed. Some Pasture/Hay remains in the less developed portions of the watershed (14.31%) and areas of wetlands and Open Water (13.55%) occur in the watershed.

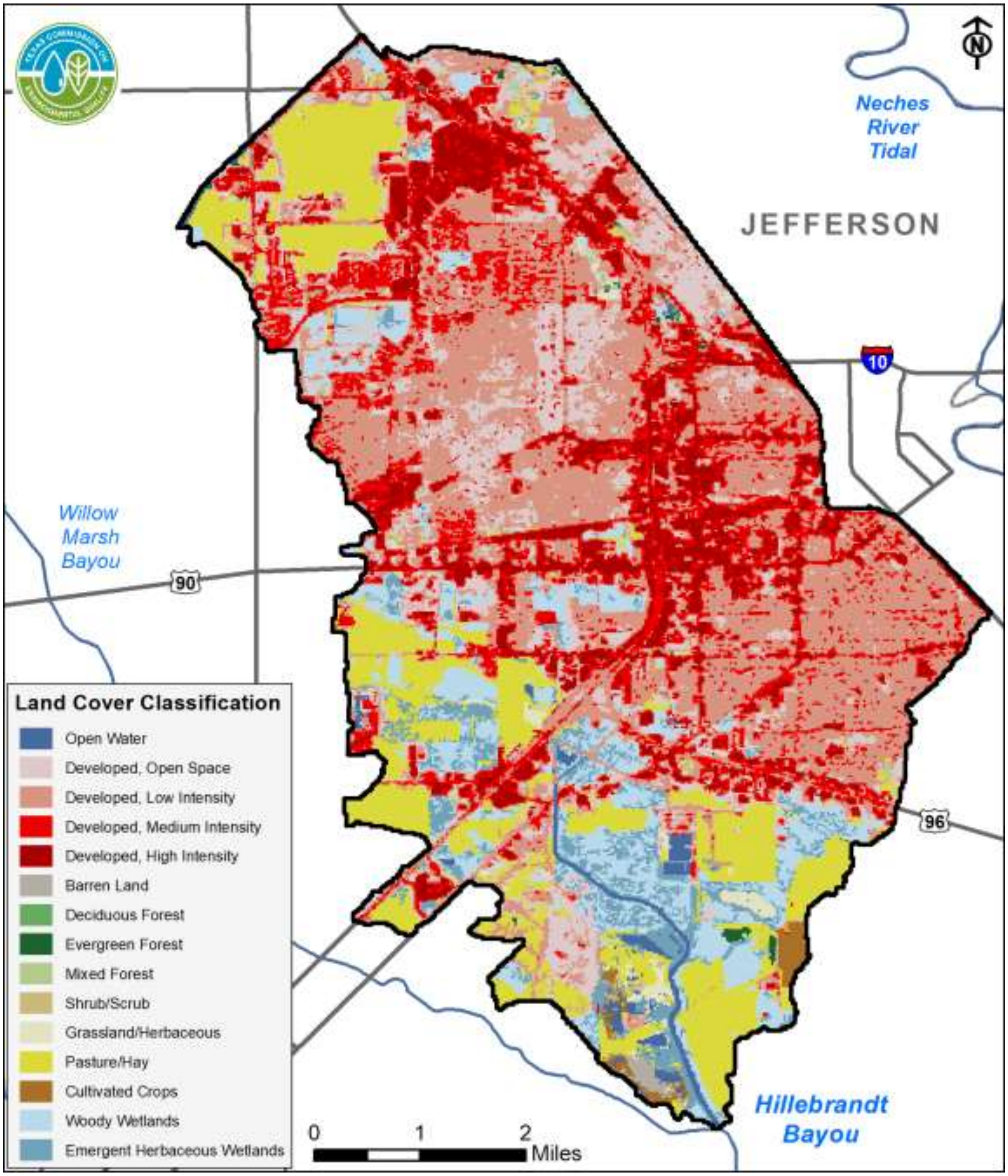

Figure 5. 2016 land cover in Hillebrandt Bayou TMDL watershed

Soils

Soil data within the TMDL watershed were examined to determine their possible runoff potential classifications or hydrological groups. These data were obtained from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic database (NRCS, 2018).

The TMDL watershed soils are entirely composed of hydrological group Type D. Type D soils are described by the NRCS as having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Table 3. Land cover summary in Hillebrandt Bayou TMDL watershed

2016 NLCD Classification	Area (Acres)	Percent of Total
Open Water	304.00	1.32%
Developed, Open Space	2,736.11	11.87%
Developed, Low Intensity	7,542.15	32.72%
Developed, Medium Intensity	3,537.31	15.34%
Developed, High Intensity	2,221.17	9.63%
Barren Land	78.45	0.34%
Deciduous Forest	0.67	0.00%
Evergreen Forest	46.01	0.20%
Mixed Forest	63.44	0.28%
Shrub/Scrub	65.67	0.28%
Grassland/Herbaceous	198.86	0.86%
Pasture/Hay	3,298.73	14.31%
Cultivated Crops	142.15	0.62%
Woody Wetlands	1,845.92	8.01%
Emergent Herbaceous Wetlands	973.14	4.22%
Total	**23,053.76a**	**100.00%**

[a] Rounding results in a slightly different sum from the total watershed area.

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 TMDL in this report is to maintain concentrations of *E. coli* below the geometric mean criterion of 126 cfu/100 mL, which is protective of the primary contact recreation 1 use in freshwater (TCEQ, 2018a).

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). WWTFs and stormwater from industries, construction, and MS4s 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.

With the exception of WWTFs, which receive individual 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 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 program. The regulated sources in the TMDL watershed include stormwater discharges from MS4s, industrial sites, and construction activities.

Domestic and Industrial WWTFs

As of April 2019, there is one facility with a TPDES permit that discharges to Hillebrandt Bayou Segment 0704 (TCEQ, 2019a; EPA, 2019). The City of Beaumont operates the Hillebrandt WWTF (WQ0010501020), which treats domestic wastewater with a discharge limit of 46.0 million gallons per day (MGD) (annual average). Although the Hillebrandt WWTF and its constructed wetlands are located within the TMDL watershed, the actual discharge is to a natural wetland, which then flows to the downstream portion of Hillebrandt Bayou (AU 0704_01) and is outside of the TMDL watershed (Figure 6). Therefore, this facility’s discharge is not considered in the AU 0704_02 flow estimation or loading allocations. There are no industrial WWTFs in the TMDL watershed.

TCEQ/TPDES Water Quality General Permits

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

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production
- TXG340000 – petroleum bulk stations and terminals
- 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)

Figure 6. Regulated sources in Hillebrandt Bayou TMDL watershed

A review of active general permits (TCEQ, 2019b) in the Hillebrandt Bayou TMDL watershed as of December 31, 2019, indicated two TXG870000 general permits are active in the watershed. They do not authorize discharge of fecal indicator bacteria and are not expected to have any impact on instream indicator bacteria concentrations. No other active general wastewater permits were found for the TMDL watershed.

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. Overflows 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.

TCEQ Central Office in Austin provided statewide data on SSOs from January 2016 through December 2018 (TCEQ, 2019c) and basin wide data on SSOs from 2005 through 2015 (TCEQ, 2019d). **Error! Reference source not found.** shows the density of SSO events across the Hillebrandt Bayou TMDL watershed. The number and volume of overflows from permitted entities in the watershed are included in Table 4.

Table 4. Summary of reported SSO events (from 2005 through 2018) in Hillebrandt Bayou TMDL watershed (in gallons)

AU	Estimated Incidents	Total Volume	Average Volume [a]	Minimum Volume	Maximum Volume
0704_02	404	174,590	435	1	60,000

[a] Average volume does not equal the total volume divided by the number of incidents due to some events missing a volume spilled in the report.

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 industrial activities, and construction activities.
2) Stormwater runoff not subject to regulation.

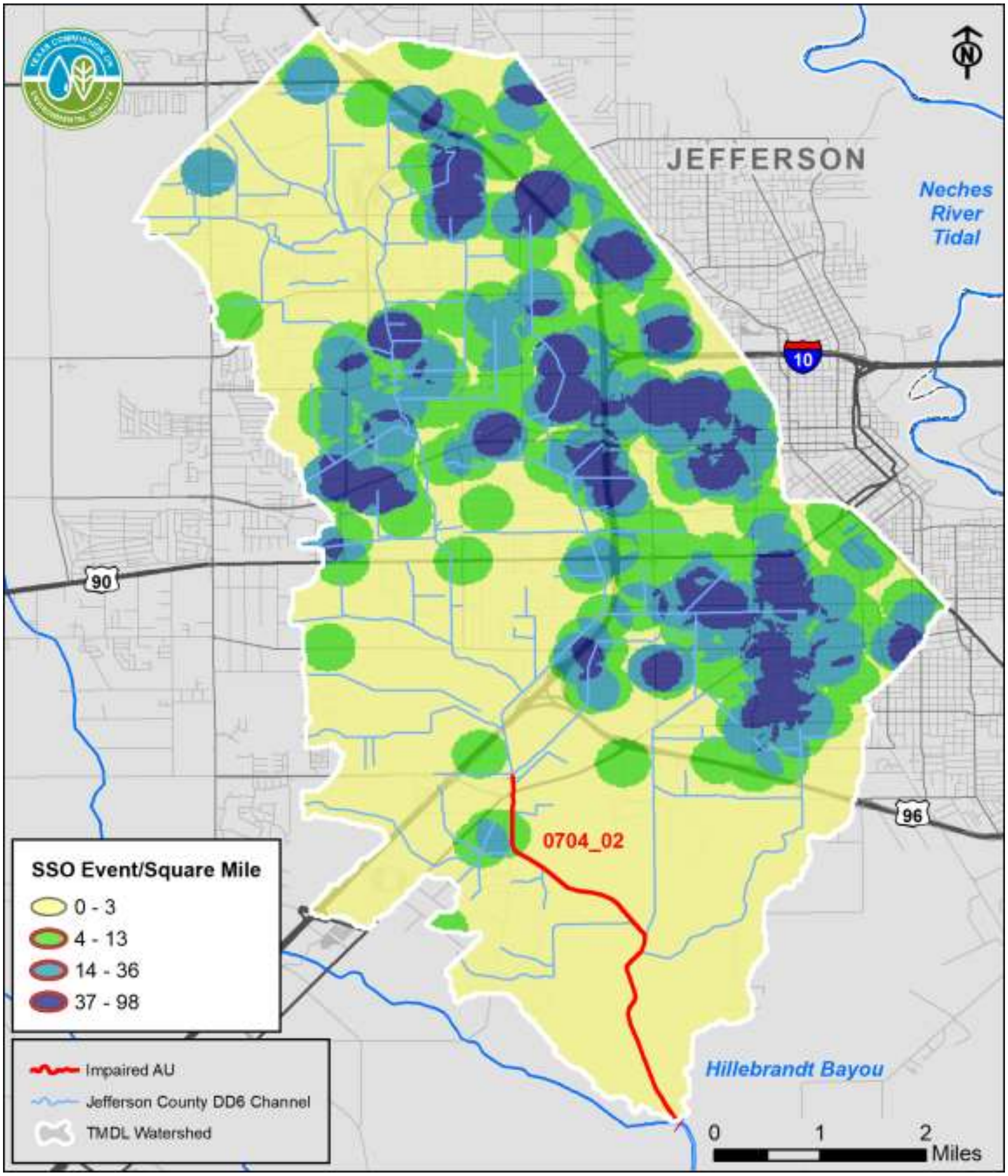

Figure 7. SSO density in Hillebrandt Bayou TMDL watershed (from 2005 through 2018)

The TPDES MS4 Phase I and II rules require municipalities and certain other entities in urban areas to obtain permit coverage for their stormwater systems. A regulated MS4 is a publicly owned system of conveyances and includes ditches, curbs, gutters, and storm sewers that do not connect to a wastewater collection system or treatment facility. Phase I MS4 permits are individual permits for large and medium sized communities with populations exceeding

100,000 or more based on the 1990 United States (US) Census, whereas the Phase II MS4 General Permit regulates smaller communities within an urbanized area (UA) as defined by USCB.

The purpose of an MS4 permit is to reduce discharges of pollutants in stormwater to the “maximum extent practicable” by developing and implementing a stormwater management program (SWMP). The SWMP describes the stormwater control practices that will be implemented, consistent with permit requirements, to minimize the discharge of pollutants from the MS4. The permits require that SWMPs specify the best management practices (BMPs) to meet several minimum control measures (MCMs) that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving water bodies. Phase II MS4 MCMs include all of the following:

- Public education, outreach, and involvement.
- Illicit discharge detection and elimination.
- Construction site stormwater runoff control.
- Post-construction stormwater management in new development and redevelopment.
- Pollution prevention and good housekeeping for municipal operations.
- Industrial stormwater sources.

Phase I MS4 individual permits have their own set of MCMs that are similar to the Phase II MCMs, but Phase I permits have additional requirements to perform water quality monitoring and implement a floatables program. The Phase I MCMs include all of the following:

- MS4 maintenance activities.
- Post-construction stormwater control measures.
- Detection and elimination of illicit discharges.
- Pollution prevention and good housekeeping for municipal operations.
- Limiting pollutants in industrial and high risk stormwater runoff.
- Limiting pollutants in stormwater runoff from construction sites.
- Public education, outreach, involvement, and participation.
- Monitoring, evaluating, and reporting.

TCEQ Central Registry includes a Phase I MS4 permit held by the City of Beaumont and Jefferson County DD6 that covers the Beaumont jurisdictional boundaries and a statewide combined Phase I and II MS4 permit held by the Texas Department of Transportation for rights-of-way in the Beaumont UA (Table 5). The area of regulated stormwater (Figure 6) is the Phase I MS4 jurisdictional boundary and the 2010 USCB Census UA located in the Hillebrandt Bayou TMDL watershed.

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

- TXR040000 – Phase II MS4 General Permit for small MS4s located in UAs
- TXR050000 – Multi-Sector General Permit (MSGP) for industrial facilities
- TXR150000 – Construction General Permit (CGP) for construction activities disturbing more than one acre

The TMDL watershed does not include any Phase II MS4 permit authorizations. General permit authorizations were obtained from the TCEQ Central Registry. Numerous MSGP-regulated facilities and construction activities were found in the TMDL watershed in locations regulated by the Phase I MS4 permit. However, areas authorized under the MSGP and CGP were not specifically determined since they occur in an MS4 area. These areas are already accounted for in the aggregate area of regulated stormwater.

The area of regulated stormwater is approximately 35 square miles or 97% of the TMDL watershed.

Table 5. MS4 permits in Hillebrandt Bayou TMDL watershed

Entity	Authorization Type	TPDES Permit No./ *NPDES ID	Location
City of Beaumont and Jefferson County Drainage District No. 6	Phase I MS4	WQ0004637000/ TXS000501	Jurisdictional boundary of Beaumont, Texas
Texas Department of Transportation	Combined Phase I and Phase II MS4	WQ0005011000/ TXS002101	TXDOT rights-of-way located within Phase I MS4s and Phase II UAs

*NPDES: National Pollutant Discharge Elimination System

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 No. TXR040000 for Phase II MS4s as “Any discharge to a municipal separate storm sewer that is not entirely composed of stormwater, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency firefighting activities.” Illicit discharges can be categorized as either direct or indirect contributions. Examples of illicit discharges identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003) include:

Direct Illicit Discharges:

- Sanitary wastewater piping that is directly connected from a home to the storm sewer.
- Materials that have been dumped illegally into a storm drain catch basin.
- A shop floor drain that is connected to the storm sewer.
- A cross-connection between the sanitary sewer and storm sewer systems.

Indirect Illicit Discharges:

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

Unregulated Sources

Unregulated sources of bacteria are generally nonpoint. Nonpoint source loading enters the impaired water body through distributed, nonspecific locations, which may include urban runoff not covered by a permit. Potential sources, detailed below, include wildlife, agricultural runoff, 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 watershed.

Watershed livestock populations were estimated using county-level data available from the 2017 Census of Agriculture (USDA, 2019). The county-level data were refined to reflect acres of grazeable land within the TMDL watershed as identified in the 2016 NLCD and were reviewed by Texas State Soil and Water Conservation Board (TSSWCB) staff. The refinement was determined by the area classified in the 2016 NLCD as Pasture/Hay and Grassland/Herbaceous in the watershed divided by the total area of the county classified as Pasture/Hay and Grassland/Herbaceous. The ratio of grazeable acres was multiplied by USDA county-level livestock estimates. The watershed level estimates are shown in Table 6. These livestock numbers, however, were not used to develop an allocation of allowable bacteria loading to livestock.

Table 6. Livestock estimates in Hillebrandt Bayou TMDL watershed

AU	Cattle and Calves	Hogs and Pigs	Goats and Sheep	Horses
0704_02	661	9	14	17

Pets can also be a source of fecal indicator bacteria because stormwater runoff carries animal waste into streams. The American Veterinary Medical Association (AVMA) estimates there are 0.614 dogs and 0.457 cats per American household (AVMA, 2018). The number of domestic cats and dogs in the watershed was estimated by applying the AVMA estimates to the number of households in the watershed. The number of households was estimated using the 2010 USCB Census Block household counts, multiplied by the proportion of the Census Block within the watershed. Table 7 summarizes the estimated number of pets in the TMDL watershed.

Table 7. Estimated households and pet populations in Hillebrandt Bayou TMDL watershed

AU	Estimated Households	Estimated Dog Population	Estimated Cat Population
0704_02	28,056	17,226	12,822

Wildlife and Unmanaged Animals

Fecal indicator bacteria, such as *E. coli*, inhabit the intestines of all warm-blooded animals, including wildlife such as mammals and birds. To develop bacteria TMDLs, it is important to identify the potential for bacteria contributions from wildlife. Riparian corridors of water bodies naturally attract wildlife. With direct access to the stream channel, 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.

The Texas Parks and Wildlife Department (TPWD) provided deer population-density estimates by Resource Management Unit (RMU) and Ecoregion in the state (TPWD, 2018). The Hillebrandt Bayou TMDL watershed lies within RMU 13, with an average deer density of 208.46 acres per deer over the period 2005-2016. Based on 6,635 acres of habitable land in the watershed (land classified in the 2016 NLCD as Cultivated Crops, Pasture/Hay, Shrub/Scrub, Grasslands/Herbaceous, Deciduous Forest, Evergreen Forest, Mixed Forest, Woody Wetlands, and Emergent Herbaceous Wetlands), there are an estimated 32 deer in the watershed (Table 8).

Texas A&M AgriLife Extension (2012) estimates one hog per 39 acres as a statewide average density for feral hogs. This density was applied to land classified in the 2016 NLCD as Cultivated Crops, Pasture/Hay, Shrub/Scrub, Grasslands/Herbaceous, Deciduous Forest, Evergreen Forest, Mixed Forest, Woody Wetlands, and Emergent Herbaceous Wetlands. Based on 6,635 acres of habitable land, there are an estimated 170 feral hogs in the watershed (Table 8).

Table 8. Estimated deer and feral hog populations in Hillebrandt Bayou TMDL watershed

AU	Estimated Number of Deer	Estimated Number of Feral Hogs
0704_02	32	170

On-Site Sewage Facilities

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

Several pathways of the liquid waste in OSSFs afford opportunities for bacteria to enter ground and surface waters if the systems are not properly operating. However, properly designed and operated OSSFs are expected to contribute virtually no fecal bacteria to surface waters. For example, it has been reported that less than 0.01% of fecal coliforms originating in household wastes move further than 6.5 feet down gradient of the drainfield of a septic system (Weiskel, 1996). The estimated OSSF failure rate in this region of Texas is about 12% (Reed, Stowe, and Yanke, 2001).

Based on Certificate of Convenience and Necessity (CCN) mapping information provided by the Public Utility Commission of Texas (PUC), most of the Hillebrandt Bayou TMDL watershed (Figure 7) is within the service area of a centralized wastewater collection and treatment system (City of Beaumont Hillebrandt WWTF WQ0010501020). The CCN area is the geographic area under which a public utility has exclusive rights to provide sewer or water service (PUC, 2017). The southern portion of the watershed is not in a wastewater service area. Estimates of the number of OSSFs in the southern portion of the TMDL watershed were determined using the TCEQ Nonpoint Source Program Coastal On-site Sewage Inventory Database (TCEQ, 2018b). Based on this data, there are an estimated four OSSFs within the watershed (Figure 7).

Bacteria Survival and Die-off

Bacteria are living organisms that survive and die. Certain enteric bacteria can survive and replicate in organic materials if appropriate conditions prevail (e.g., warm temperature). Fecal organisms can survive and replicate from improperly treated effluent during their transport in pipe networks, and they can survive and replicate in organic-rich materials such as improperly treated compost and sewage sludge (or biosolids). While 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 replication and die-off are instream processes and are not considered in the bacteria source loading estimates in the TMDL watershed.

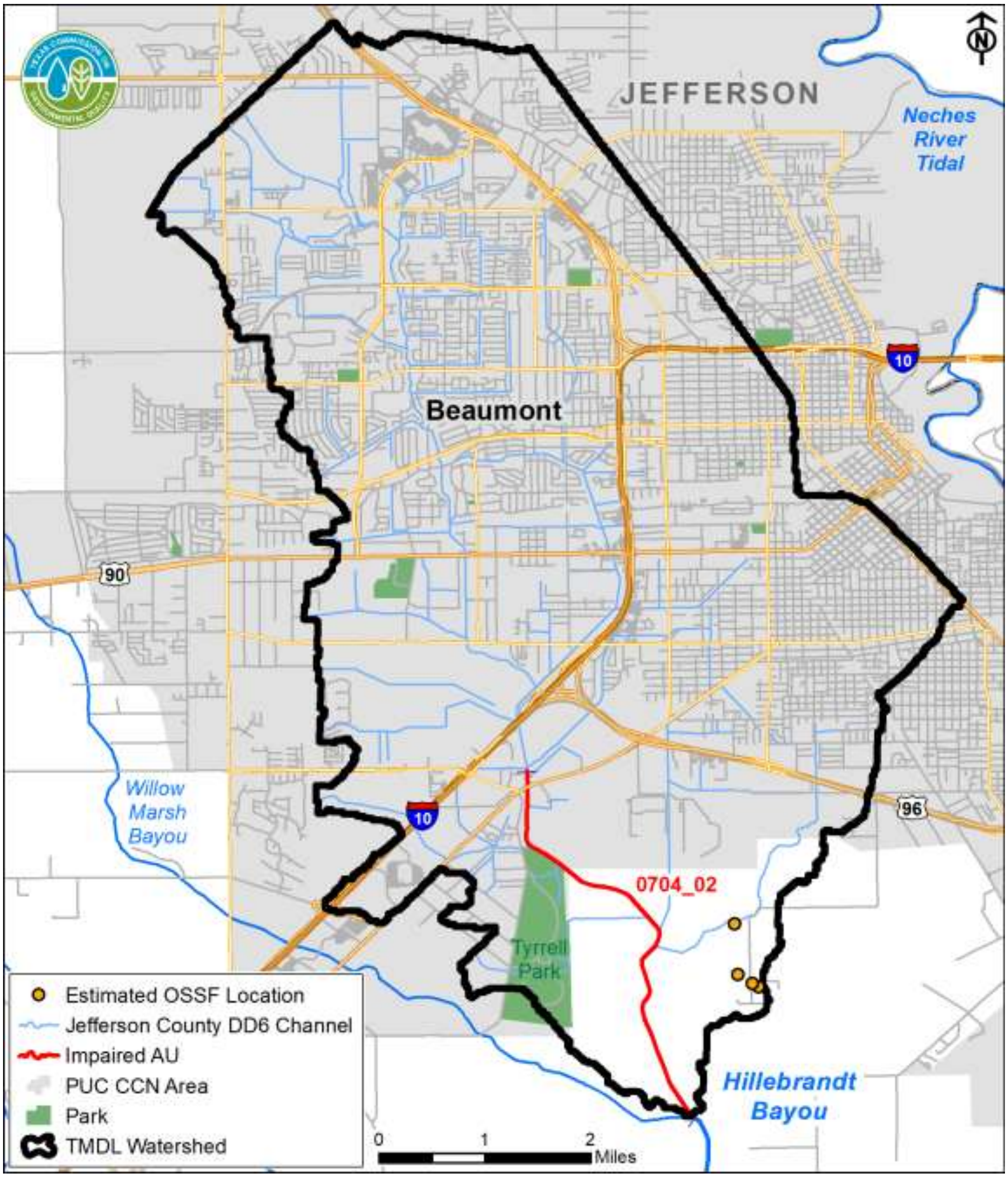

Figure 7. Estimated OSSF locations in Hillebrandt Bayou TMDL watershed

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. This relationship may be established through a variety of techniques.

Generally, if high bacteria concentrations are measured in a water body at low to median flows in the absence of runoff events, the main contributing sources are likely to be point sources and direct deposition. During ambient flows, these 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 like direct deposition 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 fecal bacteria from the land surface into the receiving stream. Generally, this loading follows a pattern of higher 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 bacteria are attenuated as runoff washes them from the land surface and the volume of runoff decreases following the rain event.

Load Duration Curve Analysis

LDCs are graphs of the frequency distribution of loads of pollutants in a water body. LDC analyses were used to examine the relationship between instream water quality and the broad sources of indicator bacteria loads, which are the basis of the TMDL allocations. In the case of this TMDL, the loads shown are of *E. coli* bacteria in cfu/day. LDCs are derived from flow duration curves (FDCs). 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. The basic steps to generate LDCs involve:

- Generating a daily flow record – the mean daily streamflow record incorporating full permitted discharges and FG was developed using a drainage area ratio (DAR) at the TCEQ SWQM station within AU 0704_02.
- Developing the FDC – the mean daily streamflow is plotted against the exceedance probability of the mean daily streamflow for each day.
- Converting the FDC to an LDC – the mean daily streamflow for each day is multiplied by the primary contact recreation 1 use geometric mean criterion and a conversion factor to produce a graph of the frequency distribution of allowable loads. and

- Overlaying the LDC with available indicator bacteria loading measurements to understand under what flow conditions indicator bacteria loading exceeds the primary contact recreation 1 use geometric mean criterion.

Hydrologic data in the form of daily streamflow records were unavailable in the TMDL watershed. However, streamflow records are available in the nearby Menard Creek and Cow Bayou watersheds. Streamflow records in both of these watersheds are collected and made available by the United States Geological Survey (USGS). Mean daily streamflow for Hillebrandt Bayou were developed using streamflow gauges 08031000 (Cow Bayou) and 08066300 (Menard Creek) (USGS, 2019b). The gauges used to develop naturalized streamflow records were chosen due to their proximity to the TMDL watershed.

The method to develop the necessary streamflow record for the FDC/LDC location (TCEQ SWQM station location) involved a DAR approach. The DAR approach involves multiplying a USGS gauging station daily streamflow value by a factor to estimate the flow at a desired TCEQ SWQM station location. The factor is determined by dividing the drainage area above the desired monitoring station location by the drainage area above the USGS gauge. Since two USGS gauging stations were selected to derive the flow for the sampling station, a DAR was applied to the flow record for each gauge. The daily streamflow value with the appropriate factor applied for each gauge was then summed and the mean of the combined daily streamflow was used to represent the daily streamflow at the SWQM monitoring station.

A drawback of the DAR approach is that it relies on the assumption of similar hydrology and landcover in the gauged and ungauged watersheds. The Hillebrandt Bayou TMDL watershed presents additional challenges because it is highly developed (approximately 70%), while nearby gauged watersheds are lightly developed. In order to account for the influence of differences in land cover on daily mean streamflow, a parameter estimation procedure was implemented to include terms that account for developed and wetland landcover. The parameters are then applied to the area ratios used to estimate flows at the ungauged site using drainage areas and streamflow from Cow Bayou and Menard Creek. Further details about the parameter estimation procedure are included in Appendix A of the *Technical Support Document for One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou*[2] (Schramm and Jha, 2020).

To summarize, the daily streamflow record for Hillebrandt Bayou AU 0704_02 was developed using the mean of the parameter corrected DARs (total area, wetland area, and developed area) applied to the naturalized streamflow records in Cow Bayou and Menard Creek. The final refinement to the streamflow record was the addition of daily streamflow allocated to FG. Additional information

[2] www.tceq.texas.gov/assets/public/waterquality/tmdl/118hillebrandt/118-hillebrandt-tsd-2020june.pdf

about the daily streamflow development procedure is available in the *Technical Support Document for One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou*[3] (Schramm and Jha, 2020).

After development of the daily streamflow record, the FDC was generated by calculating the exceedance probability for each daily streamflow record and plotting the mean daily flow against the exceedance probability. 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.

The FDC was converted to an LDC by multiplying each streamflow value by the primary contact recreation 1 use geometric mean criterion (126 cfu/100 mL) and a conversion factor (28,316.8 mL/cubic feet (ft^3) × 86,400 seconds/day (s/d)), resulting in units of cfu/day. The resulting LDC 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.

Measured bacteria loads were overlaid on the LDC plots. Historical bacteria data obtained from TCEQ SWQM station 10687 was converted to a daily load by multiplying the measured concentration by the streamflow value on the day the measurement was collected and a conversion factor. The resulting measured daily load points were plotted against the load exceedance for the day the sample was collected.

The plots of the LDC display the frequency and magnitude at which measured loads exceed the maximum allowable loadings for the geometric mean criterion. Measured loads that are above the maximum allowable loading curve indicate an exceedance of the water quality criterion, while those below the curve show compliance.

A useful refinement of the LDC approach is to divide the curve into flow-regime regions to analyze exceedance patterns in smaller portions of the duration curve. This approach can assist in determining streamflow conditions under which exceedances are occurring. A commonly used set of regimes, provided in Cleland (2003), is based on the following five intervals along the x-axis of the FDCs and LDCs: 0-10% (high flows); 10-40% (moist conditions); 40-60% (mid-range flows); 60-90% (dry conditions); and 90-100% (low flows). The selection of the flow regime intervals was based on general observation of the developed LDC.

[3] www.tceq.texas.gov/assets/public/waterquality/tmdl/118hillebrandt/118-hillebrandt-tsd-2020june.pdf

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

The *Technical Support Document for One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou*[4] (Schramm and Jha, 2020) provides further details on the methods used to develop the LDC.

Load Duration Curve Results

The LDC developed for the TMDL watershed used *E. coli* data from TCEQ SWQM station 10687 and daily mean streamflow estimated using the DAR method for the drainage area above TCEQ SWQM 10687 (Figure 8**Error! Reference source not found.**). Based on the LDC used in the pollutant load allocation process, with historical *E. coli* data added to the graphs, the following broad linkage statements can be made. For the TMDL watershed, historical *E. coli* data indicate that elevated bacteria loading primarily occurs under high flows, moist conditions, and mid-range flows. However, bacteria loads are most elevated under the high flow conditions. Under dry conditions and low flow conditions, loadings fall below the geometric mean criterion.

The majority of loadings related to high flow and moist conditions are likely attributed to regulated stormwater, which comprises a majority of the watershed. Within the watershed, there are no WWTFs to contribute point source loadings under dry and low flow conditions; however, SSOs are periodic events that may contribute to bacteria loadings within the watershed under any flow regime. Other sources of bacteria loadings under mid-range, dry, and low flow conditions and in the absence of overland flow contributions (i.e., without stormwater contribution) are most likely to contribute bacteria directly to the water. These sources may include direct deposition of fecal material from wildlife, feral hogs, birds, or livestock. OSSFs are relatively scarce within the watershed and are unlikely to be a substantial contributor to loading under any flow conditions. However, the actual contributions of bacteria loadings directly attributable to these sources cannot be determined using LDCs.

[4] www.tceq.texas.gov/assets/public/waterquality/tmdl/118hillebrandt/118-hillebrandt-tsd-2020june.pdf

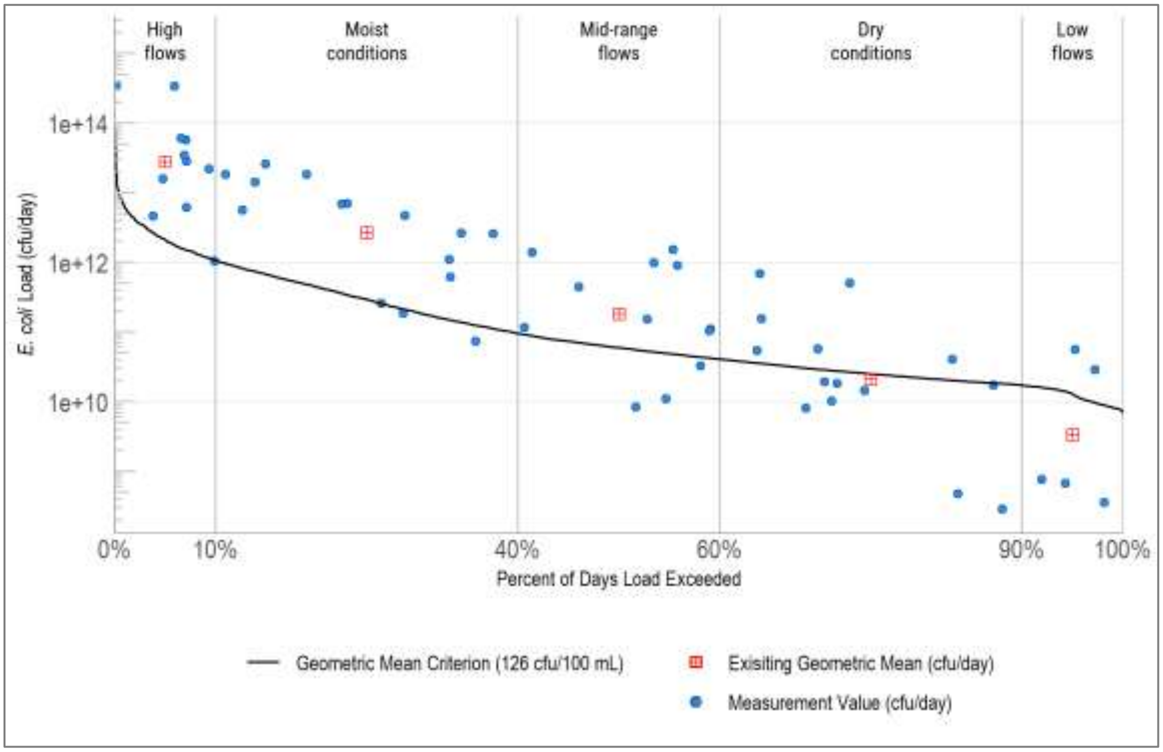

Figure 8. LDC for Hillebrandt Bayou TMDL watershed at TCEQ SWQM station 10687

Margin of Safety

The margin of safety (MOS) is used to account for uncertainty in the analysis performed to develop the TMDL and thus provides 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 in the TMDL using two methods.

1) Implicitly incorporating the MOS using conservative model assumptions to develop allocations.
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. This TMDL incorporates an explicit MOS of 5%.

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 allocation, the amount of pollutant allowed by unregulated sources

FG = loadings associated with future growth from potential regulated facilities

MOS = margin of safety load

TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures [40 CFR 130.2(i)]. For *E. coli*, TMDLs are expressed as cfu/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 impaired AU is derived using the median flow within the high flow regime (or 5% flow) of the LDC developed for the Hillebrandt Bayou TMDL watershed. For the remainder of this report, each section will present an explanation of the TMDL component first, followed by the results of the calculation for that component.

AU-Level TMDL Calculations

The TMDL for the impaired AU was developed based on information from the LDC developed for TCEQ SWQM station 10687 (Figure 8). As discussed earlier, a bacteria LDC was developed by multiplying the streamflow value along the FDC by the primary contact recreation 1 use geometric mean criterion for *E. coli* (126 cfu/100 mL) and by the conversion factor to convert to loading in cfu per day. This effectively displays the LDC as the TMDL curve of maximum allowable loading:

TMDL (cfu/day) = Criterion * Flow * Conversion Factor

Where:

Criterion = 126 cfu/100 mL *E. coli*

Flow = 5% exceedance flow from FDC in cubic feet per second (cfs)

Conversion Factor (to billion cfu/day) = 28,316.8 mL/ft^3 × 86,400 s/d × 1.0E-09 billion

At the 5% load duration exceedance, the TMDL value is provided in Table 9.

Table 9. Summary of allowable loadings for Hillebrandt Bayou AU 0704_02 watershed

AU	5% Exceedance Flow (cfs)	5% Exceedance Load (cfu/day)	TMDL (Billion cfu/day)
0704_02	681.844	2.10×10^{12}	2,101.907

Margin of Safety Formula

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

MOS = 0.05 * TMDL

Where:

MOS = margin of safety load

TMDL = total maximum daily load

The MOS for the TMDL watershed is presented in Table 10.

Table 10. MOS for Hillebrandt Bayou AU 0704_02 watershed

AU	TMDL (Billion cfu/day)	MOS (Billion cfu/day)
0704_02	2,101.907	105.095

Wasteload Allocation

The WLA consists of two parts — the wasteload that is allocated to TPDES-regulated WWTFs (WLA_{WWTF}) and the wasteload that is allocated to regulated stormwater dischargers (WLA_{SW}):

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

Wastewater Treatment Facilities

The daily allowable loading of *E. coli* assigned to WLA_{WWTF} was determined to be zero in the Hillebrandt Bayou TMDL watershed because there are no WWTFs in the watershed; therefore, there are no regulated flows from any WWTFs.

Regulated Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA_{SW} for the area was used in the development of the TMDL due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading. The percentage of land area included in the watershed that is under the jurisdiction of stormwater permits is used to estimate the amount of overall runoff load that should be allocated as 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:

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

Where:

TMDL = total maximum daily load

WLA_{WWTF} = sum of WWTF loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety load

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

In UAs currently regulated by an MS4 permit, development and/or re-development of land must implement the control measures and/or programs outlined in an approved SWMP. Although additional flow may occur from development or re-development, loading of the pollutant of concern should be controlled and/or reduced through the implementation of BMPs, as specified in the TPDES permit and the SWMP.

In order to calculate the WLA_{SW} component of the TMDL, the fractional proportion of the drainage under the jurisdiction of stormwater permits (FDA_{SWP}) must be determined in order to estimate the amount of 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 "**Error! Reference source not found.**." The results are displayed in Table 11.

Table 11. Regulated stormwater acreage and FDA_{SWP} for Hillebrandt Bayou AU 0704_02 watershed

AU	Estimated Area Under Stormwater Regulation (square miles)	Watershed Area (square miles)	FDA_{SWP}
0704_02	35.00	36.02	0.972

To complete the WLA_{SW}, a value for FG is needed. The calculation for the FG term is presented later in the document, but the results will be included here for continuity. All the needed information to calculate the WLA_{SW} is presented in Table 12.

Table 12. Regulated stormwater load for Hillebrandt Bayou AU 0704_02 watershed

AU	TMDL (Billion cfu/day)	WLA_{WWTF} (Billion cfu/day)	FG (Billion cfu/day)	MOS (Billion cfu/day)	FDA_{SWP}	WLA_{SW} (Billion cfu/day)
0704_02	2,101.907	0	86.664	105.095	0.972	1,856.664

With the WLA_{SW} and WLA_{WWTF} terms, the total WLA term can be determined by adding the two parts (Table 13).

Table 13. WLA for Hillebrandt Bayou AU 0704_02 watershed

AU	WLA_{WWTF}	WLA_{SW}	WLA
0704_02	0	1,856.664	1,856.664

All loads are expressed in billion cfu/day.

Implementation of Wasteload Allocations

The TMDL in this document will result in protection of existing uses and conform to Texas' antidegradation policy. The three-tiered antidegradation policy in the 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.

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

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 during 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 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 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 BMPs or other similar requirements, rather than as numeric effluent limits.

The November 26, 2014 memorandum from EPA relating to establishing WLAs for stormwater sources states:

> "Incorporating greater specificity and clarity echoes the approach first advanced by EPA in the 1996 Interim Permitting Policy, which anticipated that where necessary to address water quality concerns, permits would be modified in subsequent terms to include "more specific conditions or limitations [which] may include an integrated suite of BMPs, performance objectives, narrative standards, monitoring triggers, numeric WQBELs, action levels, etc."

Using this iterative adaptive BMP approach to the maximum extent practicable is appropriate to address the stormwater component of this TMDL.

Updates to Wasteload Allocations

This TMDL is, by definition, the total of the sum of the WLA, the sum of the LA, and the MOS. Changes to any future individual WLAs may be necessary 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 state's WQMP. Any future changes to effluent limitations will be addressed through the permitting process and by updating the WQMP.

Load Allocation

The LA is the sum of loads from unregulated sources, and is calculated as:

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

Where:

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

WLA_{SW} = sum of all regulated stormwater loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety load

Table 14. LA for Hillebrandt Bayou AU 0704_02 watershed

AU	TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
0704_02	2,101.907	0	1,856.664	86.664	105.095	53.484

All loads are expressed in billion cfu/day.

summarizes the LA.

Table 14. LA for Hillebrandt Bayou AU 0704_02 watershed

AU	TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
0704_02	2,101.907	0	1,856.664	86.664	105.095	53.484

All loads are expressed in billion cfu/day.

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 water bodies increases as the amount of flow increases.

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

To account for the FG component of the impaired AU, the loadings from 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 project population growth within WWTF service areas between 2020 and 2070, based on TWDB Regional Water Plan Population and Water Demand Projections (TWDB, 2019).

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

Where:

Criterion = 126 cfu/100 mL (*E. coli*)

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

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

Conversion Factor (to billion cfu/day) = 1.54723 cfs/MGD × 28,316.8 mL/ft^3 × 86,400 s/d × 1.0E-09 billion

For the Hillebrandt Bayou TMDL watershed, the conventional FG calculation is hindered by the $WWTF_{FP}$ being zero. However, the TMDL must still account for the possibility of FG for the impaired AU. In order to address this, an FG term was calculated for the TMDL watershed. Currently, the Hillebrandt WWTF is located in the TMDL watershed, but the outfall is located downstream of the TMDL watershed in a different AU. The FG term was estimated as the percent population increase multiplied by the current permitted flow of the Hillebrandt WWTF, with the assumption that the additional flow could be discharged within the TMDL watershed. The additional FG flow was calculated as described above and is shown in Table 15.

Table 15. FG load attributed to potential WWTF services in Hillebrandt Bayou AU 0704_02 watershed

AU	Current Permitted Flow (MGD)	Percent Increase	FG Flow (MGD)	FG (Billion cfu/day)
0704_02	46	39.5	18.17	86.664

FG of existing or new point sources is not limited by this TMDL 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 LDC and tables in this TMDL will guide determination of the assimilative capacity of the stream under changing conditions, including FG.

Summary of TMDL Calculations

The TMDL was calculated based on median flow in the 0-10 percentile range (5% exceedance, high flow regime) for flow exceedance from the LDC developed from TCEQ SWQM station 10687. Allocations are based on the current primary contact recreation 1 use geometric mean criterion for *E. coli* of 126 cfu/100 mL for each component of the TMDL. The TMDL allocation summary for the Hillebrandt Bayou TMDL watershed is summarized in Table 16.

Table 16. TMDL allocation for Hillebrandt Bayou AU 0704_02 watershed

AU	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA	FG
0704_02	2,101.907	105.095	0	1,856.664	53.484	86.664

All loads are expressed in billion cfu/day.

The final TMDL allocations (Table 17) needed to comply with the requirements of 40 CFR 103.7 include the FG component within the WLA_{WWTF}.

Table 17. Final TMDL allocations for Hillebrandt Bayou AU 0704_02 watershed

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
0704_02	2,101.907	86.664	1,856.664	53.484	105.095

All loads are expressed in billion cfu/day.

Seasonal Variation

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

Seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* concentrations obtained from routine monitoring samples collected in the warmer months (May-September) against those collected during cooler months (November-March). The months of April and October were considered transitional between warm and cool seasons and were excluded from the seasonal analysis. Differences in seasonal concentrations were then evaluated with a Wilcoxon Rank Sum test (also known as the “Mann-Whitney” test). The test was considered significant at the $\alpha = 0.05$ level.

The Wilcoxon Rank Sum test suggests there is a seasonal difference in *E. coli* concentrations in the Hillebrandt Bayou TMDL watershed ($W = 142$, $p < 0.01$) (Figure 9). As shown in Figure 9, the distribution of cool season *E. coli* measurements is significantly higher than the distribution of warm season measurements. It should be noted that the criteria used by TCEQ to assess recreational uses apply to water bodies during all seasons of the year. Therefore, seasonal variation is accounted for in the bacteria TMDL presented in this document by virtue of the fact that these variations affect neither the calculation nor the implementation of bacteria TMDLs in Texas.

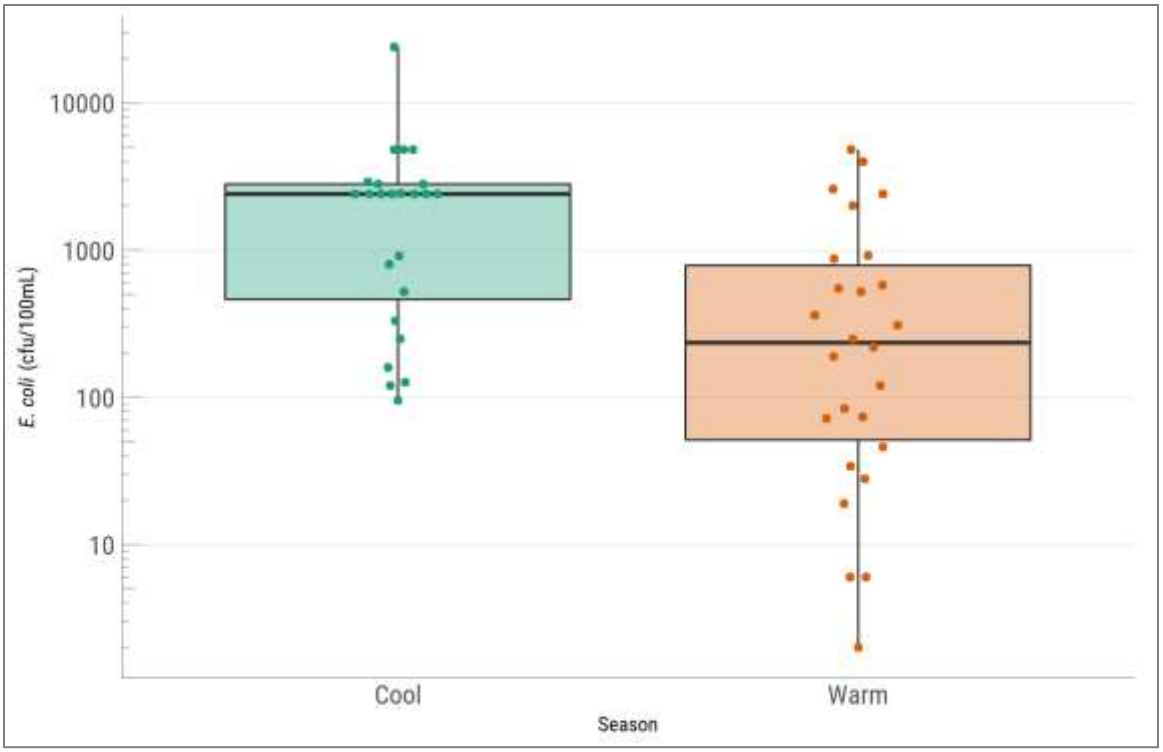

Figure 9. Distribution of *E. coli* concentration by season in Hillebrandt Bayou TMDL watershed

Public Participation

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.

TCEQ and the Texas Water Resources Institute (TWRI) are jointly providing coordination of public participation for development of both the TMDL and Implementation Plan (I-Plan). The first of a series of public meetings to engage stakeholders was held on August 22, 2019 in Beaumont to discuss the project and keep the public aware of the TMDL. A webinar was held on April 9, 2020 to initiate I-Plan development. A webinar was held on August 14, 2020 to present preliminary TMDL allocation information. A webinar was held August 19, 2020 to provide specific WLA information.

Notices of meetings were posted on the project webpages for both TCEQ and TWRI. At least two weeks prior to scheduled meetings, TWRI issued media releases through Texas A&M AgriLife and local AgriLife Extension Offices, and formally invited stakeholders to attend. To ensure that absent or new stakeholders could get information about past meetings and pertinent material, the TCEQ project webpage[5] provides meeting summaries, presentations, and documents produced for review.

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 [40 CFR 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, TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the Commission. Based on the TMDL and I-Plan, TCEQ will propose and certify WQMP updates if needed to establish required WQBELs for specific TPDES wastewater discharge permits.

For MS4 entities, where numeric effluent limitations are infeasible, the permits require that the MS4 develop and implement BMPs under each MCM, which are a substitute for effluent limitations, as allowed by federal rules. How a regulated MS4 meets each MCM is not prescribed in detail in the MS4 permits, but is included in the permittee's SWMP. During the permit renewal process, TCEQ revises its MS4 permits as needed to require the implementation of other specific revisions in accordance with an approved TMDL and 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. 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.

[5] www.tceq.texas.gov/waterquality/tmdl/nav/118-hillebrandtbayou-bacteria

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. Hillebrandt Bayou and nearby Neches River Tidal TMDL for contact recreation will be included together in a regional I-Plan.

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.

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. 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 identifies the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the approved I-Plan 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.

References

AgriLife Extension (2012). *Feral Hog Population Growth, Density and Harvest in Texas.* SP-472. College Station. Online. wildpigs.nri.tamu.edu/media/1155/sp-472-feral-hog-population-growth-density-and-harvest-in-texas-edited.pdf.

AVMA [American Veterinary Medical Association] (2018). *2017-2018 U.S. Pet Ownership & Demographics Sourcebook.* Online. www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics#formulas.

Cleland, B. (2003). *TMDL Development From the "Bottom Up" - Part III: Duration Curves and Wet-Weather Assessments.* Online. www.researchgate.net/publication/228822472_TMDL_Development_from_the_Bottom_Up-_PART_III_Durations_Curves_and_Wet-Weather_Assessments.

EPA [United States Environmental Protection Agency] (1991). *Guidance for Water Quality-Based Decisions: The TMDL Process*. Online. EPA 440/4-91-001. nepis.epa.gov/Exe/ZyNET.exe/00001KIO.TXT.

EPA (2019). *Enforcement and Compliance History Online* (ECHO). Retrieved March 20, 2019, from echo.epa.gov.

NEIWPCC (2003). *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities*. Online. neiwpcc.org/neiwpcc_docs/iddmanual.pdf.

NOAA [National Oceanic and Atmospheric Administration] (2019). *Daily Summaries Station Details.* Retrieved May 2, 2019, from National Climatic Data Center: www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00410611/detail.

NRCS [Natural Resources Conservation Service] (2018). *2018 SSURGO Snapshot.* Online. datagateway.nrcs.usda.gov/.

PUC (2017). *CCN Mapping Information*. PUC CCN Water and Sewer GIS Shapefiles. Online. www.puc.texas.gov/industry/water/utilities/gis.aspx.

Reed, Stowe, and Yanke, LLC. (2001). *Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas.* Online. www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/StudyToDetermine.pdf.

Schramm, M., and Jha, A. (2020). *Technical Support Document for One Total Maximum Daily Load for Indicator Bacteria in Hillebrandt Bayou.* Prepared by the Texas Water Resources Institute for the Texas Commission on Environmental Quality. Online. www.tceq.texas.gov/assets/public/waterquality/tmdl/118hillebrandt/118-hillebrandt-tsd-2020june.pdf.

TCEQ (2011). *2010 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d).* Online. www.tceq.texas.gov/waterquality/assessment/10twqi/10twqi.

TCEQ (2018a). Texas Surface Water Quality Standards, 30 TAC Chapter 307. Online. texreg.sos.state.tx.us/public/readtac%24ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y.

TCEQ (2018b). *Coastal On-site Sewage Inventory Database*. TCEQ Nonpoint Source Program. Personal communication, D. Grundmann. E-mail received May 23, 2019.

TCEQ (2019a). *Central Registry.* Query – ID Search. Retrieved March 20, 2019 and February 27, 2020. www15.tceq.texas.gov/crpub/.

TCEQ (2019b). *Water Quality General Permits and Registration Search*. Retrieved March 20, 2019 and February 24, 2020. www2.tceq.texas.gov/wq_dpa/index.cfm.

TCEQ (2019c). Statewide SSO Report January 2016 - December 2018. Personal communication, D. Grundmann. Email received January 31, 2019.

TCEQ (2019d). Basin SSO Report January 2005 - December 2015. Personal communication, D. Grundmann. E-mail received May 29, 2019.

TCEQ (2020). *2020 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d).* Online. www.tceq.texas.gov/waterquality/assessment/20twqi/20txir.

TPWD [Texas Parks and Wildlife Department] (2018). Statewide white-tailed deer density data request (pdf files). Personal communication, A. Cain. Email received January 9, 2018.

TWDB [Texas Water Development Board] (2019). *Regional Water Plan Population & Water Demand Projections.* Retrieved March 28, 2019 and April 27, 2020. www.twdb.texas.gov/waterplanning/data/projections/2022/popproj.asp.

USCB [United States Census Bureau] (2010). *2010 TIGER/Line Shapefiles.* Online. www.census.gov/geo/maps-data/data/tiger-line.html.

USDA [United States Department of Agriculture] (2019a). *2017 Census of Agriculture*. Online. www.nass.usda.gov/Publications/AgCensus/2017/index.php/.

USGS [United States Geological Survey] (2019a). *NLCD 2016 Land Cover Conterminous United States. (Remote sensing image files).* Sioux Falls, SD. U.S. Geological Survey. Online. www.mrlc.gov/data.

USGS (2019b). *National Water Information System (NWIS)*. Online. waterdata.usgs.gov/nwis/si.

Weiskel, P.K., Howes, B.L., and Heufelder, G.R. (1996). Coliform Contamination of Coastal Embayment: Sources and Transport Pathways. *Environmental Science and Technology,* 30, 1872-1881.

Appendix A. Population and Population Projections

The following series of steps was followed to estimate the watershed population and future population projections:

Estimate 2010 watershed population

1) Census block level population and spatial data for Jefferson county for the year 2010 was obtained from U.S. Census Bureau.
2) The Hillebrandt Bayou TMDL watershed includes 1,743 census blocks, located entirely or partially in the watershed. Population was estimated for those census blocks partially located in the watershed by multiplying the census block population and the percent of each block within the TMDL watershed. It was assumed for this estimation that population was evenly distributed within a census block.
3) The estimated partial census block populations were then summed with the populations from the census blocks located entirely within the TMDL watershed. This was the resulting 2010 population estimate for the Hillebrandt Bayou TMDL watershed.

Estimate 2020–2070 watershed population

1) TWDB Regional Water Plan Population Projections by WUG in Texas were obtained for the Beaumont WUG for 2020–2070.
2) The proportional increase from the published 2010 Beaumont WUG population and the published 2020 Beaumont WUG projected population was calculated to estimate the 2020 watershed population.
3) The projected population percentage increase in each decade from 2020 to 2070 was calculated from the TWDB Regional Water Plan data for the Beaumont WUG.
4) The percentage increase for each decade was applied to the estimated 2020 watershed population. These watershed population projections are consistent with, the 39.5 percent population increase developed by TWDB for the Beaumont WUG from 2020 through 2070.