Bacteria Modeling Report for the Brays and Sims Bayou Watershed

December 2025

This document was prepared by the Houston-Galveston Area Council (H-GAC) for the stakeholders of the Brays and Sims Bayou Watershed Partnership. It was prepared in cooperation with the Texas Commission on Environmental Quality (TCEQ) and the United States Environmental Protection Agency (EPA).

Table of Contents

Figure Index

Table Index

Abbreviations List

AU	Assessment Unit
CAFO	Concentrated Animal Feeding Operation
cfs	Cubic Feet per second
cfu/day	Colony Forming Units per day
CRP	Clean Rivers Program
E. coli	*Escherichia coli*
d	Dry
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
GIS	Geographic Information System
h	High Flow
H-GAC	Houston-Galveston Area Council
l	Low Flow
LDC	Load Duration Curve
m	Moist
MGD	Millions of Gallons per Day
mr	Mid-range
OSSF	On-Site Sewage Facility
R	Reduction Value
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSO	Sanitary Sewer Overflow
SWAT	Soil and Water Assessment Tool
TCEQ	Texas Commission on Environmental Quality
Texas Integrated Report	Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)
USGS	United States Geological Survey
W	Weighting Factor or Percent of Flows
WPP	Watershed Protection Plan
WWTF	Wastewater Treatment Facility

SECTION 1: INTRODUCTION

Brays Bayou flows east and south from its headwaters near the crossing of State Highway 6 and the Westpark Tollway (**Figure 1**). Sims Bayou is just south of Brays Bayou, also flowing east from its headwaters near the border between Harris and Fort Bend counties. The Brays and Sims Bayou watershed is composed of the drainage area of the unclassified segments Brays Bayou Above Tidal (1007B) and Sims Bayou Above Tidal (1007D), as well as smaller unclassified segment tributaries, and a network of natural and manmade drainage channels. This watershed area spans approximately 220 square miles of portions of Harris and Fort Bend counties (**Figure 2**). Land cover in the watershed is mostly developed with the exception of a small percentage of forest, wetland, and pasture (mostly in the Sims Bayou watershed) (**Figure 2**). Major transportation corridors include Interstate 10, Interstate 45, Interstate 69/US Highway 59, US Highway 90, the Sam Houston Tollway/Beltway 8, the Westpark Tollway, State Highway 6, State Highway 35, and State Highway 288. The watersheds overlap portions of Bellaire, Four Corners, Houston, Mission Bend, Meadows Place, South Houston, Southside Place, Stafford, University Place, and small portions of Missouri City, Pasadena, and Sugar Land.

The most recent version of the Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d) (Texas Integrated Report)[1] produced by the Texas Commission on Environmental Quality (TCEQ) indicated exceedances of state water quality standards in Brays and Sims Bayou and their tributaries[2]. Specifically, high concentrations of the fecal indicator bacteria *Escherichia coli* (*E. coli*) and Enterococci resulting in impairments to contact recreation use were observed. Because fecal indicator bacteria such as *E. coli* and Enterococci are found in the digestive systems of people and animals, detecting high concentrations of this organism in surface water indicates potential contamination from sources such as untreated sewage, agricultural runoff, or deposits from wild animals. Especially in cases where human waste pressures are indicated, there is also a likelihood that additional pathogens could be present in waterways. Without taking action to manage sources of contamination, recreation activities such as swimming and wading in streams will not be safe for communities of the watershed.

To address these challenges, a watershed protection plan (WPP) will be developed which will outline the specific goals and action strategies set forth by local stakeholders to achieve water quality improvements. In their roles as facilitators to this stakeholder group, the Houston-Galveston Area Council (H-GAC) conducted a series of modeling efforts to provide stakeholders with a more comprehensive understanding of fecal bacteria sources impacting the Brays and Sims Bayou watershed. These modeling efforts include estimations for fecal bacteria load reductions and dissolved oxygen (DO) improvements needed to comply with state water quality standards determined with load duration curve (LDC) analyses. Additionally, potential fecal bacteria source load assessments for each of the subwatersheds in the project area were conducted using the Spatially Explicit Load Enrichment Calculation Tool (SELECT). These assessments will help to determine where and how improvements can be made to reduce negative impacts to water quality.

---

[1] This report references the 2024 version of the Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d). These assessments determine which streams are classified as having impairments (measurements exceeding numerical or other specific state water quality standards) or concerns (exceedances of screening levels or other non-numeric/specific criteria).

[2] A more detailed analysis of water quality is discussed further in the Preliminary Acquired Data Analysis Report for the Brays and Sims Bayou Watershed. This document and more information on data quality objectives, concerns, and methodologies used in these analyses (detailed in the Brays and Sims Bayou Modeling Quality Assurance Project Plan) are available for review at https://www.h-gac.com/watershed-based-plans/brays-sims-bayou.

The following sections of this document will discuss:

- Needs of the project that will be met through modeling analyses.
- Types of models used in this report and how they fit into the design of the overall analysis.
- Results of LDC evaluations.
- Results of SELECT model evaluations.
- An overview of the outcomes and implications of the findings from this report.
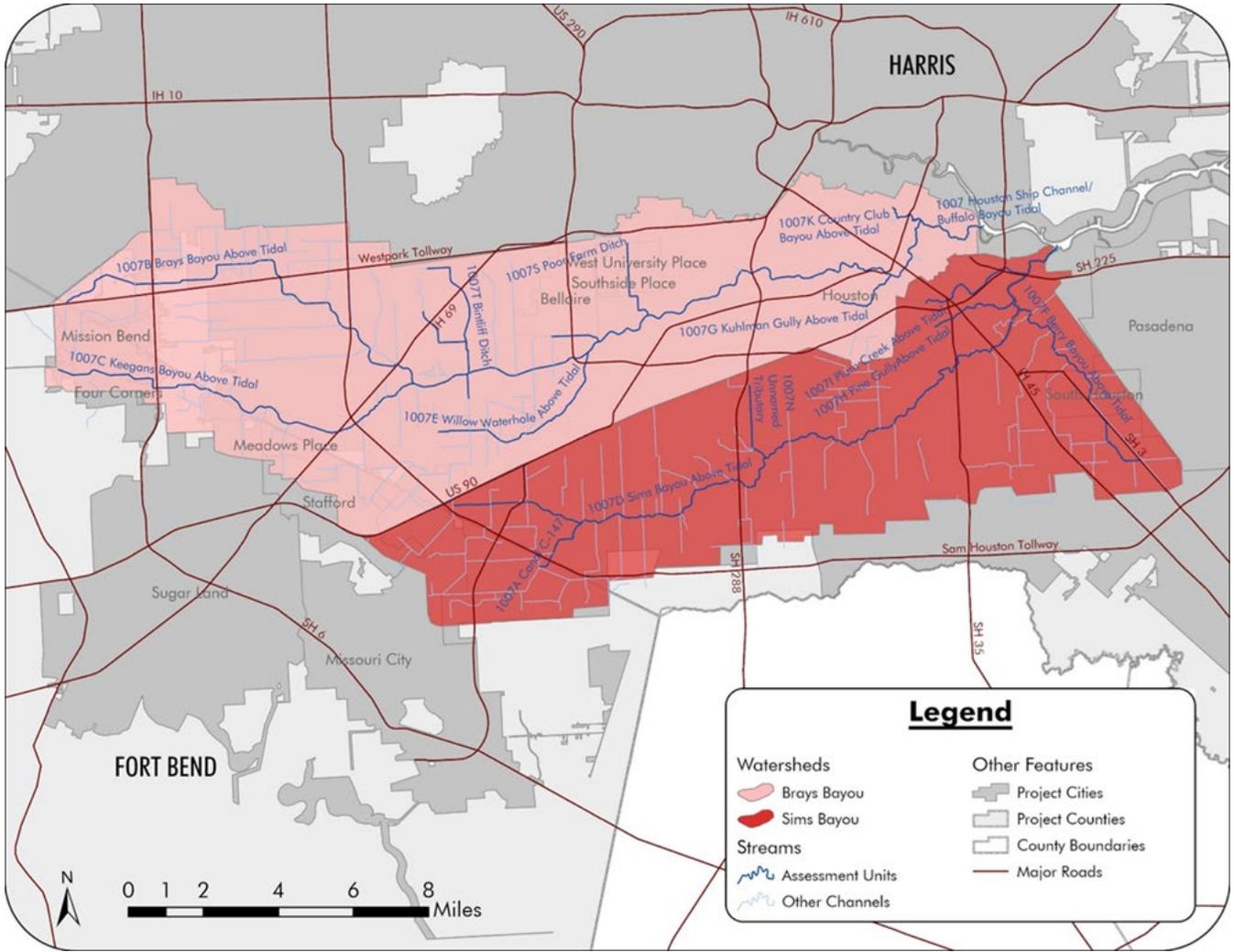
Figure 1. *The Brays and Sims Bayou Watershed*
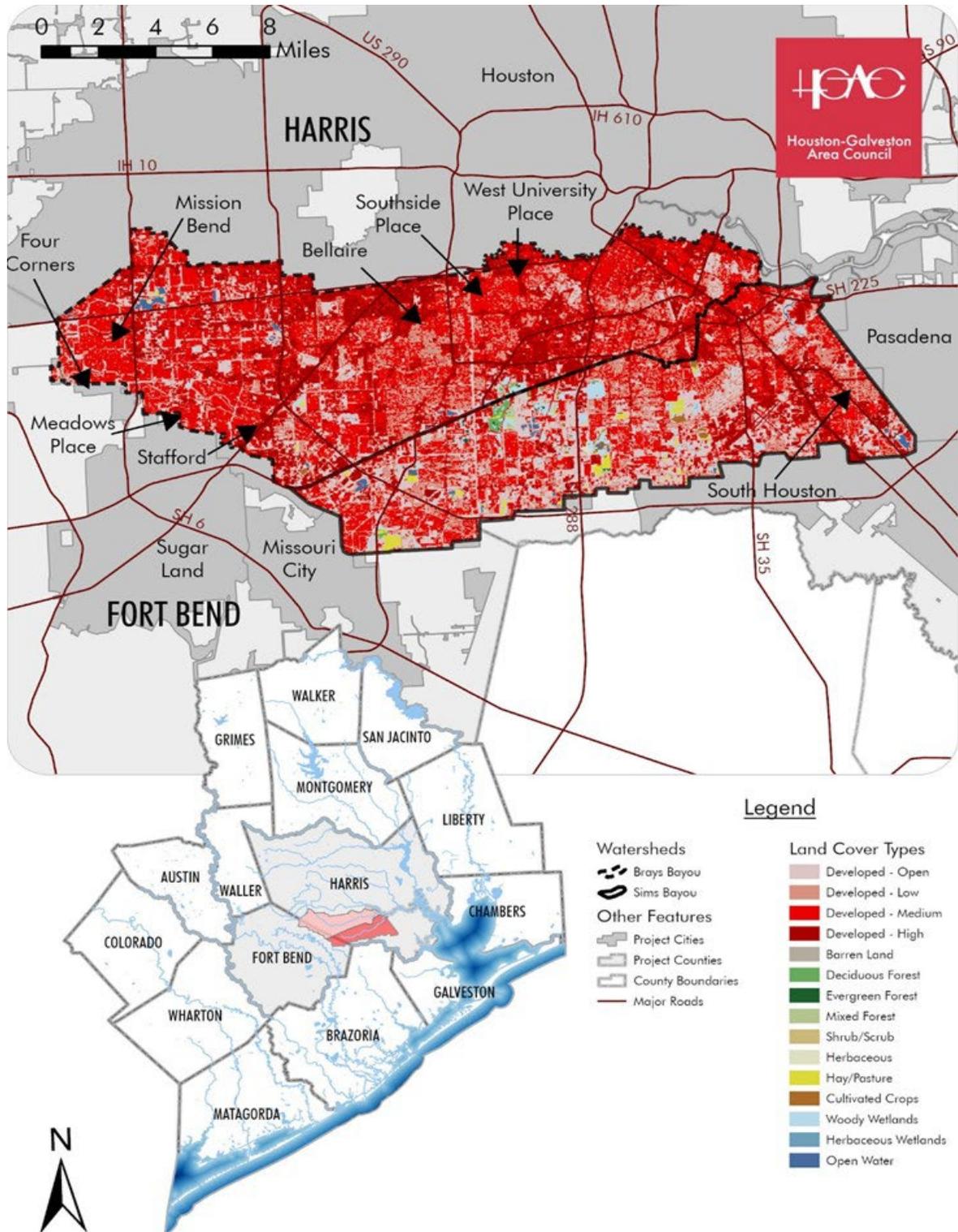
Figure 2. Regional Context and Land Cover in the Brays and Sims Bayou Watershed

SECTION 2: PROJECT NEEDS

Model results are an important resource for stakeholders seeking to make watershed planning decisions. By observing modeled data, stakeholders will develop a better understanding of what pollutant sources are impacting the watershed, at what magnitudes pollutants are delivered to the system, where pollutant pressures are spatially distributed, and how to address these concerns most effectively. Beyond this primary need, the combination of modeling results, other data analyses, and stakeholder input is essential to the fulfillment of Element A of the United States Environmental Protection Agency (EPA) 9-element model for watershed-based plans[3].

Needs specific to the development of a WPP for Brays and Sims Bayou and their tributaries include:

- Relating stream flow to pollutant loads to identify at which flow conditions exceedances of water quality standards are observed using LDC models.
- Establishing goals (fecal bacteria load reduction and DO improvement benchmarks) necessary for compliance with state water quality standards using LDC models.
- Using fecal indicator bacteria data as a proxy for estimating spatial relationships and source analysis of fecal waste loading in area subwatersheds using SELECT models.
- Using the LDC and SELECT model results to relate load reductions to source load data and estimate specific source load reductions.

Additionally, future source loading conditions will be assessed to account for the expansion of developed area and other land changes forecasted to take place in the watershed in the next 25 years.

SECTION 3: MODEL SELECTION AND ANALYSIS DESIGN

3.1 Model Selection

To best suit the project needs described in Section 2, H-GAC staff selected LDC and SELECT models to represent pollutant loading data in the Brays and Sims Bayou watershed. These models strike the balance between efficiency and complexity and have been used widely on other WPP projects throughout the region. After discussions between H-GAC and TCEQ regarding this project as well as similar watershed planning efforts, relating LDC reduction percentages linearly to SELECT source load estimation models was determined to be appropriate for decision-making needs related to WPP development. Fate and transport of pollutants are not captured by these models between source loads and could be more precisely represented by complex modes such as the Soil and Water Assessment Tool (SWAT). However, the level of detail rendered from these intensive analyses ultimately does not provide more meaningful support for stakeholder decision-making and requires additional cost and time to develop. As part of the WPP, long-term monitoring and assessments of efficacy will be carried out which will help to offset the need for complex, predictive modeling.

Additionally, H-GAC staff incorporated modifications to the standard SELECT modeling process to counteract spatial generalization of results. By utilizing buffers—zones within a set distance of another feature—models can assign more weight to certain sets of results based on spatial relationships. In the case of watershed planning, potential pollutant loads from sources within buffers immediately surrounding waterways can be given more weight than sources distributed outside the buffer according to higher likelihood of impact. Another modification to the SELECT models used in this report involved the

---

[3] As referenced at https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters

utilization of a base assumption for wildlife impacts throughout the watershed. This helps to bridge the gap that the SELECT model can sometimes face when limited by sparse or insufficient wildlife data.

3.2 Analysis Design

According to findings from the most recent version of the Texas Integrated Report produced by TCEQ, the most widespread and frequently occurring impairment in the Brays and Sims Bayou watershed is caused by high levels of fecal indicator bacteria, which can indicate the presence of fecal waste and pathogens in surface water. Concerns for low levels of DO and impairments for aquatic life use due to depressed DO were also observed throughout the watershed. Water quality and spatial data used in this report were collected from quality assured sources including the Surface Water Quality Monitoring Information System and the National Hydrography Dataset. Using LDCs and SELECT models, the following analyses were designed to consider:

- Whether adequate water quality and flow data exist for the study area.
- Which of the major flow categories are of the highest concern in this watershed.
- Which locations throughout the watershed could act as benchmarks for monitoring progress toward water quality goals.
- What pollutant sources need to be incorporated into the models and where to acquire data to represent these sources.
- How to determine the best source estimations.
- At which points in the future to forecast projected loading values and how to develop them.
- How to incorporate the buffer method into a modified SELECT output.
- How stakeholder input could be used to refine these assessments.

Model results from LDCs and SELECT evaluations were combined to link reduction goals to specific source loads and develop effective water quality improvement strategies for the WPP. Future reduction targets derived from this assessment represent five-year benchmarks through the year 2050.

SECTION 4: LDC EVALUATIONS

4.1 Overview

LDCs were used to characterize the relationship between pollutant loads and stream flow. By determining the difference between modeled loads and the maximum loads permitted by state water quality standards, reduction targets can be estimated. Because impairments due to elevated levels of fecal indicator bacteria and depressed levels of DO were noted for segments in this watershed in the latest Texas Integrated Report produced by TCEQ, LDCs were used for both sets of pollutants.

4.2 Load Estimation

Origins of fecal waste indicated by bacteria in waterways are informed by the stream flow conditions observed at the time of sample collection. This information is also helpful in determining the strategies that will be most effective in reducing contamination. For example, if bacteria levels are highest in periods of high flows or flooding events, then stormwater flows and other nonpoint sources are likely to be the major contributors to impairment. If fecal bacteria levels are highest when flows are limited, then point sources or sources known to steadily contribute contaminants into waterways are indicated as the greater concern.

To calculate LDCs for Brays and Sims Bayou and their tributaries, stream flow data from the United States Geological Survey (USGS) and Clean Rivers Program (CRP) water quality data from the Surface

Water Quality Monitoring Information System were used. USGS gage data is ideal to produce flow duration curves used in LDC analyses due to the long-term, continuous measurements recorded by the gages. Based on the percentage of days during the study period in which flows of a known magnitude are observed, a flow duration curve is developed and plotted. Additional curves resulting from the multiplication of state water quality standards and values of the flow duration curve are added to the plot to represent the maximum allowable contaminant loads during each flow condition. Finally, individual observed pollutant levels collected during the study period and a curve modeled from these observations are plotted. For areas where the modeled curve exceeds the maximum allowable contaminant load curve, reductions are needed.

4.3 Site Selection

Locations of monitoring data used for LDC analyses were selected based on their periods of record, water quality conditions, availability of corresponding stream flow data, and representativeness of smaller drainage areas within the greater watershed known as subwatersheds. Subwatershed delineation is useful as a means of yielding more spatially specific information that can be used to target source load reductions with greater precision. This analysis references the fifteen subwatersheds (**Figure 2**) described below.

1) **Brays Above Tidal - Headwaters (B1)**– the drainage area of Assessment Unit (AU) 1007B_01, the headwaters of Brays Bayou Above Tidal. Like the rest of the subwatersheds, land cover in this subwatershed is densely developed. This waterbody represents the headwaters of Brays Bayou Above Tidal. This area is represented by Station 11140 (Brays Bayou at South Gessner Drive) and stream flow was assessed from USGS gage 08074810.

2) **Brays Above Tidal - Middle (B2, B3, B4, B5, B6, B7, B9)**– the drainage area of the mid-watershed attainment area for Brays which include the following Aus:
   - 1007B_01-Brays Bayou Above Tidal
   - 1007T_01-Bintliff Ditch
   - 1007U_01-Mimosa Ditch
   - 1007S_01-Poor Farm Ditch
   - 1007L_01- Unnamed Non-Tidal Tributary of Brays Bayou
   - 1007E_01-Willow Waterhole Bayou

   This area is represented by USGS gage 08075000 which was used to measure flow at Station 11139 (Brays Bayou at South Main St).

3) **Brays Tidal (B8)** – the drainage area of AUs 1007_04 and 1007K_01 the tidal portion of Brays Bayou. This area is represented by Station 11306. (Brays Bayou Tidal at 75th Street). This station is not represented by a USGS gage, so stream flow was estimated by applying a drainage area ratio. The reference gage data was taken from a nearby watershed of similar size and geography on Vince Bayou in Pasadena, TX. To do this, the drainage area of USGS gage 08075730 on Vince Bayou was compared to that of station 11306 to determine a ratio to use as a multiplier for daily mean stream gage measurements taken at 08075730. While station 11306 is tidally influenced, there was no salinity data available to estimate, and thus a seawater flow adjustment formula was not applied to the representative LDC.

4) **Kuhlman Gully (B10)**– the drainage area of AU 1007G_01, Kuhlman Gully Above Tidal. Ambient data for this area are represented by Station 16653 (Kuhlman Gully at Brock Street). Similar to Brays Tidal, this station is not represented by a USGS gage, so stream flow was estimated by applying a drainage area ratio. The reference gage data was taken from a nearby watershed of similar size and geography on Vince Bayou in Pasadena, TX. To do this, the drainage area of USGS gage 08075730 on Vince Bayou was compared to that of station 16653 to determine a ratio to use as a multiplier for daily mean stream gage measurements taken at 08075730.

5) **Sims Above Tidal – Headwaters (S1)**– the drainage area of segments 1007A, 1007D, and 1007N, the headwaters of Sims Bayou Above Tidal. Ambient data for this area are represented by Station 11135 (Sims Bayou at Hiram Clarke Rd) and stream flow was assessed from USGS gage 08075400.

6) **Sims Above Tidal – Middle (S2, S3)** – the drainage area of the mid-watershed attainment area for Sims Bayou Above Tidal (segment 1007D). Ambient data for this area are represented by Station 11132 (Sims Bayou at Telephone Road SH35). This station is not represented by a USGS gage, so stream flow was estimated by applying a drainage area ratio. Similarly to other subwatersheds, the reference gage data was taken from a nearby watershed of similar size and geography on Vince Bayou in Pasadena, TX. To do this, the drainage area of USGS gage 08075730 on Vince Bayou was compared to that of station 11132 to determine a ratio to use as a multiplier for daily mean stream gage measurements taken at 08075730.

7) **Sims Tidal (S4) –** the drainage area of AUs 1007I_01, 1007_02, and 1007H_01, the tidal portion of Sims Bayou. This area is represented by Station 11302 (Sims Bayou at Lawndale Ave). As with other subwatersheds, this station is not represented by a USGS gage, so stream flow was estimated by applying a drainage area ratio. Similarly to other subwatersheds, the reference gage data was taken from a nearby watershed of similar size and geography on Vince Bayou in Pasadena, TX. To do this, the drainage area of USGS gage 08075730 on Vince Bayou was compared to that of station 11302 to determine a ratio to use as a multiplier for daily mean stream gage measurements taken at 08075730. While station 11302 is tidally influenced, there was no salinity data available to estimate, and thus a seawater flow adjustment formula was not applied to the representative LDC.

8) **Berry Bayou (S5) –** the drainage area of AU 1007F_01, Berry Bayou Above Tidal. Ambient data for this area are represented by Station 16661 (Berry Bayou at South Richey Street) and stream flow was assessed from USGS gage 08075605.
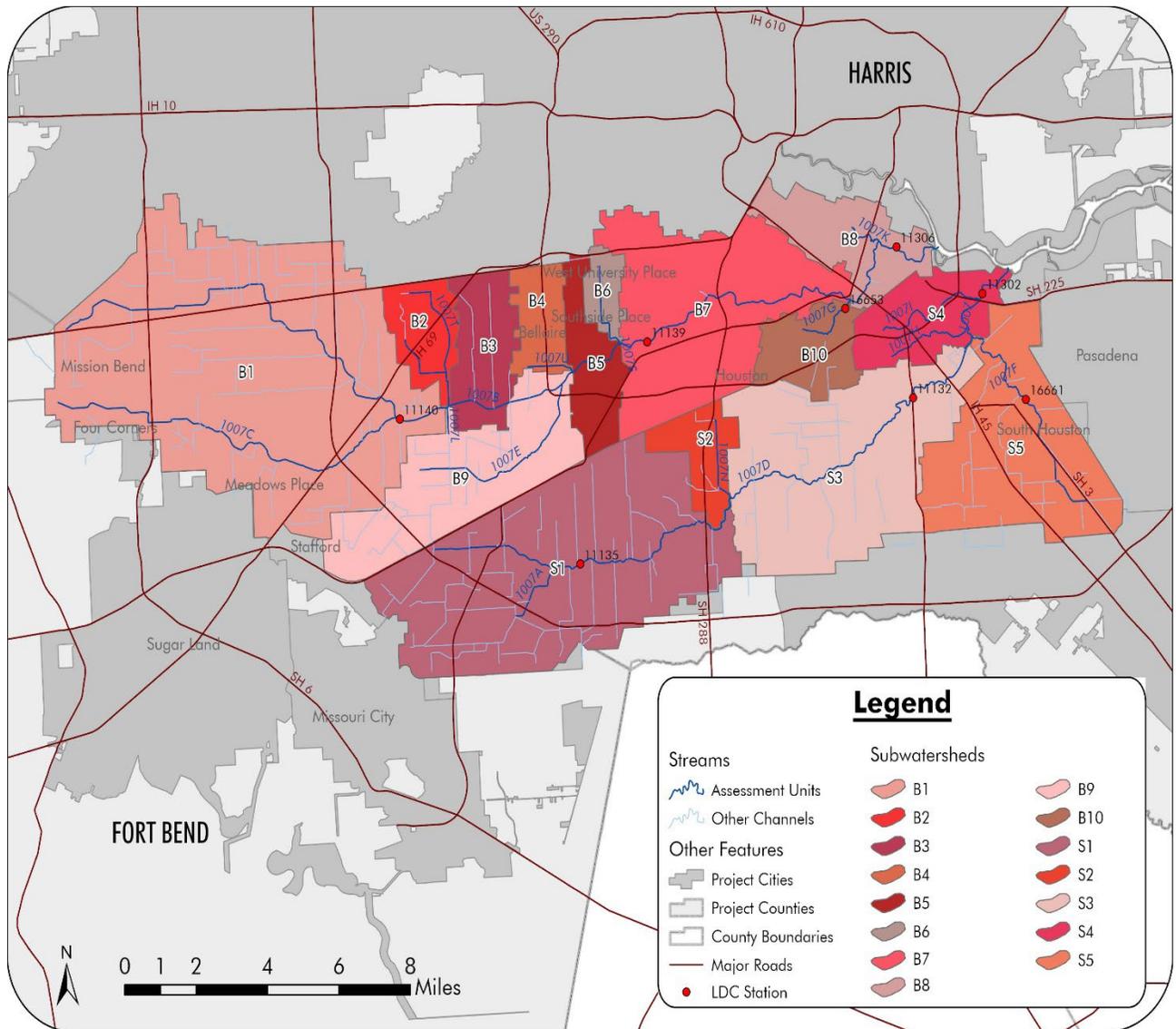
Figure 3. Subwatersheds of the Brays and Sims Bayou watershed

Ambient water quality data are collected at over 400 sites in the 13-county Houston-Galveston region by H-GAC, local partners, and TCEQ as part of CRP. In general, most monitoring stations are sampled by CRP partners on a quarterly frequency for a suite of field, bacteriological, and conventional parameters. The final determination of the regulatory status of each segment is based primarily on these ambient data. The impetus for development of the WPP was formed largely in response to the current regulatory status of Brays and Sims Bayou and their tributaries, therefore ambient data is a relevant source of information for informing stakeholder decisions. Ambient data used for LDC analyses were collected in the Brays and Sims Bayou watershed between 2014 and 2024 at eight locations (**Figure 2**; **Table 1**).

Table 1. LDC locations

LDC Site	CRP Station	USGS Gage	Assessed Area
Brays Bayou at South Gessner Drive	11140	08074810	B1
Brays Bayou at South Main St	11139	08075000	B2, B3, B4, B5, B6, B7, B9
Brays Bayou Tidal at 75th Street	11306	No Gage	B8
Kuhlman Gully at Brock Street	16653	No Gage	B10
Sims Bayou at Hiram Clarke Rd	11135	08075400	S1
Sims Bayou at Telephone Road SH35	11132	No Gage	S2, S3
Sims Bayou at Lawndale Ave	11302	No Gage	S4
Berry Bayou at South Richey Street	16661	08075605	S5

4.4 Data Development

In addition to location and availability of stream flow data, sufficiency and consistency of ambient data collection were important factors leading to the selection of the eight CRP stations used for LDC analysis. The number of quality assured data values for bacteria and DO are expressed in **Table 2**. All stations in the Brays and Sims Bayou watershed have at least 10 years of data available and range from 83 to 112 samples for bacteria and 117 to 121 samples for DO.

Table 2. Number of samples by station

LDC Location	Station	# of Bacteria Samples	# of DO Samples
Brays Bayou at South Gessner Drive	11140	84	-
Brays Bayou at South Main St	11139	84	-
Brays Bayou Tidal at 75th Street	11306	111	117
Kuhlman Gully at Brock Street	16653	83	-
Sims Bayou at Hiram Clarke Rd	11135	84	-
Sims Bayou at Telephone Road SH35	11132	83	-
Sims Bayou at Lawndale Ave	11302	112	121
Berry Bayou at South Richey Street	16661	83	-

4.5 LDC Implementation

Project staff used the data referenced above to generate flow curves and LDCs. While both geomean and single sample data for fecal bacteria were assessed, at each station observed in this report, only the geomean results were used for determining reduction targets. Values labeled "Geometric Mean Load" (gray squares) represent the geometric mean of the modeled bacteria load values within a specific flow condition. The

distance between this point and the standard curve represents the reduction needed (represented as percentages in the corresponding table). Negative values indicate that no reductions or improvements are needed in associated stream flow conditions. When interpreting DO results, it should be noted that LDCs were only generated for representative sites featuring DO impairments. The TCEQ assessment of several of the unclassified tributaries and assessment units of the main stem indicated concerns and impairments related to various standards or screening levels regarding DO levels based on the outlying exceedances. The data also naturally skew toward high DO samples because monitoring is not conducted at night, when the daily DO cycle leads to lower DO levels in some conditions. No appreciable issues were identified in LDC development based on quality assured internal review; however, results of these analyses will be discussed in greater detail with project stakeholders to verify accuracy and representativeness.

Station 11140 – Brays Bayou at South Gessner Drive

Station 11140 is located on the western portion of AU 1007B_01, Brays Bayou Above Tidal. As with all other subwatersheds, the majority (99%) is developed. The majority (99%) of daily average rates of stream flow in cubic feet per second (cfs) on AU 1007B_01 are estimated to be between 0 and 1,600 cfs. The highest 1% of flows ranged from just over 1,600 to just over 13,000 cfs with the highest recorded value occurring during the peak of Hurricane Harvey in 2017.

The results of LDC analyses for bacteria at Station 11140 (**Figure 3**; **Table 3**) indicate a need for significant reductions in *E. coli* geomean loads expressed in billion colony forming units per day (cfu/day) at all five levels of flow conditions.

Table 3. Flow specific values for LDC 11140

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean
High Flows	0-10%	99.37%
Moist Conditions	10-40%	96.95%
Mid-Range Conditions	40-60%	94.43%
Dry Conditions	60-90%	93.48%
Low Flows	90-100%	92.21%
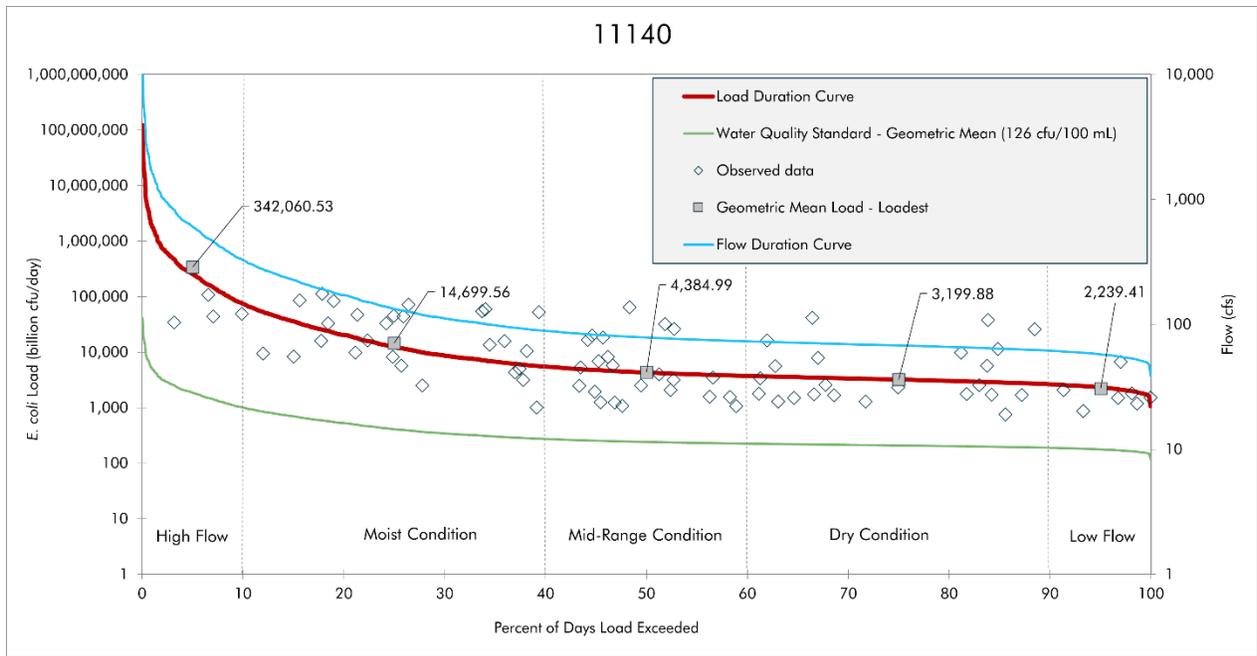
Figure 4. *E. coli* LDC for Station 11140

Station 11139 – Brays Bayou at South Main St

Station 11139 is located on the eastern portion of AU 1007B_01, Brays Bayou Above Tidal. Developed areas make up 99% of the land cover in the drainage area for this waterbody. At this station, 99% of flows ranged from 0 to over 3,000 cfs. The top 1% ranged from over 3,000 to just over 32,000 cfs. As with 11140, the highest flows were observed during the flooding associated with Hurricane Harvey in 2017.

The results of LDC analyses for Station 11139 (**Figure 5**; **Table 4**) indicate that fecal bacteria require reduction in all five flow conditions.

Table 4. Flow specific values for LDC 11139

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean
High Flows	0-10%	99.57%
Moist Conditions	10-40%	96.82%
Mid-Range Conditions	40-60%	93.66%
Dry Conditions	60-90%	92.26%
Low Flows	90-100%	90.31%
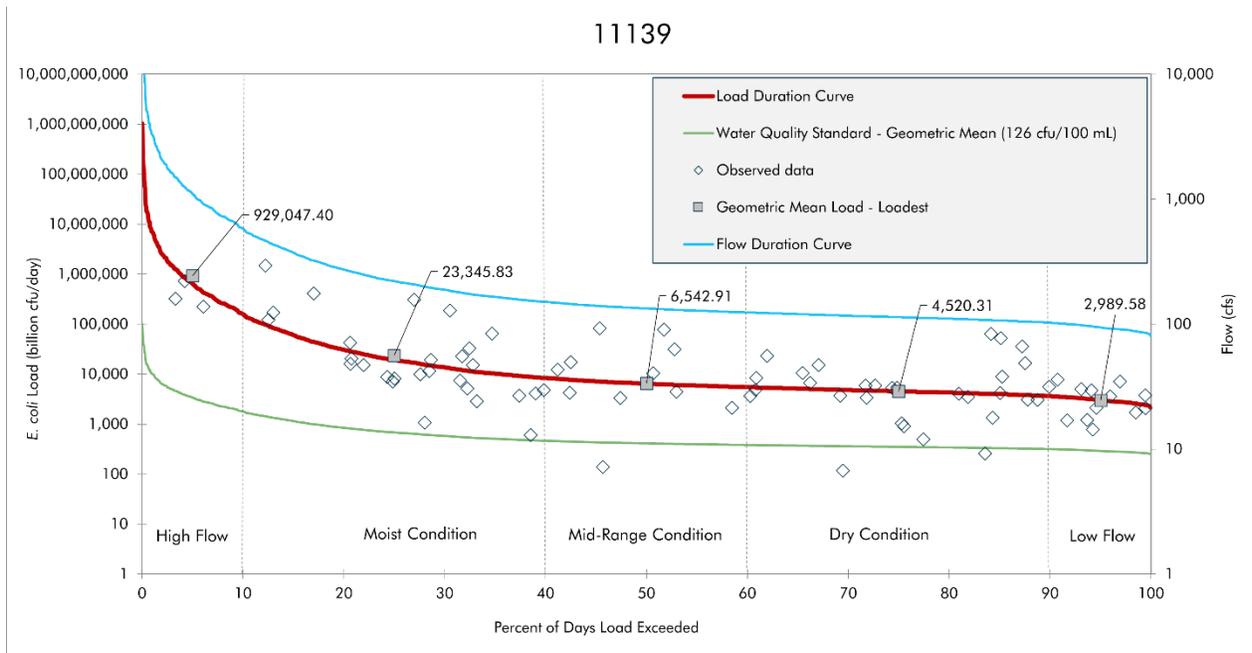
Figure 5. *E. coli* LDC for Station 11139

Station 11306 – Brays Bayou Tidal at 75th Street
Station 11306 is located on Brays Bayou Tidal (AU 1007_04). Developed areas make up 99.9% of the land cover in the drainage area for this waterbody. 99% of stream flows on this portion of the bayou ranged from 0 to over 200 cfs with the top 1% of flows ranging between over 200 and approximately 3,000 cfs. As with the previous stations, the highest flows were observed during the flooding associated with Hurricane Harvey in 2017.

Because this station is tidally influenced, Enterococci rather than *E. coli* was used as the fecal indicator bacteria for surface water. The results of LDC analyses for Station 11306 (**Figure 6**; **Table 5**) show that reductions in fecal bacteria are recommended for all flow conditions excluding low flow. Results of the LDC analysis for DO (**Figure 7; Table 5)** show all negative values which indicate that no improvements are recommended in order to attain the DO minimum standard for surface water at this site. An aquatic life impairment due to depressed DO was not indicated for this AU, however, a tributary to this AU (1007K_01) was indicated as not supported for aquatic life use due to depressed DO.

Table 5. Flow specific values for LDC 11306

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean	DO Percent Improvement Needed
High Flows	0-10%	97.03%	-36.39%
Moist Conditions	10-40%	80.23%	-37.17%
Mid-Range Conditions	40-60%	58.56%	-37.47%
Dry Conditions	60-90%	34.09%	-37.66%
Low Flows	90-100%	-47.76%	-37.99%
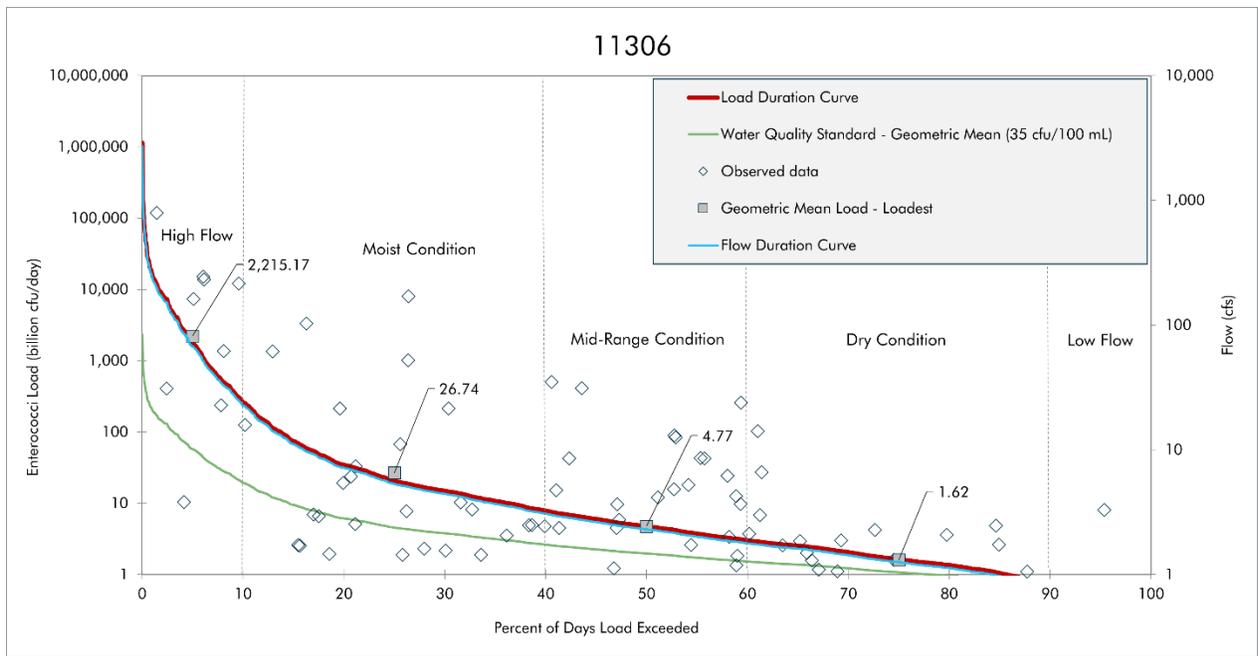
Figure 6. Enterococci LDC for Station 11306
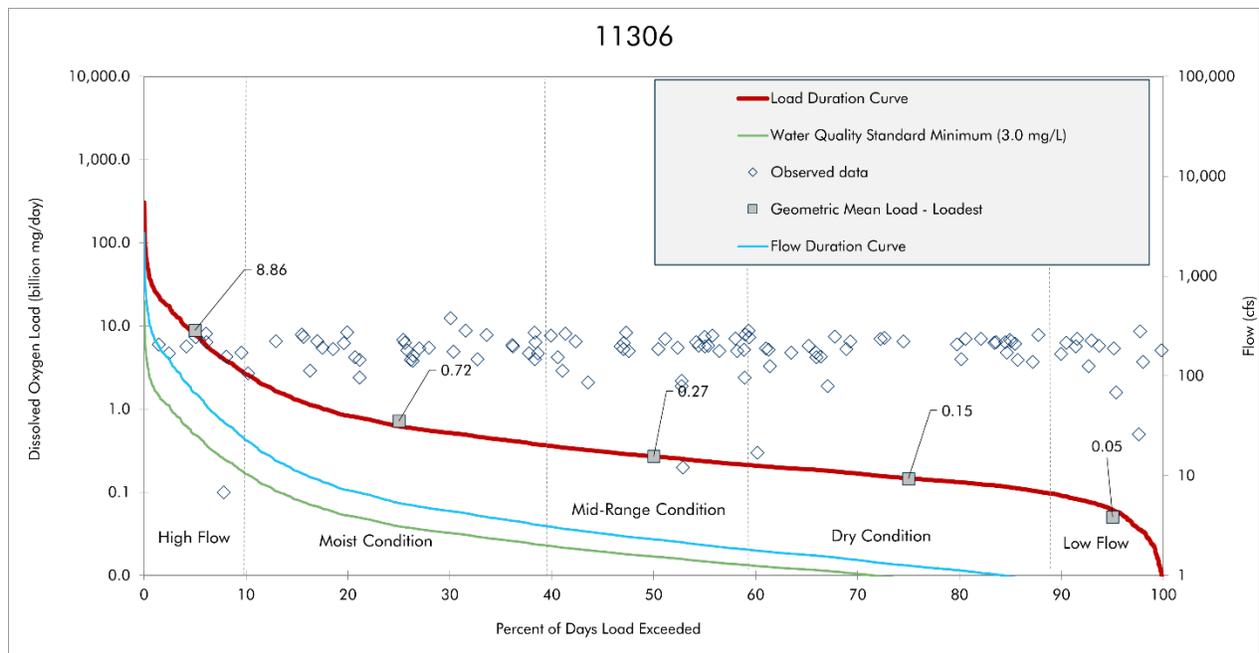
Figure 7. DO LDC for Station 11306

Station 16653 – Kuhlman Gully at Brock Street

Station 16653 occurs on Kuhlman Gully (AU 1007G_01), a tributary to Brays Bayou. Developed areas make up 100% of the land cover in the drainage area for this waterbody. Most flows ranged from 0 to approximately 200 cfs with the top 1% of flows ranging between approximately 200 and just over 2,000 cfs. As with previous LDCs, the highest flows were observed during the flooding observed from Hurricane Harvey in 2017.

The results of LDC analyses for Station 16653 (**Figure 8**; **Table 6**) indicate that considerable *E. coli* reductions are needed in all five flow conditions.

Table 6. Flow specific values for LDC 16653

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean
High Flows	0-10%	96.36%
Moist Conditions	10-40%	88.74%
Mid-Range Conditions	40-60%	82.50%
Dry Conditions	60-90%	76.94%
Low Flows	90-100%	62.70%
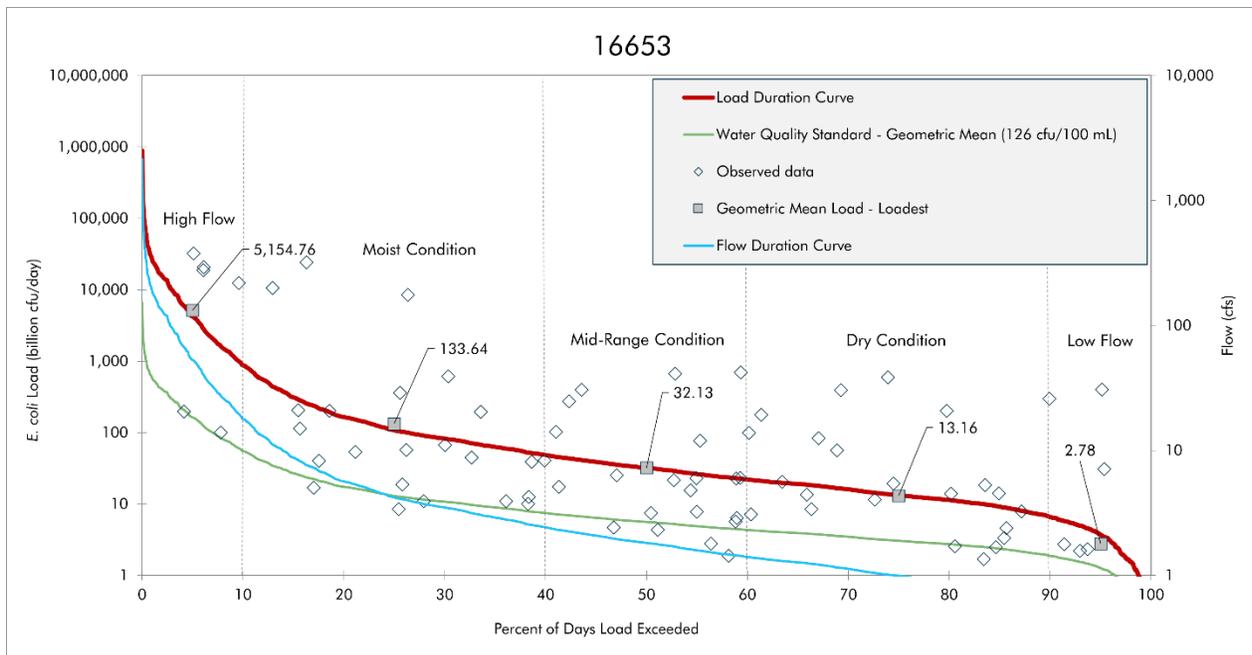
Figure 8. *E. coli* LDC for Station 16653

Station 11135 – Sims Bayou at Hiram Clarke Rd

Station 11135 occurs on Sims Bayou Above Tidal (1007D). The drainage area for this waterbody is dominated by developed land cover types (91%). Most flows ranged from 0 to 669 cfs with the top 1% ranging between 694 and 7,350 cfs (as with all previous stations, the highest value occurring during Hurricane Harvey).

At Station 11135 (**Figure 9**; **Table 7**), exceedances of the *E. coli* water quality standard were observed in all periods of flow.

Table 7. Flow specific values for LDC 11135

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean
High Flows	0-10%	98.57%
Moist Conditions	10-40%	87.97%
Mid-Range Conditions	40-60%	77.37%
Dry Conditions	60-90%	70.65%
Low Flows	90-100%	61.70%
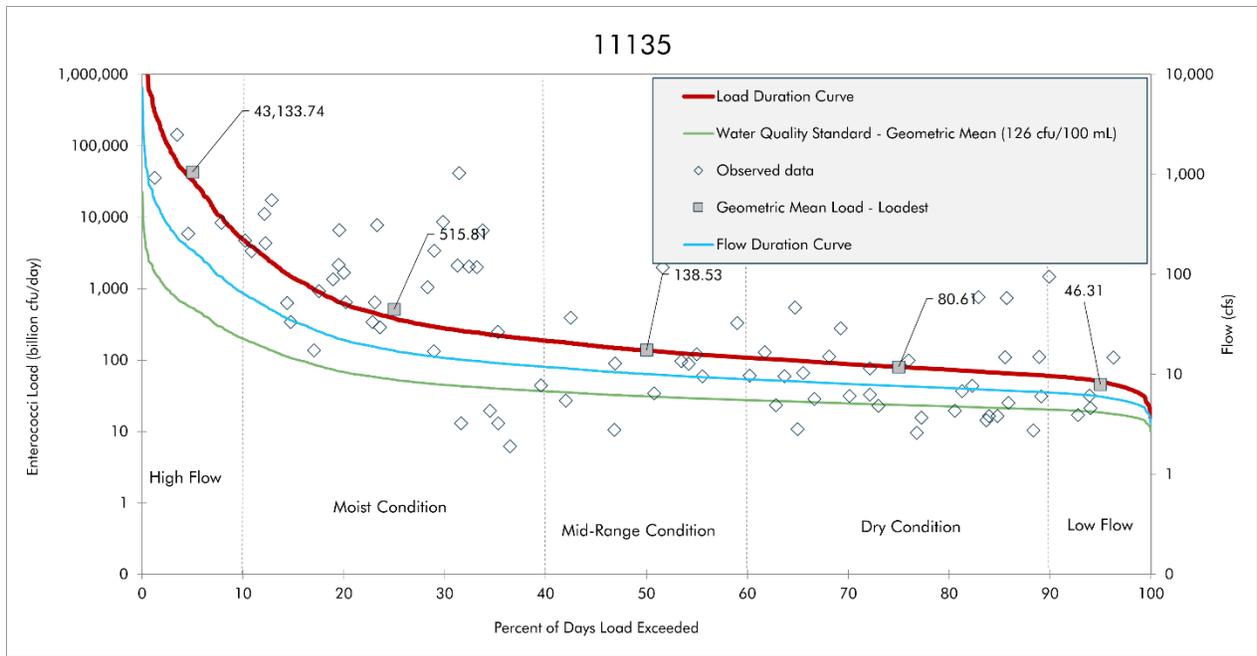
Figure 9. *E. coli* LDC for Station 11135

Station 11132– Sims Bayou at Telephone Road SH35

Station 11132 occurs on Sims Bayou Above Tidal (1007D). The drainage area for this waterbody, just as with 11135, is vastly developed (91%). Most flows ranged from 0 to 280 cfs with the top 1% of flows associated with flooding events ranging between approximately 280 and approximately 3,000 cfs.

At Station 11132 (**Figure 10**; **Table 8**), exceedances of the *E. coli* water quality standard were observed in all periods of flow.

Table 8. Flow specific values for LDC 11132

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean
High Flows	0-10%	93.97%
Moist Conditions	10-40%	84.42%
Mid-Range Conditions	40-60%	77.44%
Dry Conditions	60-90%	71.55%
Low Flows	90-100%	57.40%
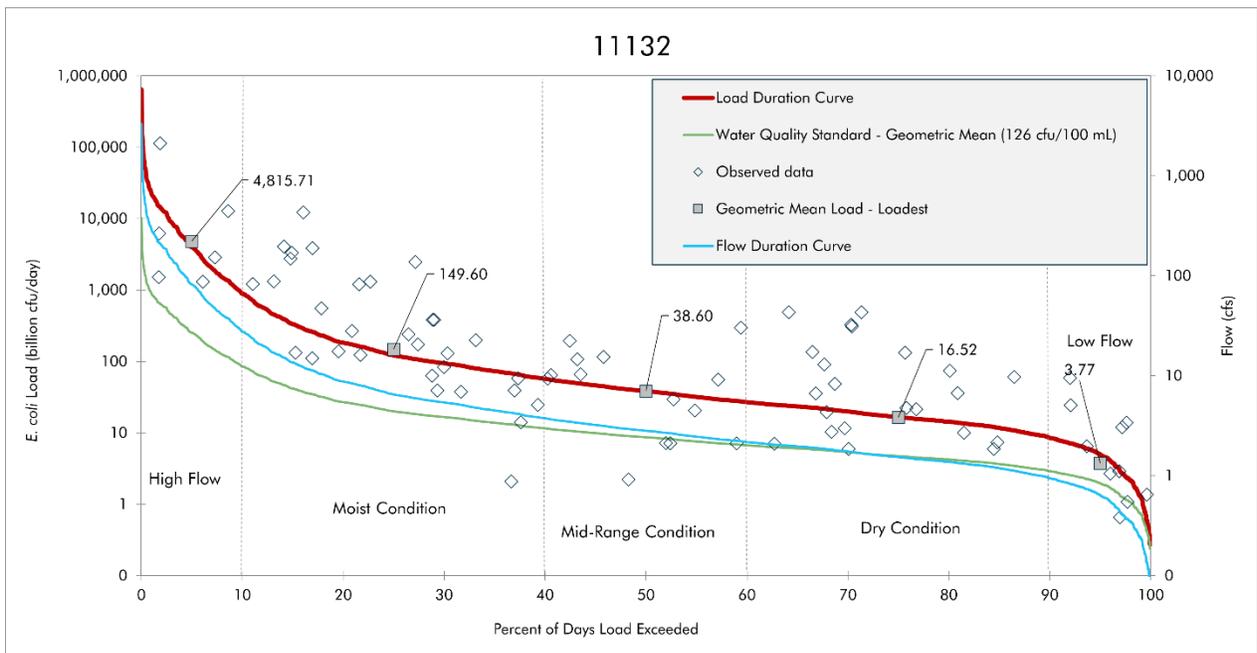
Figure 10. *E. coli* LDC for Station 11132

Station 11302– Sims Bayou at Lawndale Ave

Station 11302 occurs on Houston Ship Channel/Buffalo Bayou Tidal (AU 1007_02). The drainage area for this waterbody, just as with the others, is vastly developed (99%). Most flows ranged from 0 to 280 cfs with the top 1% of flows associated with flooding events ranging between approximately 280 and approximately 3,000 cfs.

The results of LDC analyses for Station 11302 (**Figure 11**; **Table 9**), show that reductions in fecal bacteria are recommended for all flow conditions excluding low flow. Results of the LDC analysis for DO (**Figure 12; Table 9)** show all negative values which indicate that no improvements are recommended in order to attain the DO minimum standard for surface water at this site. An aquatic life impairment due to depressed DO was not indicated for this AU, however, a tributary to this AU (1007I_01) was indicated as not supported for aquatic life use due to depressed DO.

Table 9. Flow specific values for LDC 11302

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean	DO Percent Improvement Needed
High Flows	0-10%	91.55%	-56.89%
Moist Conditions	10-40%	70.34%	-59.42%
Mid-Range Conditions	40-60%	51.58%	-60.37%
Dry Conditions	60-90%	34.19%	-60.95%
Low Flows	90-100%	-12.30%	-61.95%
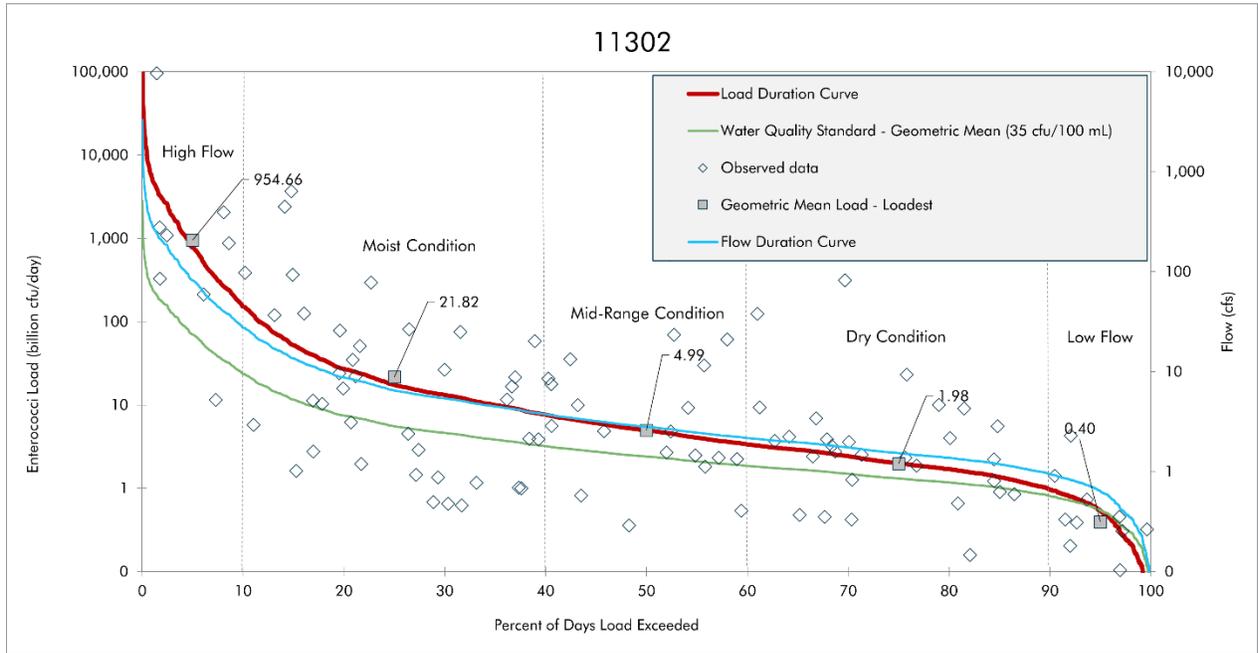
Figure 11. Enterococci LDC for Station 11302
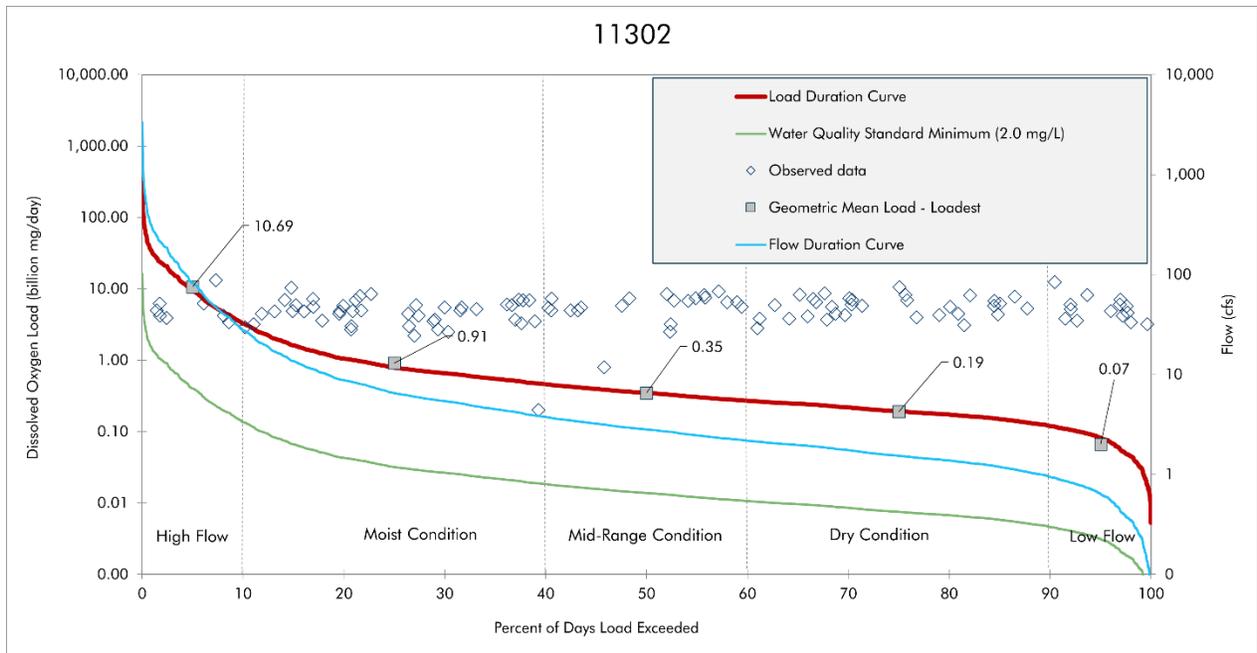
Figure 12. DO LDC for Station 11302

Station 16661– Berry Bayou at South Richey Street

Station 16661 occurs on Berry Bayou Above Tidal (AU 1007F_01), a tributary to Sims Bayou. Developed areas make up 97% of the land cover in the drainage area for this waterbody. Flow was noticeably lower here when compared to the other sites, with most flows ranging from 0 to 138 cfs with the top 1% of flows ranging between 139 and over 2,000 cfs, with the highest flow recorded during the flooding observed from Hurricane Harvey in 2017.

At Station 16661 (**Figure 13**; **Table 10**), exceedances of the *E. coli* water quality standard were observed in all periods of flow.

Table 10. Flow specific values for LDC 16661

Flow Category	Percent of Days Flow Exceeded	*E. coli* Percent Reduction Needed - Geomean
High Flows	0-10%	99.02%
Moist Conditions	10-40%	96.02%
Mid-Range Conditions	40-60%	94.61%
Dry Conditions	60-90%	93.60%
Low Flows	90-100%	91.94%
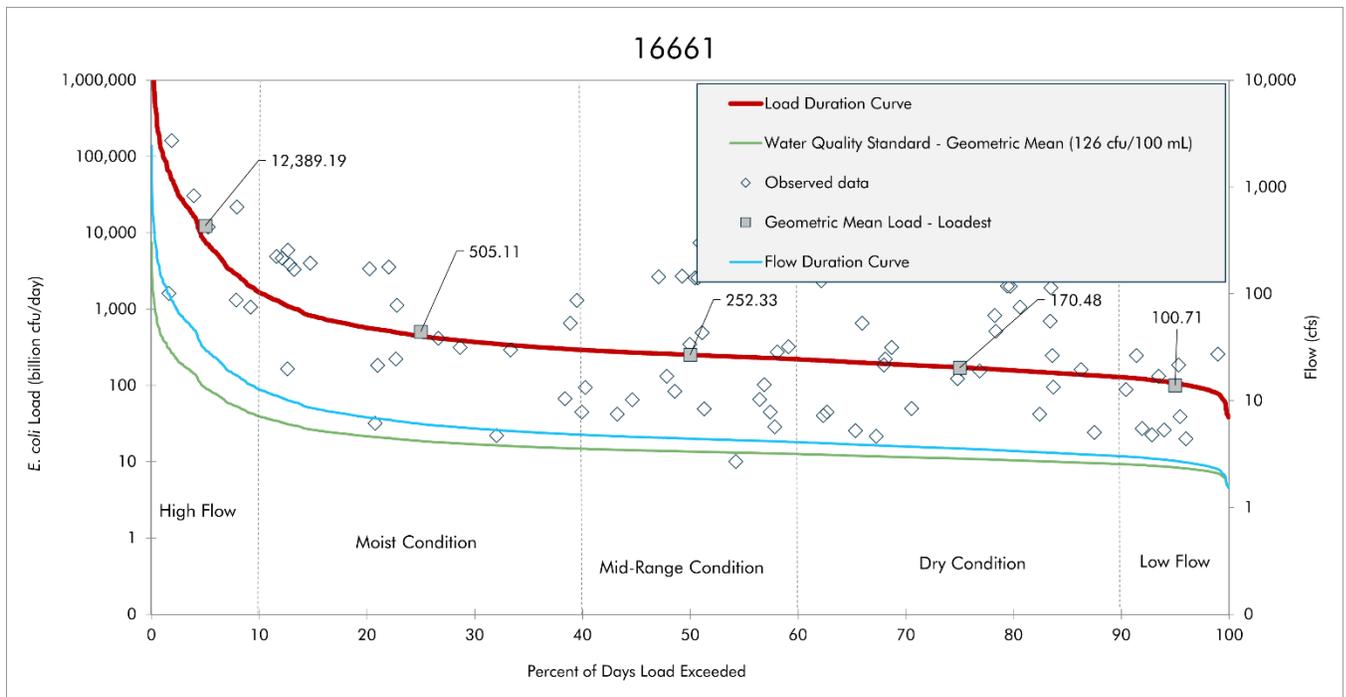
Figure 13. *E. coli* LDC for Station 16661

4.6 LDC Summary

Currently, LDC results for the Brays and Sims Bayou watershed have been reviewed internally but have not been subjected to thorough stakeholder analysis. H-GAC staff hope to discuss these results with stakeholders at future partnership meetings and in more focused, one-on-one conversations. These discussions will further refine the assessment to produce data that most accurately reflect fecal bacteria loadings and reduction targets for the Brays and Sims Bayou watershed.

Some of the most important observations to be made from the LDC analysis of Brays and Sims Bayou and its tributaries are:

- Fecal indicator bacteria loading exceeded the standard in high flow through dry conditions across the watershed.
- Flow magnitudes varied among sites and fecal indicator bacteria loading in other low flow conditions varied among sites.
- No needed improvements in DO were indicated through the LDC analyses but DO is still a constituent of concern per results of TCEQ's latest Texas Integrated Report.

SECTION 5: SELECT EVALUATIONS

5.1 Overview

SELECT is a Geographic Information System (GIS)-based tool for estimating potential fecal bacteria loads in a watershed area developed by the Spatial Sciences Laboratory and the Biological and Agricultural Engineering Department at Texas A&M University[4]. This analysis can also determine the relative contributions of fecal indicator bacteria made by a range of potential sources and expresses source contribution data spatially by subwatershed. SELECT analyses result from the combination of land use and land cover data, known source locations (e.g., outfalls), literature assumption values for nonpoint sources (e.g., pet waste, livestock census data, wildlife population density), and stakeholder input. The model does not account for instream loading or other natural processes which may affect fecal bacteria concentrations, nor does it estimate the relative proximity of loading sources to the waterway. Therefore, all references to load estimates in this section refer to potential source loads and not necessarily the actual amounts of fecal bacteria transported into the streams and tributaries of the Brays and Sims Bayou watershed.

To meet the needs of this project, modifications to the original SELECT model were made. The first of these modifications was the use of buffers or zones within a specified distance from a feature (in this case, waterways) to differentiate source load estimations by proximity to streams. Loads generated adjacent to streams are more likely to contribute to instream loading. Because the original SELECT model cannot account for fate and transport of pollutant loads, incorporating buffers around riparian corridors and assigning lower loading rates to sources located in areas outside the buffer minimizes overrepresentation of sources located farther from waterways. Without this consideration, false equivalencies could be interpreted between loads of equal size but different location relative to riparian corridors. For the purposes of this project, 100 percent of the waste generated by sources within a 300-foot buffer zone was assumed to impact waterways. For sources located in areas outside this zone, only 25 percent of the total waste was assumed to be transmitted to the stream network. For sources with no associated spatial data (e.g., deer population density per acre), uniform distribution was assumed for appropriate land uses both inside and outside the buffer boundaries.

The second modification made to the original design of the SELECT model was to estimate fecal bacteria loading changes associated with increased development in five-year increments throughout the next 25 years. By accounting for changes in spatial distribution and magnitude of source loads related to predicted changes in land use between current conditions[5] and the year 2050, reduction estimates can be anticipated at the loading rate observed in the present day and those projected in the future. As with any forecasting effort, a certain level of uncertainty is expected with these predictions especially as they relate to sources assumed to be linked to land use types. For example, in this model, wildlife populations are assumed to decrease as developed area increases within the watershed. This does not account for the adaptability of wildlife to consolidate or redistribute within the watershed area. Further monitoring and assessments of such sources should be incorporated into the management recommendations of the WPP to more accurately account for these factors and counteract this uncertainty.

---

[4] Additional information about SELECT can be found at http://ssl.tamu.edu/media/11291/select-aarin.pdf. Information about specific implementation of SELECT for this project can be found in the project modeling QAPP.
[5] At the time of this report, the most updated land use data represents parcel allocations in the year 2024 for Harris County.

5.2 SELECT Results

Wastewater Treatment Facilities (WWTFs)

Wastewater utilities serve a number of communities throughout the watershed and occur in various sizes and capacities. For areas outside city boundaries, centralized waste treatment is commonly managed by municipal utility districts and other districts. Considering all types of WWTFs, 42 permitted facilities with discharge monitoring report data are found within the watershed boundary of Brays and Sims Bayou. Sizes of WWTFs vary throughout the watershed and range between capacities of less than 0.1 millions of gallons per day (MGD) to greater than 10 MGD.

According to the results of a previous data review[6], WWTFs in the Brays and Sims Bayou watershed are not expected to be major contributors to fecal indicator bacteria loading. However, as the risks associated with human waste processed by WWTFs can be considerable in the event of improper treatment or other localized incidents, it is important to consider estimates of potential WWTF loadings in the overall SELECT model. These estimates are derived by multiplying the total discharge capacity of each facility by the state water quality standard for fecal bacteria. As loads were estimated to reflect the impacts of direct outfalls, all results are indicated within the buffer zone surrounding the watershed stream network. For future projections, models continued to estimate fecal bacteria loads at the state standard but adapted flow rates to reflect the projected increase in the number of households within service area boundaries. As many facilities discharge well below their maximum permitted rates, this results in a potential overestimation of fecal bacteria loading from this source. As noted previously, this method is still deemed appropriate for this watershed to account for exceedances or variations throughout daily discharges that could have greater impacts to public health.

In the Brays and Sims Bayou watershed, fecal bacteria loading from WWTFs is more prevalent in the Middle Brays Bayou Above Tidal and Middle Sims Bayou Above Tidal subwatersheds where WWTF densities and sizes are greater (**Figure 14**; **Table 11**).

When considering the anticipated expansion of the population throughout the watershed in the coming 25 years, overall fecal bacteria loading in the watershed is expected to increase (**Figure 15**). However, the values of fecal bacteria loads delivered to Brays and Sims Bayou and their tributaries via WWTFs are several orders of magnitude lower than those estimated for other modeled sources described in this section. Therefore, WWTFs are still considered only minor contributors to overall potential fecal bacteria loading in the watershed. These sources are still important to consider in the WPP however, as the health risks associated with any introduction of improperly treated human waste by WWTFs into the watershed are far greater than those associated with other sources[7].

---

[6] A more detailed analysis of water quality is discussed further in the Preliminary Acquired Data Analysis Report for the Brays and Sims Bayou Watershed. This document and more information on data quality objectives, concerns, and methodologies used in these analyses (detailed in the Brays and Sims Bayou Modeling Quality Assurance Project Plan) are available for review at https://www.h-gac.com/watershed-based-plans/brays-sims-bayou.

[7] Results of quantitative microbial risk assessment studies, including work done in the Leon River Watershed (https://oaktrust.library.tamu.edu/handle/1969.1/158640) have indicated that sources with equivalent loads may have pronounced differences in expected microbial risk, with human sources being the most potentially problematic.
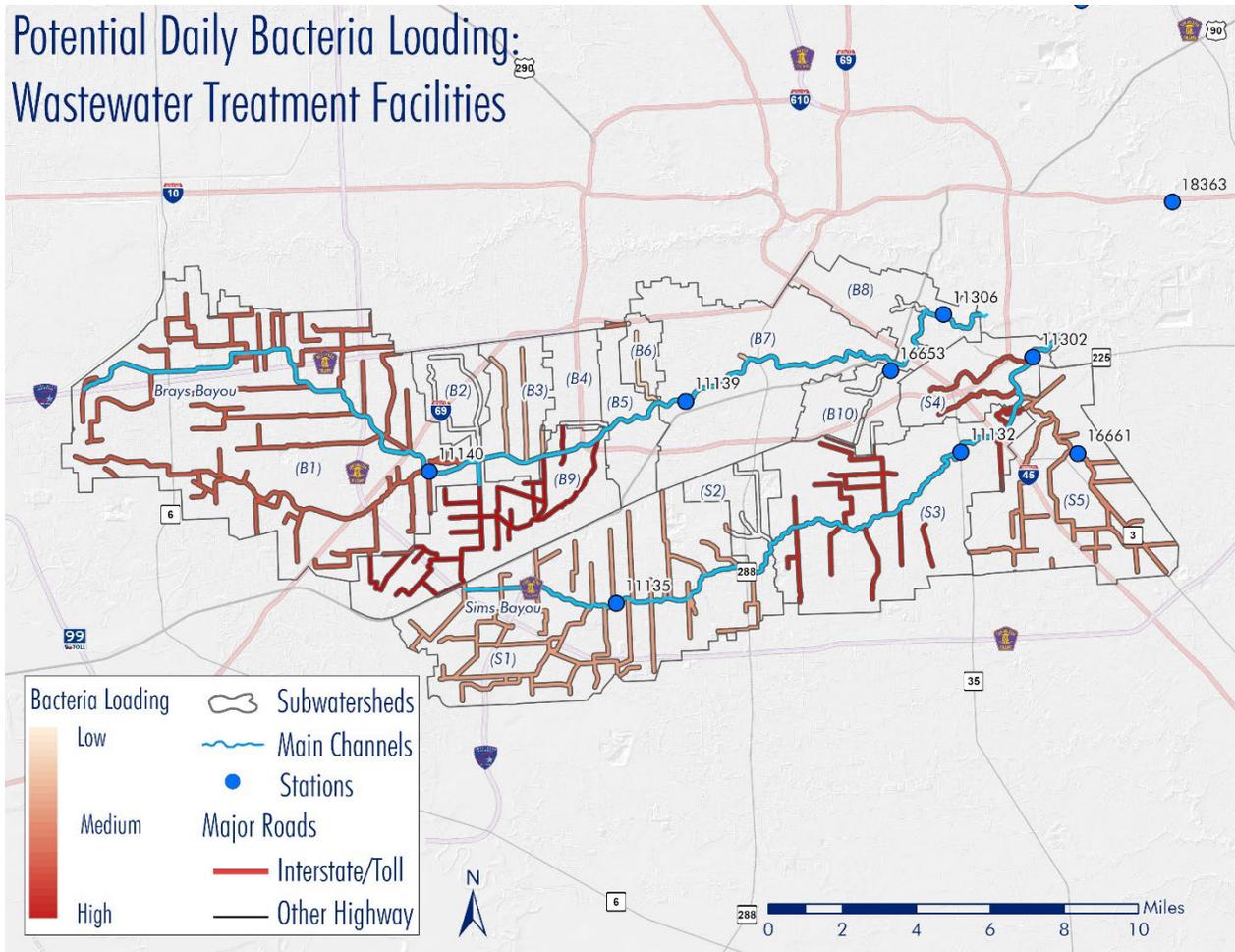
Figure 14. Bacteria loadings from WWTFs by subwatershed
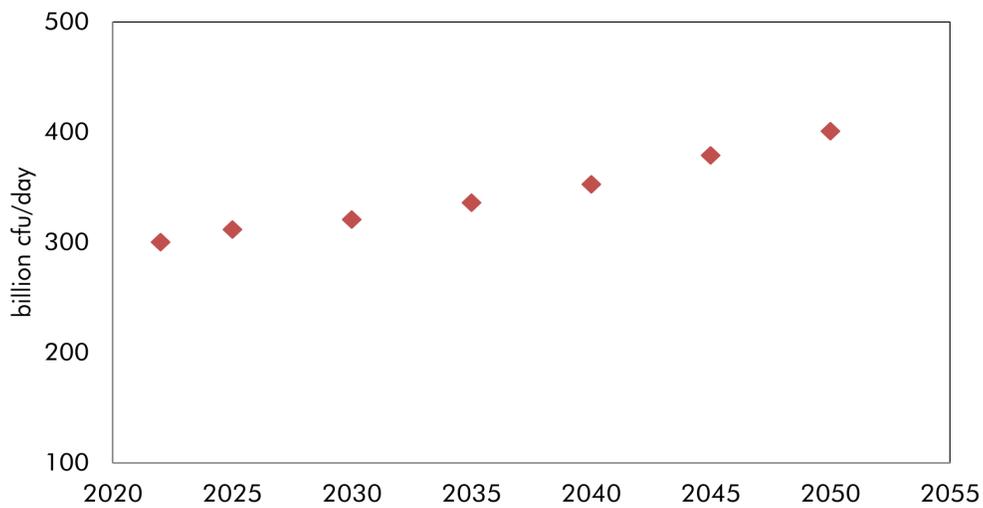
Figure 15. Future bacteria loadings from WWTFs

Table 11. Wastewater outfalls and loadings by subwatershed

Subwatershed	# of Outfalls	Load Estimate in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	16	21.84	7%
Brays Above Tidal - Middle (B2)	0	0.00	0%
Brays Above Tidal - Middle (B3)	1	10.97	4%
Brays Above Tidal - Middle (B4)	0	0.00	0%
Brays Above Tidal - Middle (B5)	1	21.46	7%
Brays Above Tidal - Middle (B6)	3	0.79	0%
Brays Above Tidal - Middle (B7)	2	4.77	2%
Brays Tidal (B8)	2	0.00	0%
Brays Above Tidal - Middle (B9)	3	96.98	32%
Kuhlman Gully (B10)	1	0.00	0%
Sims Above Tidal – Upper (S1)	8	15.19	5%
Sims Above Tidal – Middle (S2)	0	0.00	0%
Sims Above Tidal – Middle (S3)	2	76.31	26%
Sims Tidal (S4)	7	36.82	12%
Berry Bayou (S5)	4	15.29	5%
Total	**50**	**300.43**	**100%**

On-Site Sewage Facilities (OSSFs)

While centralized wastewater treatment is common in developed areas, OSSFs are more likely to be used in parts of the watershed outside service area boundaries such as rural communities. OSSFs such as septic and aerobic systems are an efficient and effective way to manage wastewater, however, aging or improperly maintained units run the risk of failing. Significant sources of fecal bacteria can be transmitted to waterways in the event of an OSSF failure.

OSSF distribution throughout the Brays and Sims Bayou watershed was estimated using the spatial data of permitted systems collected under a federal 604(b) grant agreement between H-GAC and TCEQ, and quality assured under the auspices of that contract[8]. This dataset is not comprehensive as some data may be subject to insufficiencies such as a lack of geocoding. This uncertainty is accounted for in the SELECT model through an estimation of any unrecorded or otherwise unpermitted OSSFs in the watershed area based on land use. Regardless of permit information, OSSFs throughout the watershed were estimated by assessing the number of occupied parcels outside wastewater service area boundaries. Loading rates observed from improperly maintained and failed systems were used to estimate total load contribution from OSSFs. Literature values for OSSF failure rates range between 10 and 15%[9]. A rate of 10% was applied to the number units indicated by the current dataset and for each of the five-year interval projections through 2050. This method is subject to review in further focused workgroup discussions with the partnership.

OSSF loadings are highest in the subwatersheds of Upper Brays Bayou Above Tidal and Sims Bayou Above Tidal (**Figure 16**; **Table 12**), and are expected to increase through 2050 as the population increases throughout the watershed (**Figure 17**). These future projections are based on an assumed 10% failure rate. If systems are found to exceed the 10% failure rate, a new percentage value may be determined. However, stakeholders may choose to incorporate continued monitoring of these systems in the coming years as OSSF installments age. Failure rates among these newly developed systems are likely to be lower as regular maintenance will be required by permit. As improperly maintained OSSFs could also have a negative impact on property values, communities may be more likely to adhere to

routine maintenance standards. However, as the health risks associated with any introduction of improperly treated human waste by OSSFs into the watershed are far greater than those associated with other sources, these sources are still important to consider in the WPP.

---

[8] Use of this acquired data is detailed in the project modeling QAPP for this project available for review at https://www.h-gac.com/watershed-based-plans/brays-sims-bayou.
[9] Reed, Stowe & Yanke, LLC. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas. Texas On-site Wastewater Treatment Council.

Figure 16. Bacteria loading from OSSFs by subwatershed

Figure 17. Future bacteria loadings from OSSFs

Table 12. OSSFs and loadings by subwatershed

Subwatershed	OSSFs Outside Buffer	OSSFs Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	2,507	716	224.22	256.15	65%
Brays Above Tidal - Middle (B2)	0	0	0	0	0%
Brays Above Tidal - Middle (B3)	0	0	0	0	0%
Brays Above Tidal - Middle (B4)	0	0	0	0	0%
Brays Above Tidal - Middle (B5)	0	0	0	0	0%
Brays Above Tidal - Middle (B6)	0	0	0	0	0%
Brays Above Tidal - Middle (B7)	0	0	0	0	0%
Brays Tidal (B8)	0	0	0	0	0%
Brays Above Tidal - Middle (B9)	41	46	3.67	16.46	3%
Kuhlman Gully (B10)	0	0	0	0	0%
Sims Above Tidal – Upper (S1)	1,284	221	114.84	79.06	26%
Sims Above Tidal – Middle (S2)	60	64	5.37	22.90	4%
Sims Above Tidal – Middle (S3)	163	9	14.58	3.22	2%
Sims Tidal (S4)	0	0	0	0	0%
Berry Bayou (S5)	0	0	0	0	0%
Total	**4,055**	**1,056**	**362.68**	**377.79**	**100%**

Dogs

Domestic and feral dog populations are significant contributors to fecal bacteria contamination in densely developed areas and are a common source of loading in the greater Houston region. Waste from other domestic pets (e.g., cats) is typically managed through collection in waste receptacles, whereas dog waste is more likely to be deposited directly into the environment. For SELECT analysis, fecal bacteria loading from dog populations was estimated by assessing pet ownership. Statistical data for Texas established by the American Veterinary Medical Association[10] of 1.5 dogs per household were used in SELECT models. This value was applied to current household data and future projections through 2050. Finally, these estimates were reduced by 20% to account for dog owners practicing proper pet waste management. While this method has been used in other WPP projects with similar land use and drainage areas, stakeholder feedback received during reviews of model results could lead to a revision of these assumptions based on the specific needs of the Brays and Sims Bayou watershed.

---

[10] As referenced at https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx

Stakeholder insights will be of particular importance to source load estimation of dog waste due to recent efforts to control pet waste throughout the region. Loading estimations could be adjusted to reflect management strategies and community use of waste bags, etc. already underway in the watershed.

Dog ownership, and therefore dog waste, is most densely concentrated in the subwatersheds of Upper and Middle Brays Bayou Above Tidal. (**Figure 18**; **Table 13**). As the human population of the watershed increases in the coming years, dog populations will also increase (**Figure 19**).
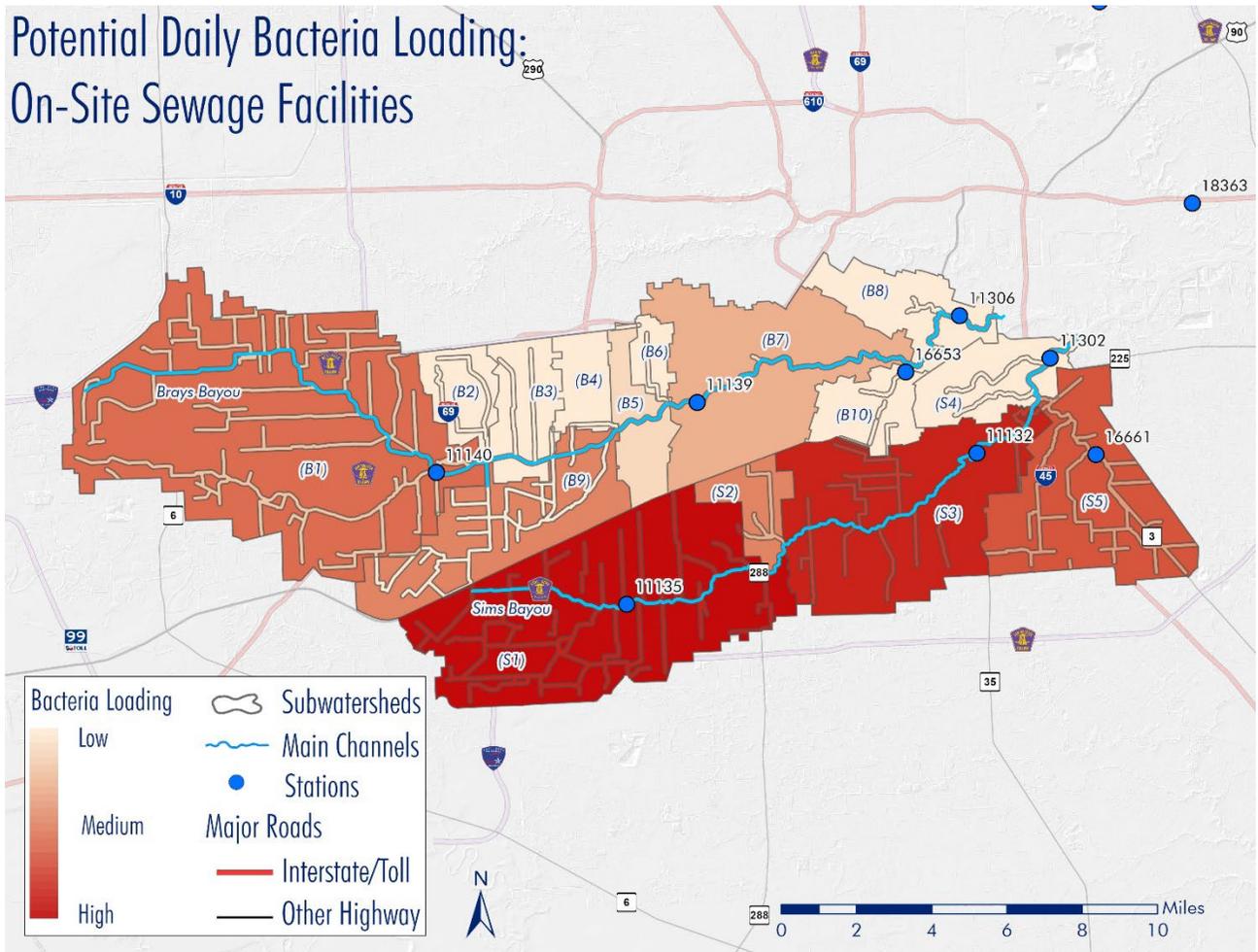

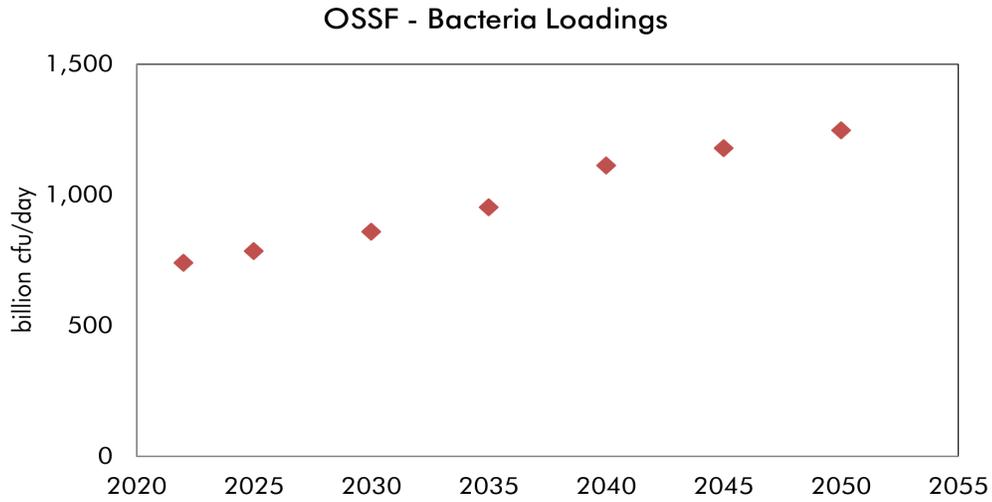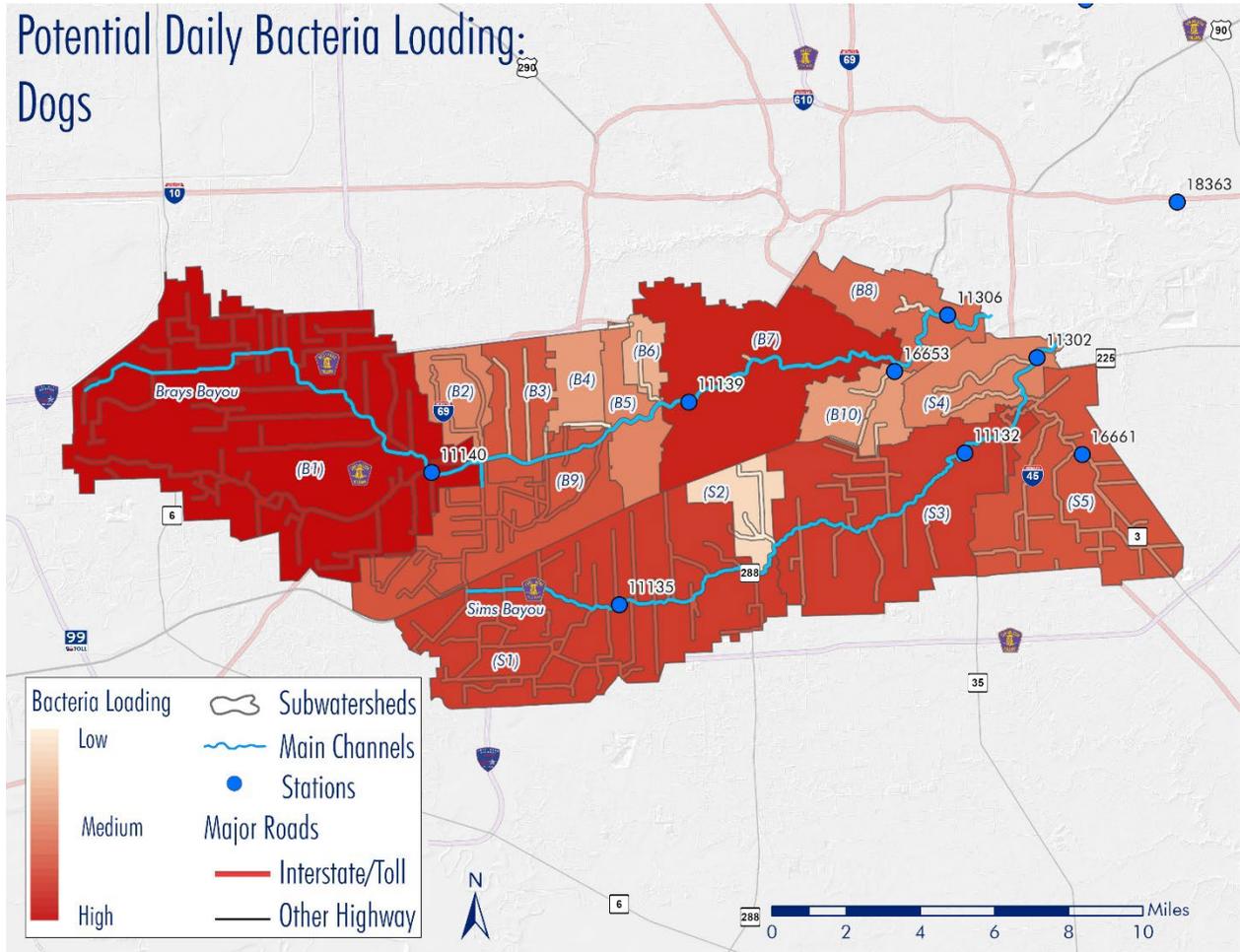**Figure 18.** Bacteria loading from dogs by subwatershed
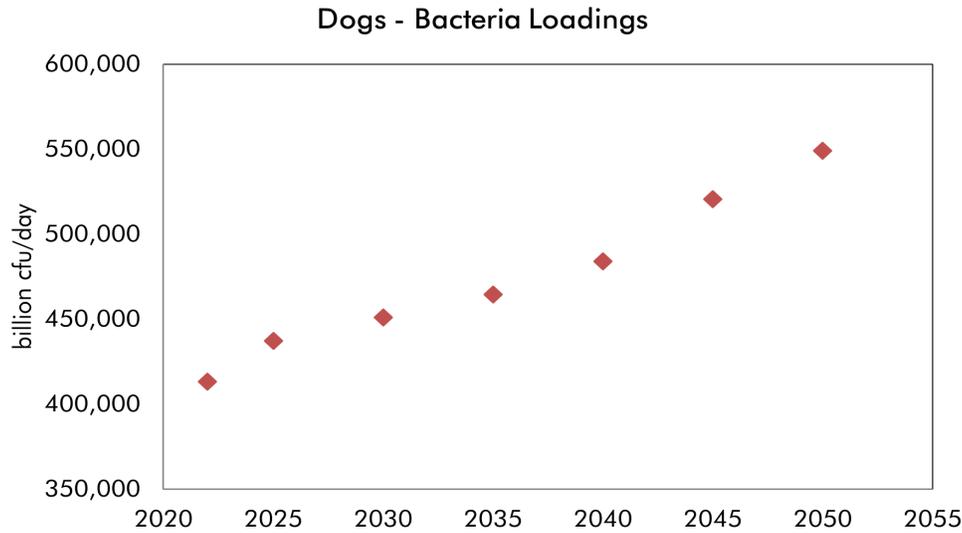
Figure 19. Future bacteria loading from dogs

Table 13. Dogs and loadings by subwatershed

Subwatershed	Dogs Outside Buffer	Dogs Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	179,292	24,012	89,646.00	48,024.00	10%
Brays Above Tidal - Middle (B2)	15,754.5	3,985.5	7,877.25	7,971.00	1%
Brays Above Tidal - Middle (B3)	31,740	1,624.5	15,870.00	3,249.00	8%
Brays Above Tidal - Middle (B4)	12,147	337.5	6,073.50	675.00	3%
Brays Above Tidal - Middle (B5)	17,829	243	8,914.50	486.00	6%
Brays Above Tidal - Middle (B6)	8,064	712.5	4,032.00	1,425.00	33%
Brays Above Tidal - Middle (B7)	89,883	2,050.5	44,941.50	4,101.00	4%
Brays Tidal (B8)	22,987.5	666	11,493.75	1,332.00	5%
Brays Above Tidal - Middle (B9)	38,229	8,484	19,114.50	16,968.00	2%
Kuhlman Gully (B10)	10,702.5	1,249.5	5,351.25	2,499.00	2%
Sims Above Tidal – Upper (S1)	50,559	7,960.5	25,279.50	15,921.00	1%
Sims Above Tidal – Middle (S2)	3,129	357	1,564.50	714.00	12%
Sims Above Tidal – Middle (S3)	45,682.5	5,596.5	22,841.25	11,193.00	3%
Sims Tidal (S4)	15,235.5	1,632	7,617.75	3,264.00	9%
Berry Bayou (S5)	31,240.5	4,650	15,620.25	9,300.00	2%
Total	**572,475**	**63,561**	**286,237.50**	**127,122.00**	**100%**

Cattle

Agricultural land, grassland, and pastures are most common in Sims Bayou. National livestock populations including cattle were most recently assessed in a 2022 census by the United States Department of Agriculture. Census data are available by county and are not specific to the watershed area. To estimate

cattle in the Brays and Sims Bayou watershed, a ratio of the county's portion of the watershed's acreage in appropriate land cover types was applied to agricultural census data from the county. This approach ensures that the density of cattle in the county's applicable land cover acreage (hay/pasture) was the same as the density in the watershed's applicable land use acreage. In addition, reductions were made from the current (2022) calculation for each of the subsequent five-year intervals in order to reflect declining livestock populations observed throughout the state at a rate proportional to the difference in 2017 and 2022 agricultural census values. Model results generated from these assumptions will be reviewed with stakeholders for accuracy.

Cattle loads from the subwatersheds of Upper and Middle Sims Bayou Above Tidal are greater compared to other subwatersheds (**Figure 20**; **Table 14**). Projections of future fecal bacteria loading by cattle decrease over the next 25 years (**Figure 21**). This rate of decline reflects statewide trends in decreasing livestock populations.
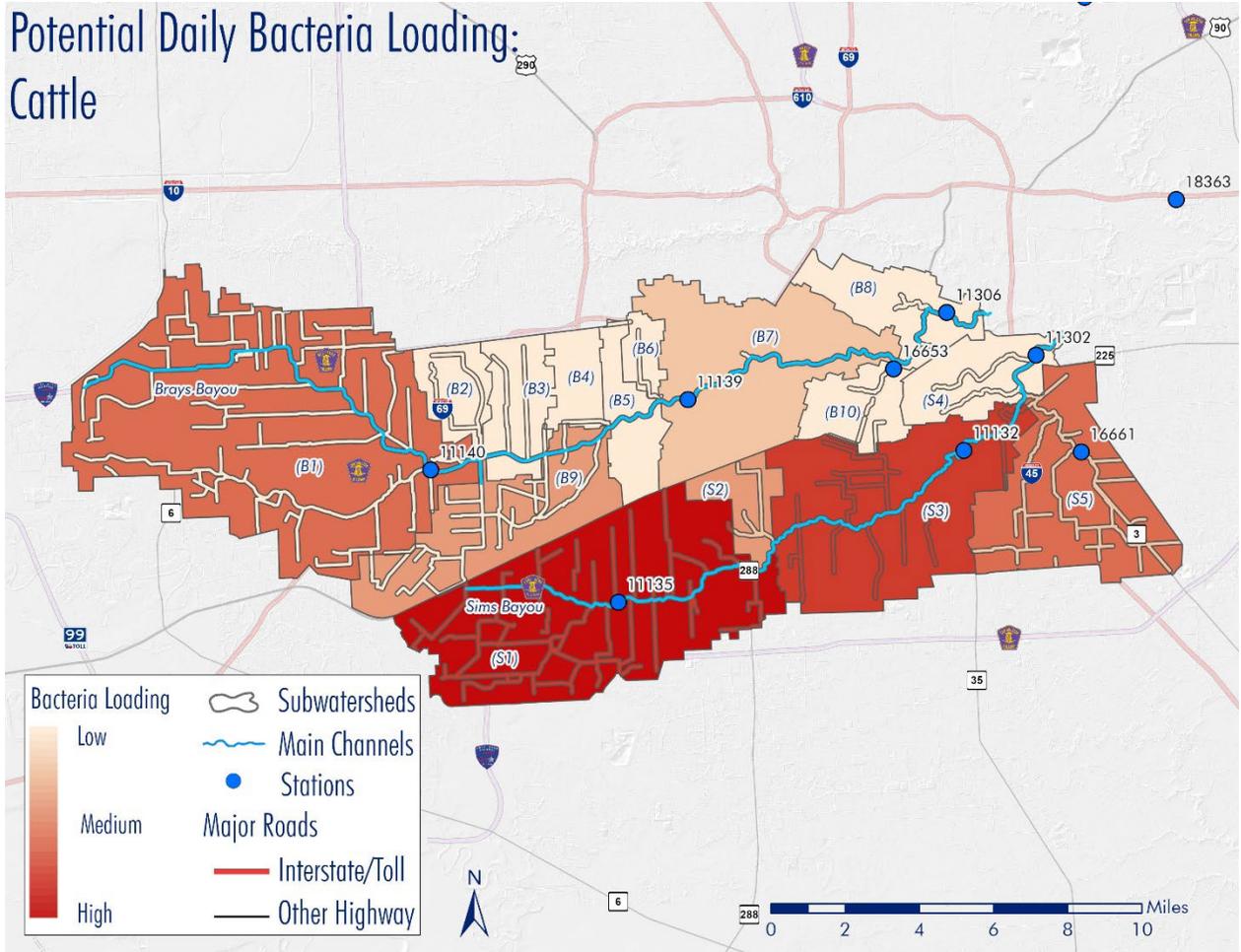
Figure 20. Bacteria loading from cattle by subwatershed

Figure 21. Future bacteria loading from cattle

Table 14. Cattle and loadings by subwatershed

Subwatershed	Cattle Outside Buffer	Cattle Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	8.85	0.05	5.97	0.15	3.48%
Brays Above Tidal - Middle (B2)	0.00	0.00	0	0	0.00%
Brays Above Tidal - Middle (B3)	0.00	0.00	0	0	0.00%
Brays Above Tidal - Middle (B4)	0.00	0.00	0	0	0.00%
Brays Above Tidal - Middle (B5)	0.06	0.00	0.04	0	0.02%
Brays Above Tidal - Middle (B6)	0.00	0.00	0	0	0.00%
Brays Above Tidal - Middle (B7)	0.53	0.02	0.36	0.07	0.24%
Brays Tidal (B8)	0.00	0.00	0	0	0.00%
Brays Above Tidal - Middle (B9)	2.03	0.00	1.37	0	0.78%
Kuhlman Gully (B10)	0.00	0.00	0	0	0.00%
Sims Above Tidal – Upper (S1)	86.28	14.32	58.24	38.67	55.05%
Sims Above Tidal – Middle (S2)	1.80	0.19	1.21	0.51	0.98%
Sims Above Tidal – Middle (S3)	51.62	8.47	34.84	22.88	32.79%
Sims Tidal (S4)	0.00	0.00	0	0	0.00%
Berry Bayou (S5)	16.28	0.02	10.99	0.73	6.66%
Total	**167.45**	**23.07**	**113.02**	**63.01**	**100%**

Horses

Similar to cattle, horse population estimates were calculated based on agricultural census data modified by the ratio of watershed area of relevant land use types to total county area. This method assesses only the horses designated for livestock use in the watershed. Horses owned for recreational purposes may not be well represented by these estimates. Discussions with watershed stakeholders are ongoing and may result in a revised method to more accurately reflect horse populations in the Brays and Sims Bayou watershed.

As with cattle, horse bacteria loading is highest in the subwatersheds of Upper and Middle Sims Bayou Above Tidal (**Figure 22**; **Table 15**). The rate of decline in **Figure 23** reflects statewide trends in decreasing livestock populations.
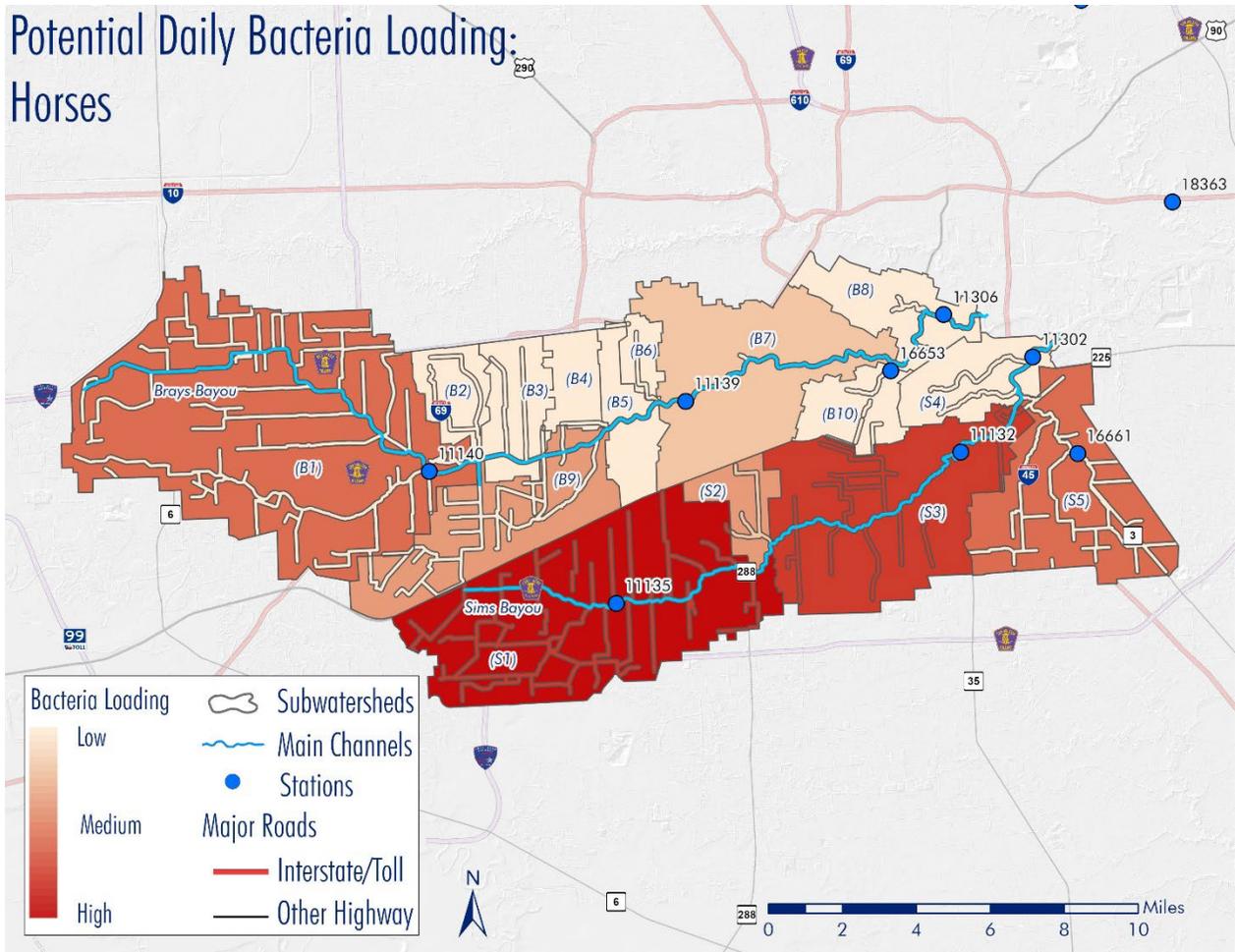
Figure 22. Bacteria loading from horses by subwatershed

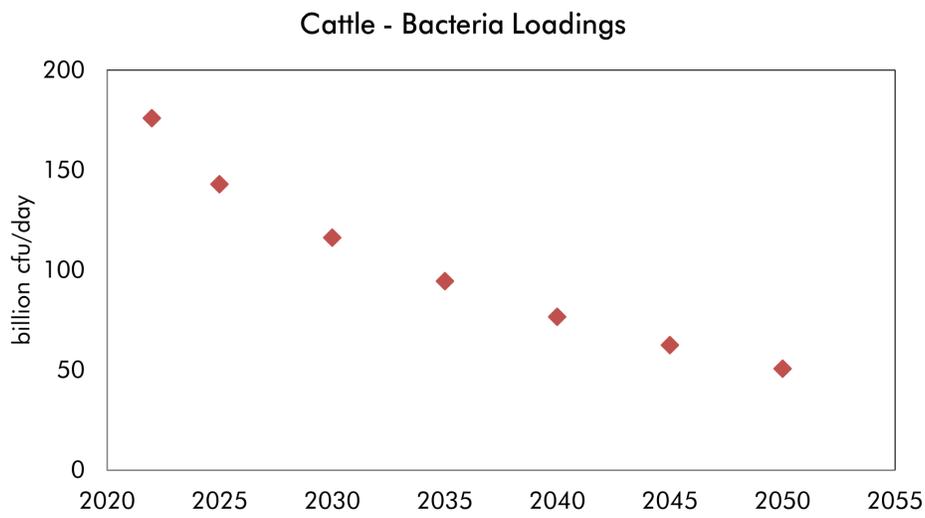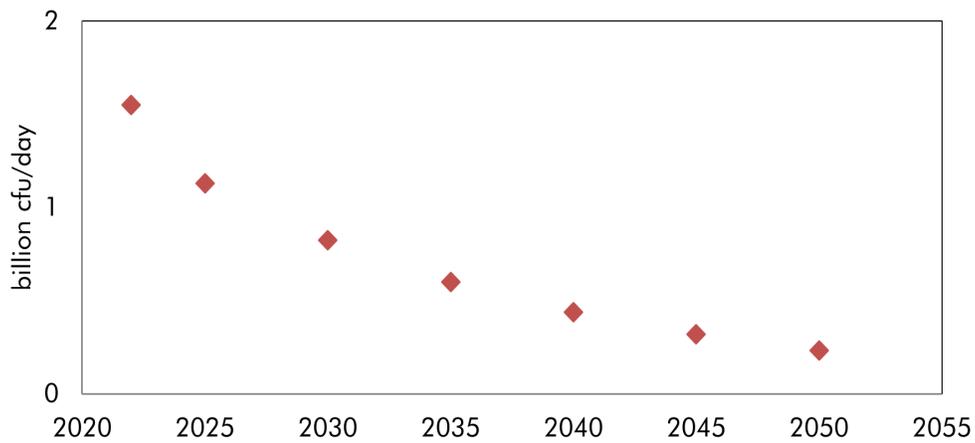**Figure 23.** Future bacteria loadings from horses

Table 15. Horses and loadings by subwatershed

Subwatershed	Horses Outside Buffer	Horses Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	1.01	0.01	0.05	0.00	3.49%
Brays Above Tidal - Middle (B2)	0.00	0.00	0.00	0.00	0.00%
Brays Above Tidal - Middle (B3)	0.00	0.00	0.00	0.00	0.00%
Brays Above Tidal - Middle (B4)	0.00	0.00	0.00	0.00	0.00%
Brays Above Tidal - Middle (B5)	0.01	0.00	0.00	0.00	0.02%
Brays Above Tidal - Middle (B6)	0.00	0.00	0.00	0.00	0.00%
Brays Above Tidal - Middle (B7)	0.06	0.00	0.00	0.00	0.24%
Brays Tidal (B8)	0.00	0.00	0.00	0.00	0.00%
Brays Above Tidal - Middle (B9)	0.23	0.00	0.01	0.00	0.78%
Kuhlman Gully (B10)	0.00	0.00	0.00	0.00	0.00%
Sims Above Tidal – Upper (S1)	9.80	1.63	0.51	0.34	55.26%
Sims Above Tidal – Middle (S2)	0.20	0.02	0.01	0.00	0.98%
Sims Above Tidal – Middle (S3)	5.86	0.96	0.31	0.20	32.92%
Sims Tidal (S4)	0.00	0.00	0.00	0.00	0.00%
Berry Bayou (S5)	1.85	0.00	0.10	0.00	6.30%
Total	**19.02**	**2.62**	**1.00**	**0.55**	**100%**

Sheep and Goats

Sheep and goat populations represent a smaller portion of the livestock in the watershed, but still retain a presence in rural areas. Both animal populations are grouped into a single statistic in the agricultural census. To estimate the size of these populations, the same method used for cattle and horses was applied to agricultural census data for sheep and goats. Assessment and revision of the initial population estimates may be explored after further discussion with stakeholder groups.

Sheep and goat bacteria loading bears a strong special similarity to cattle and horse bacteria loading with the highest concentration occurring in the Upper and Middle Sims Bayou Above Tidal (**Figure 24**; **Table 16**). This is likely due to the high percentage of agricultural land of the subwatersheds occurring in the drainage area for the Upper and Middle Sims Bayou Above Tidal subwatersheds. As with other agricultural animals, sheep and goat populations are expected to decline as a result of statewide trends in decreasing livestock populations. (**Figure 25**).
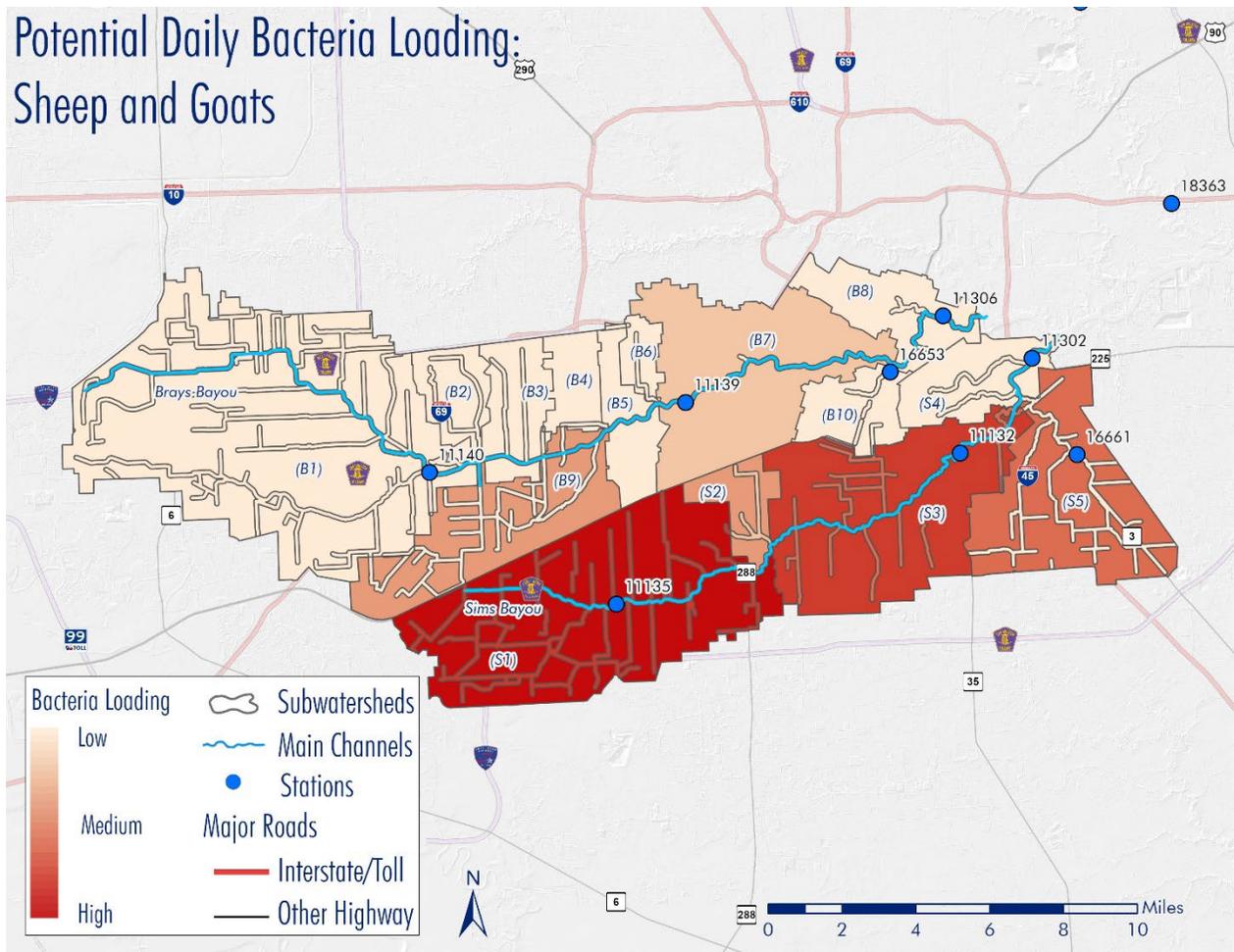
Figure 24. Bacteria loadings from sheep and goats by subwatershed
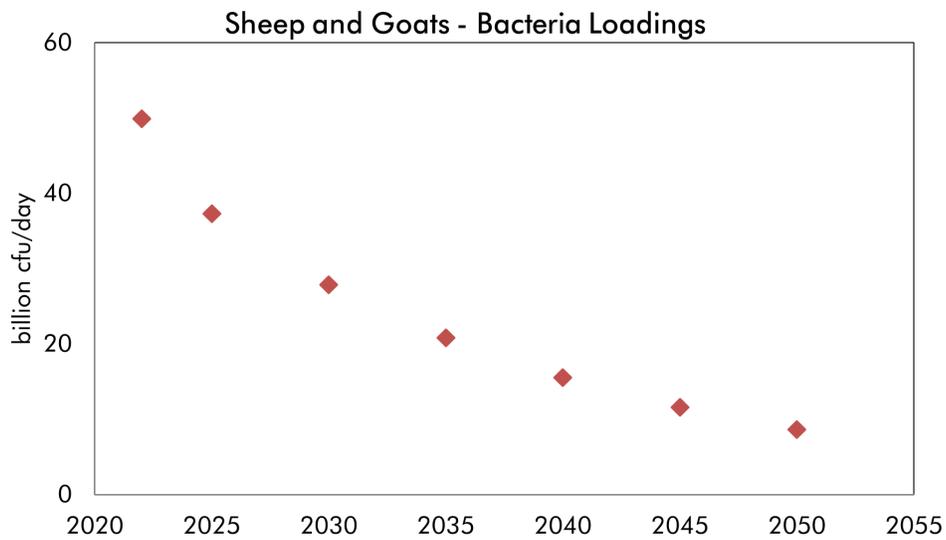
Figure 25. Future bacteria loadings from sheep and goats

Table 16. Sheep and goats and loadings by subwatershed

Subwatershed	Sheep & Goats Outside Buffer	Sheep & Goats Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	1.01	0.01	0.006	0.78	0%
Brays Above Tidal - Middle (B2)	0.00	0.00	0.00	0.00	0%
Brays Above Tidal - Middle (B3)	0.00	0.00	0.00	0.00	0%
Brays Above Tidal - Middle (B4)	0.00	0.00	0.00	0.00	0%
Brays Above Tidal - Middle (B5)	0.01	0.00	0.00	0.005	0%
Brays Above Tidal - Middle (B6)	0.00	0.00	0.00	0.00	0%
Brays Above Tidal - Middle (B7)	0.05	0.00	0.11	0.02	0.25%
Brays Tidal (B8)	0.00	0.00	0.00	0.00	0%
Brays Above Tidal - Middle (B9)	0.18	0.00	0.40	0.00	0.81%
Kuhlman Gully (B10)	0.00	0.00	0.00	0.00	0%
Sims Above Tidal – Upper (S1)	7.63	1.27	17.16	11.39	57.28%
Sims Above Tidal – Middle (S2)	0.16	0.02	0.36	0.15	1.02%
Sims Above Tidal – Middle (S3)	4.56	0.75	10.26	6.74	34.11%
Sims Tidal (S4)	0.00	0.00	0.00	0.00	0%
Berry Bayou (S5)	1.44	0.00	3.24	0.02	6.53%
Total	**15.04**	**2.05**	**31.54**	**19.11**	**100%**

Deer

Forests and open grasslands in the less developed areas of the watershed provide ample habitat area for white-tailed deer. However, deer are among the few species that are adaptable to the encroachment of developed areas. Loss of natural areas may lead deer to explore larger lots of suburban and light urban development as alternative habitat. Because of this, natural areas and open and low intensity developed areas were considered as possible deer habitat for the purposes of load estimation. Assessment and revision of the initial population estimates may be explored after further discussion with stakeholder groups. Resource Management Unit population density data accessed from the Texas Parks and Wildlife Department assuming one deer for every 40.2 acres of forest, shrubland and open developed areas was used to estimate deer populations and their associated fecal bacteria loading potential. In low intensity developed areas, deer density was assumed to be one deer for every 80.4 acres. With this approach, population dynamics are not well represented with respect to movements between land cover types and possible increases in density of natural areas after the built environment extends into previously undeveloped spaces.

Estimated deer bacteria loadings were highest in the subwatersheds of Upper Brays and Sims Bayou Above Tidal (**Figure 26**; **Table 17**). Despite their ability to adapt to more developed land areas when faced with the loss of natural habitat, deer populations in the Brays and Sims Bayou watershed are predicted to slightly decrease over time (**Figure 27**). As the SELECT model only accounts for gains and losses of fecal bacteria load pressures, migration between parcels could be underestimated. Further discussions with stakeholders will focus on assessing the accuracy of these estimations and what modifications may be appropriate for data adjustment.
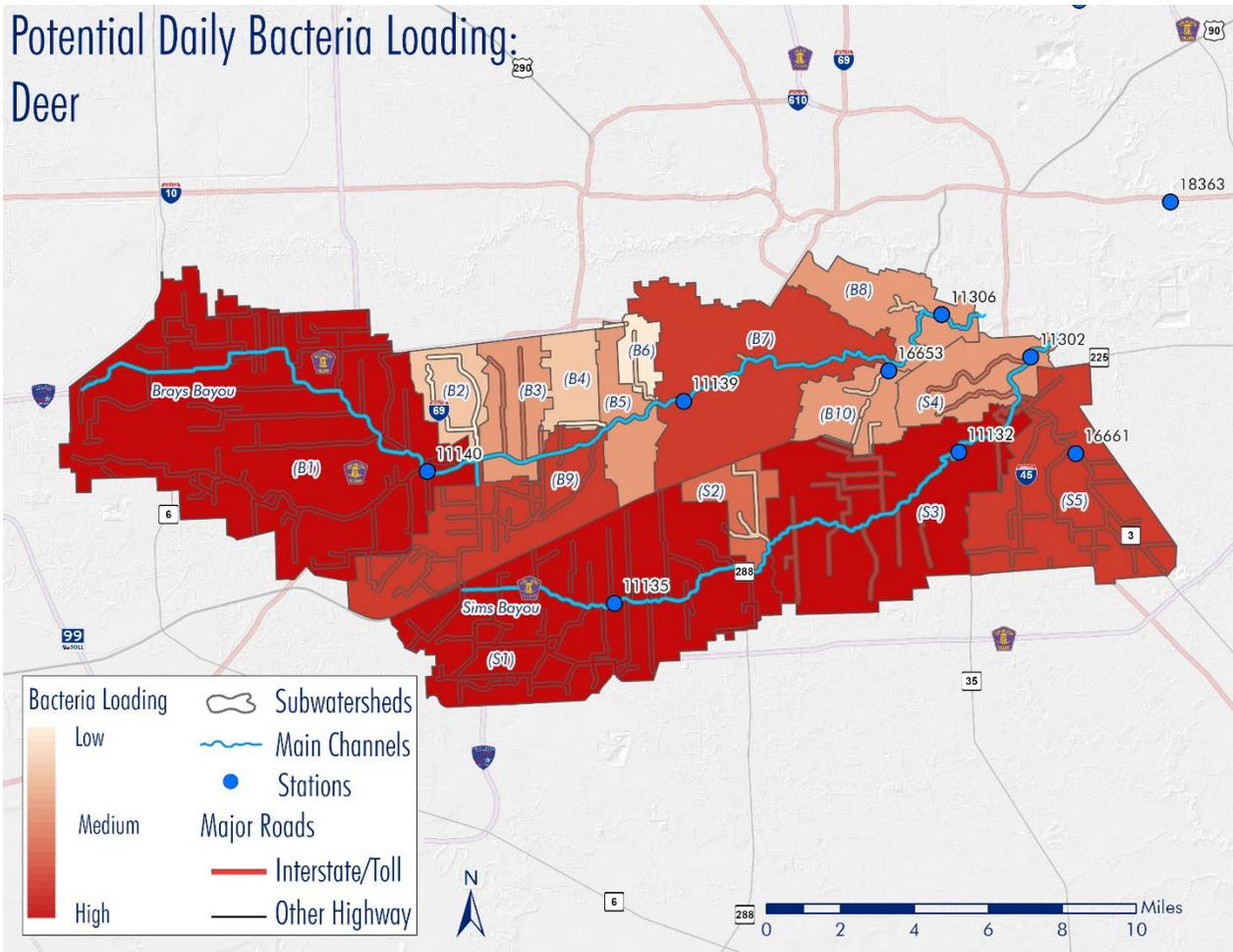
Figure 26. Bacteria loadings from deer by subwatershed
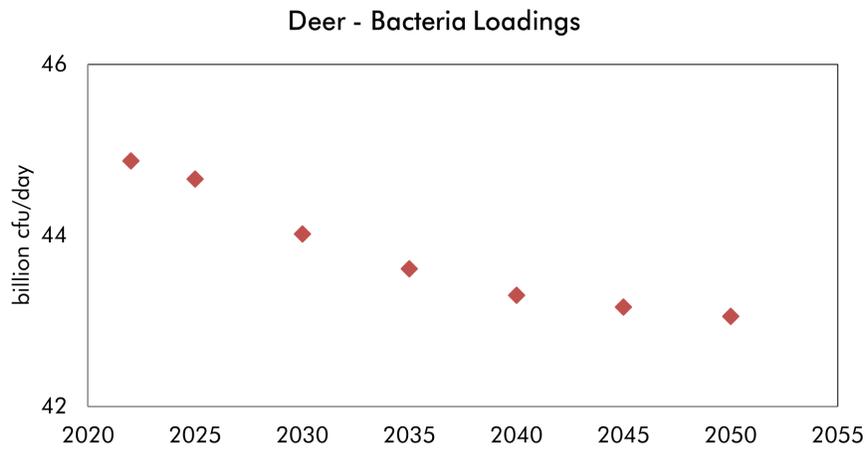
Figure 27. Future bacteria loadings from deer

Table 17. Deer and loadings by subwatershed

Subwatershed	Deer Outside Buffer	Deer Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	92.59	37.50	4.05	6.56	23.66%
Brays Above Tidal - Middle (B2)	7.42	1.25	0.32	0.22	1.21%
Brays Above Tidal - Middle (B3)	10.06	4.81	0.44	0.84	2.86%
Brays Above Tidal - Middle (B4)	7.96	0.87	0.35	0.15	1.11%
Brays Above Tidal - Middle (B5)	14.41	0.65	0.63	0.11	1.66%
Brays Above Tidal - Middle (B6)	1.96	1.56	0.09	0.27	0.80%
Brays Above Tidal - Middle (B7)	37.64	3.61	1.65	0.63	5.08%
Brays Tidal (B8)	10.09	1.97	0.44	0.34	1.75%
Brays Above Tidal - Middle (B9)	40.19	13.58	1.76	2.38	9.22%
Kuhlman Gully (B10)	11.88	2.10	0.52	0.37	1.98%
Sims Above Tidal – Upper (S1)	140.81	20.72	6.16	3.63	21.81%
Sims Above Tidal – Middle (S2)	17.20	2.01	0.75	0.35	2.46%
Sims Above Tidal – Middle (S3)	99.79	10.66	4.37	1.86	13.89%
Sims Tidal (S4)	11.39	4.17	0.50	0.73	2.74%
Berry Bayou (S5)	53.62	11.68	2.35	2.04	9.78%
Total	**557.01**	**117.14**	**24.38**	**20.48**	**100%**

Feral Hogs

In the Houston-Galveston region feral hogs (*Sus scrofa*) are an invasive species that negatively impact agriculture, wildlife species and their habitats, and human landscapes. Efforts to control feral hogs have been carried out by communities within the Brays and Sims Bayou watershed that have already recognized the environmental pressures associated with their populations. Feral hogs are of particular concern as carriers of diseases that can be dangerous to domestic livestock, pets, and humans. These animals are known to use land around waterways as shelter and transportation corridors between food resources and can generate large volumes of waste where they concentrate.

Though they occur in the highest densities along riparian corridors and other natural areas, feral hogs are pervasive and can be found in all land cover types aside from developed areas and open water. Population density estimates used in the SELECT model for feral hog source loads referenced land cover types in the watershed area are based on AgriLife literature values[11]. In areas of development and open water, hog densities of zero were assumed. In areas of barren land, 8.9 hogs per square mile were assumed. In cultivated areas and pasture, that density increased to 12.7 hogs per square mile. Grasslands, forests, shrublands, and wetland areas were assumed to have an even higher density of 16.4 hogs per square mile. Due to this association with land cover, future projections of feral hog loads will be tied to changes in development.

Potential fecal bacteria loading by feral hogs was estimated to be higher in the Middle Brays Bayou Above Tidal and Upper Sims Bayou Above Tidal subwatersheds (**Figure 28**; **Table 18**). Future projections of feral hog loads predict a steady decline in magnitude as time progresses (**Figure 29**). However, the SELECT model does not account for the adaptability of feral hog populations that have anecdotally been observed to redistribute or condense when faced with the loss of their preferred habitats. Therefore, without literature support or evidence from local stakeholders, the estimates presented in this SELECT model should be considered conservative.

---

[11] As referenced at
http://agrilife.org/feralhogs/files/2010/04/FeralHogPopulationGrwothDensityandHervestinTexasedited.pdf
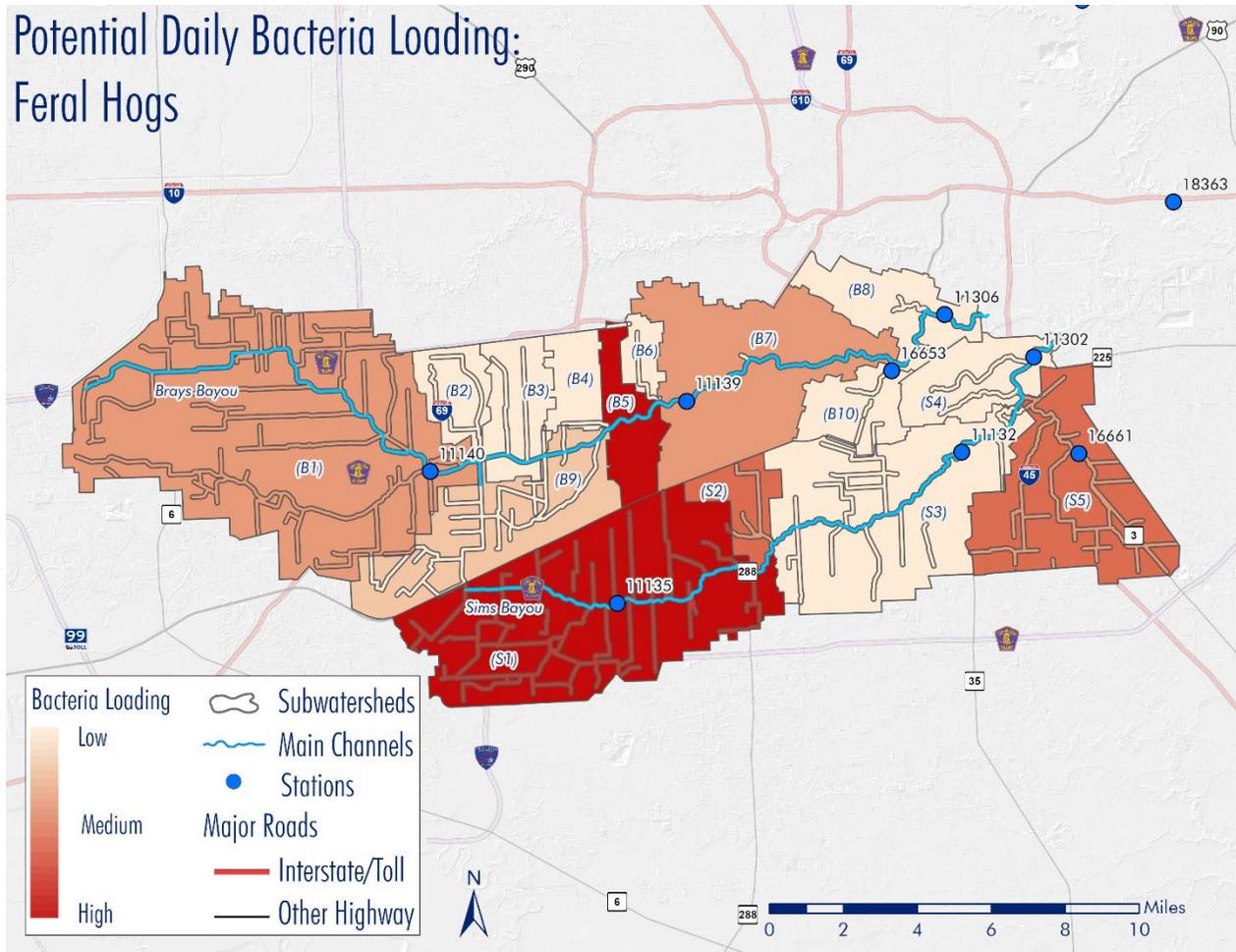
Figure 28. Bacteria loadings from feral hogs by subwatershed

Figure 29. Future bacteria loadings from feral hogs

Table 18. Feral hogs and loadings by subwatershed

Subwatershed	Feral Hogs Outside Buffer	Feral Hogs Within Buffer	Load Outside Buffer in Billion cfu/day	Load Within Buffer in Billion cfu/day	Subwatershed Percent of Total Load
Brays Above Tidal - Upper (B1)	4	1	5.00	4.24	4%
Brays Above Tidal - Middle (B2)	0	0	0.00	0.00	0%
Brays Above Tidal - Middle (B3)	0	0	0.00	0.00	0%
Brays Above Tidal - Middle (B4)	0	0	0.00	0.00	0%
Brays Above Tidal - Middle (B5)	37	0	51.37	0.00	23%
Brays Above Tidal - Middle (B6)	0	0	0	0	0%
Brays Above Tidal - Middle (B7)	3	0	3.85	0.03	2%
Brays Tidal (B8)	0	0	0	0	0%
Brays Above Tidal - Middle (B9)	2	0	2.18	0.24	1%
Kuhlman Gully (B10)	0	0	0	0	0%
Sims Above Tidal – Upper (S1)	37	5	50.58	30.14	36%
Sims Above Tidal – Middle (S2)	10	1	14.41	5.84	9%
Sims Above Tidal – Middle (S3)	16	3	22.12	18.46	18%
Sims Tidal (S4)	0	0	0.15	0.31	0%
Berry Bayou (S5)	6	1	8.22	4.10	6%
Total	**115**	**12**	**157.86**	**63.38**	**100%**

Other Sources

Most of the project's understanding of fecal bacteria loading in the Brays and Sims Bayou watershed is based on the modeled sources described above. However, many other sources are recognized as contributors to the total fecal bacteria load that are less easily characterized. Further explanation regarding how those sources will be accounted for in the WPP development process are described below.

Human Waste – Direct Deposition

In other watershed projects, potential impacts from homeless communities and areas not serviced by centralized or localized wastewater treatment were considered. Further discussion with area stakeholders is needed to assess the extent of these impacts in the Brays and Sims Bayou watershed.

Land Deposition of Sewage Sludge

If improper use of manure spreading, or violations of sludge application have occurred in the watershed area, action would be required to intervene and reduce the resulting fecal bacteria loading impacts. However, these impacts would likely be addressed in best management practices for agricultural sources of pollution.

Sanitary Sewer Overflows (SSOs)

Though SSOs occur episodically, they represent a high-risk vector for fecal bacteria contamination because they can have concentrations of fecal bacteria several orders of magnitude higher than treated effluent. Untreated sewage can contain large volumes of raw fecal waste, making it a significant health risk where SSOs are sizeable or chronic issues. Events are self-reported and may vary in quality. Descriptions of frequencies, causes, durations, and volumes of SSOs may be subject to logistical inadequacies such as unknown duration of discharge, and inability to accurately gage discharge volume. Actual SSO volumes and incidences are generally expected to be greater than reported due to these fundamental challenges.

After reviewing data compiled in SSO reports submitted by permit holders in the Brays and Sims Bayou watershed[12], SSO events were not found to follow any specific spatial, seasonal, or annual pattern. In terms of general cause, blockages accounted for the highest number of events respective to the other general categories of weather, malfunctions, and unknown causes. In terms of volume, weather contributed the highest overflow observed between 2020 and 2024.

Due to the episodic nature and spatial inconsistency of SSO events, fecal bacteria loads from these sources are not expected to have an appreciable long-term impact on the overall loading for the watershed and were excluded from SELECT model analysis. Though the estimations of SSO impacts in this watershed are not represented by SELECT models, they are no less important to consider in the overall assessment of fecal bacteria loading. The most extreme method of estimating fecal bacteria loads from SSOs would be to calculate loading based on EPA literature values[13] suggested for general causes related to each event multiplied by the highest observed volumes of discharge recorded for each cause. A more conservative method would be to calculate the average daily volume of discharge and use that as the multiplier for cause related load estimates. In other area watershed projects, stakeholders elected to refrain from the aforementioned calculations and treat SSOs as a separate, high-priority item for inclusion in the management strategies outlined in the WPP. SSO data regarding unique events impacting stream segments within the watershed area over the most recent five years of reports provided by TCEQ were used in these assessments. This approach could be explored in the Brays and Sims Bayou watershed according to the decision making of the stakeholder group.

Concentrated Animal Feeding Operation (CAFO)
No active CAFOs are in operation within the Brays and Sims Bayou watershed.

Birds
The greater Houston area is well known as part of the great Central Flyway migration path used by various bird populations. Many migratory bird species only utilize the land area for short periods of time while in transit, but migratory waterfowl and resident species represent longer-term populations, especially in coastal marshes. Similar watershed projects have evaluated the potential impact of waterfowl in terms of duration, potential fecal bacteria load, and other considerations, and found them to not be significant sources to be modeled. Colonial birds such as swallows have been identified by other watershed projects as potential sources of fecal bacteria load. Unfortunately, little or no data is available to characterize the impacts of fecal bacteria loading from colonial bird sources or to implicate colonial bird influenced fecal bacteria loading as significant health risks to the watershed community. Stakeholder knowledge will be critical to an improved understanding of the dynamics and magnitude of avian populations. Beyond lack of data, relatively small fecal bacteria loads and health risks associated with bird waste compared to human sources, and general lack of management strategies available to deal with wild birds have limited the emphasis of this source as a meaningful component of management efforts in similar projects.

---

[12] A more detailed analysis of water quality is discussed further in the Acquired Data Analysis Report for the Brays and Sims Bayou Watershed. This document and more information on data quality objectives, concerns, and methodologies used in these analyses (detailed in the Brays and Sims Bayou Modeling Quality Assurance Project Plan) are available for review at https://www.h-gac.com/watershed-based-plans/brays-sims-bayou.
[13] As referenced in Appendix H Estimation of SSO Impacts in Streams and Rivers

Bats

Though bats are present in the watershed area, only large colonies of these animals are estimated to have an appreciable impact on water quality. No known nesting sites of significant size or density have been indicated in the Brays and Sims Bayou watershed.

Other Wildlife

Specific data for wildlife such as coyotes, opossums, rodents, wild cats, skunks, raccoons, and other mammals is not widely available. Similar watershed projects have recognized these wildlife animals as potentially appreciable contributors to fecal bacteria loads, but lacked a reasonable method for quantifying their potential impacts. One method of improving understanding of wildlife impacts in the Brays and Sims Bayou watershed would be to implement fecal bacteria source tracking or assessments of genetic material found in waterways to identify species depositing fecal waste in and around streams. Data collected with this method in other watersheds showed that wildlife impacts are significant[14] and should be incorporated into fecal bacteria reduction strategies. As no such data are presently available for the Brays and Sims Bayou watershed, the understanding of wildlife species in this area will be largely informed by anecdotal information provided by stakeholders and general estimations decided by stakeholder input. In nearby Clear Creek, a similarly developed watershed spanning Harris and Galveston counties, wildlife impacts were assumed to be equivalent to a conservative 20% of the other modeled loads assessed in the watershed. The value was generated by finding the total for all other sources in all subwatersheds, setting that total as 80% of the total load, and then assuming wildlife to be the other 20%. This method was also applied for Brays and Sims Bayou. In addition, the value calculated for the current year (2022) was kept consistent for the subsequent five-year forecasting intervals rather than recalculating 20% of each new total load. This was done with the assumption that no new habitat will become available for wildlife and that their populations will not grow. After reviewing modeled results with stakeholders, this percentage may be adjusted according to the specific needs of the watershed.

Cats

Domestic dogs are included in the SELECT model analysis as a concern of particular interest to the watershed due to the likelihood of improperly managed dog waste deposited outdoors making its way to streams via runoff. Domestic cat waste management is typically handled indoors and restricted to litter boxes. Therefore, pet waste from cats was not estimated as part of this project. Feral cats, however, can be a local source when found in sufficiently dense urban populations, though very little data exists to quantify these impacts. Generally, impacts from feral cats may be accounted for in other loading assumptions such as diffuse urban stormwater or as part of the impacts from other wildlife.

Dumping

Illegal dumping is not typically a widespread or appreciable contributor to fecal bacteria loads in watersheds as these events occur locally and/or episodically. This factor may still be important for stakeholders to consider addressing in the WPP in terms of aesthetic and other regulatory issues.

---

[14] For example, bacteria source tracking completed by Texas A&M University for Attoyac Bayou showed *E. coli* from wildlife at greater than 50% of load across flow conditions (https://oaktrust.library.tamu.edu/handle/1969.1/152424) and a similar analysis (https://oaktrust.library.tamu.edu/handle/1969.1/149197) conducted for the Lampasas and Leon Rivers showed comparable results.

Sediment

Sedimentation has been identified by stakeholders in nearby watersheds including Spring and Cypress Creek. With increased availability of sediment and other suspended solids in waterways, fecal bacteria may benefit from increases in substrate and decreases in insolation that prevent natural processes of die-off. Sedimentation can also impact DO levels and have pronounced hydrologic impacts on flow. If stakeholders indicate similar concerns for the Brays and Sims Bayou watershed, these concerns will be addressed in the WPP.

5.3 Summary of Results

SELECT analyses indicated the highest loads from the total mix of modeled sources are concentrated in the Upper Brays Bayou Above Tidal subwatershed because of pressures from dog waste and wildlife (**Table 19**). Similarly, there is also a pronounced concentration of loading in the Middle Brays Bayou Above Tidal subwatershed associated with the same pressures previously described (**Table 19**). Future projections for increased overall fecal bacteria loading throughout the watershed are also important to consider in the development of a WPP (**Table 20**). Without taking action to reduce fecal bacteria sources in the watershed, loads will continue to increase between 2022 and 2050 (**Figure 30**), with dogs having the largest estimated increase (**Figure 31**; **Figure 32**). Stakeholder input will be crucial for determining whether less traditional load estimation approaches for wildlife and other sources yield accurate and defensible results for the watershed. Modeled predictions may be adjusted after review with stakeholders at partnership meetings, focused workgroups, and one-on-one conversations.

Table 19. Daily average bacteria loads in billion cfu/day by source and subwatershed, 2022

Source	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	S1	S2	S3	S4	S5	% Total Load
OSSFs	480.37	0	0	0	0	0	0	0	20.12	0	193.90	28.26	17.80	0	0	5%
WWTFs	21.84	0	10.97	0	21.46	0.79	4.77	0	96.98	0	15.19	0	76.31	36.82	15.28	0%
Dogs	137,670	15,848.3	19,119	6,748.5	9,400.5	5,457	49,042.5	12,826	36,083	7,850.3	41,200.5	2,278.5	34,034.25	10,881.8	24,920.3	72%
Cattle	6.12	0	0	0	0.04	0	0.43	0	1.37	0	96.91	1.72	57.72	0	11.72	1%
Horses	0.05	0	0	0	0.00036	0	0.0038	0	0.012	0	0.86	0.02	0.51	0	0.098	0%
Sheep & Goats	7.9E-10	0	0	0	5.4E-12	0	0.126	0	0.40	0	28.6	0.51	17.00	0	3.25	0%
Deer	10.61	0.54	1.28	0.50	0.74	0.36	2.28	0.79	4.14	0.89	9.79	1.10	6.23	1.23	4.39	0%
Wildlife	172,748	19,811	23,914.1	8,436.2	11,842.6	6,822.69	61,317.8	16,033	45,260	9,813.9	52,033	2,912.95	42,762.28	13,650	31,209.2	20%
Feral Hogs	9.24	0	0	0	51.37	0	3.88	0	2.42	0	80.71	20.25	1.94E-08	0.46	12.33	2%

Table 20. Daily average bacteria loads in billion cfu/day by source for all milestone years

| Source		2022	2025	2030	2035	2040	2045	2050
Human Waste	OSSFs	740.45	786.07	860.03	952.51	1,112.69	1,179.32	1,247.30
	WWTFs	300.43	311.89	320.70	336.21	352.69	378.88	400.93
Pets	Dogs	413,359.50	437,119.50	451,090.50	464,558.25	484,144.50	520,655.25	549,151.50
Livestock	Cattle	176.03	143.03	116.24	94.49	76.84	62.52	50.89
	Horses	1.55	1.13	0.82	0.60	0.44	0.32	0.23
	Sheep & Goats	49.85	37.23	27.81	20.77	15.52	11.59	8.66
Wildlife	Deer	44.87	44.66	44.02	43.61	43.30	43.16	43.05
	Wildlife	103,713.33	103,713.33	103,713.33	103,713.33	103,713.33	103,713.33	103,713.33
Invasives	Feral Hogs	180.66	170.90	135.90	111.14	90.62	82.32	75.99
TOTAL		**518,566.67**	**542,327.74**	**556,309.36**	**569,830.92**	**589,549.94**	**626,126.69**	**654,691.88**
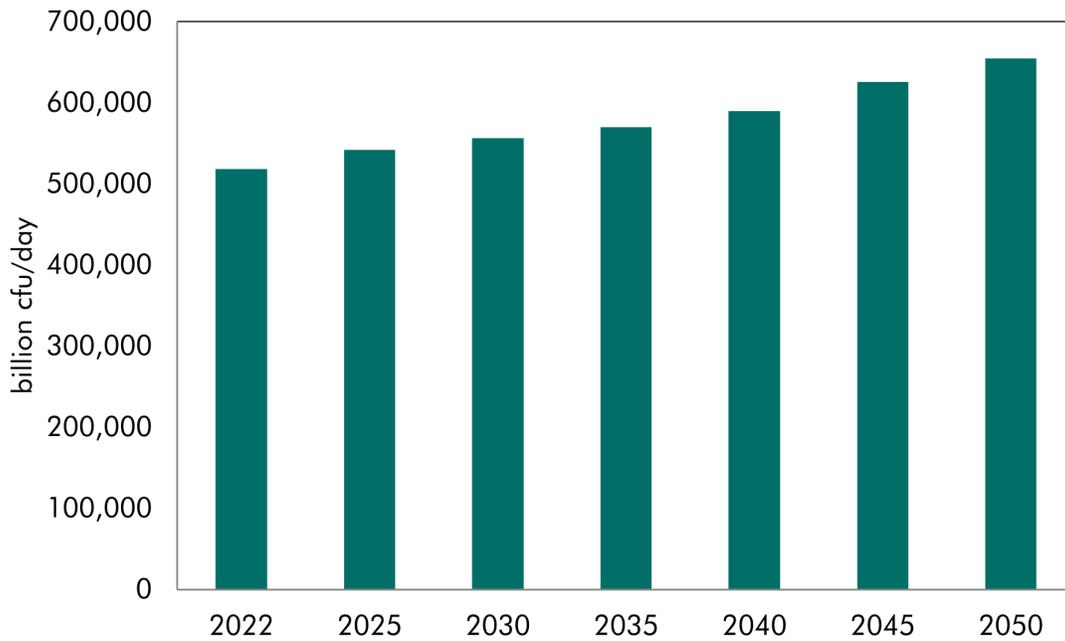
Figure 30. Total potential daily bacteria loads, 2022-2050
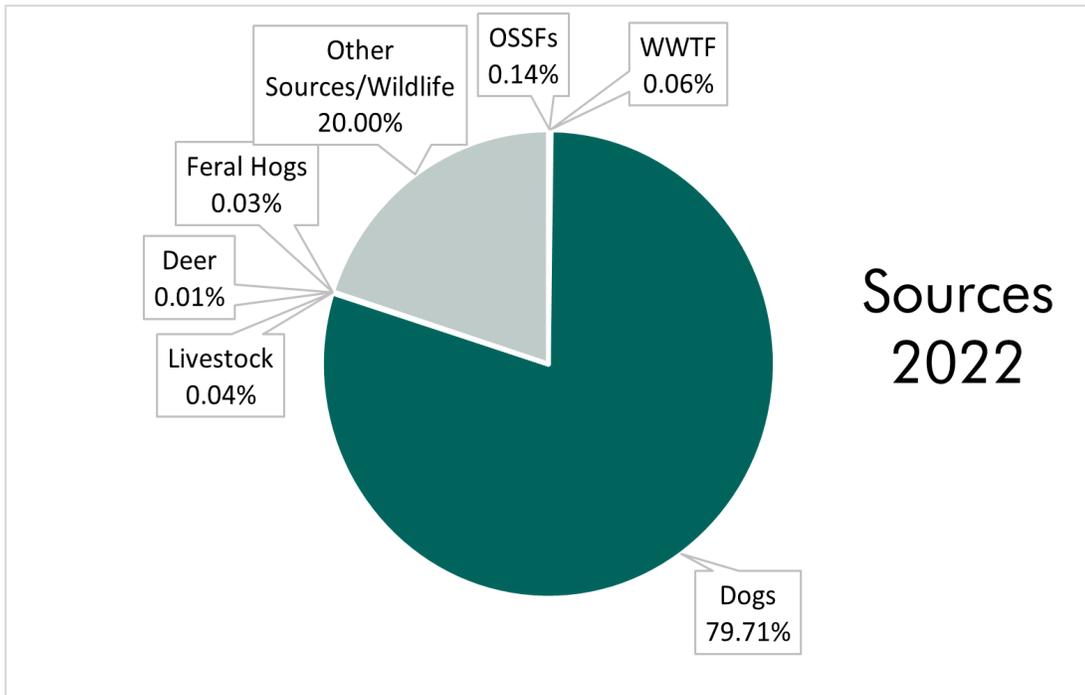
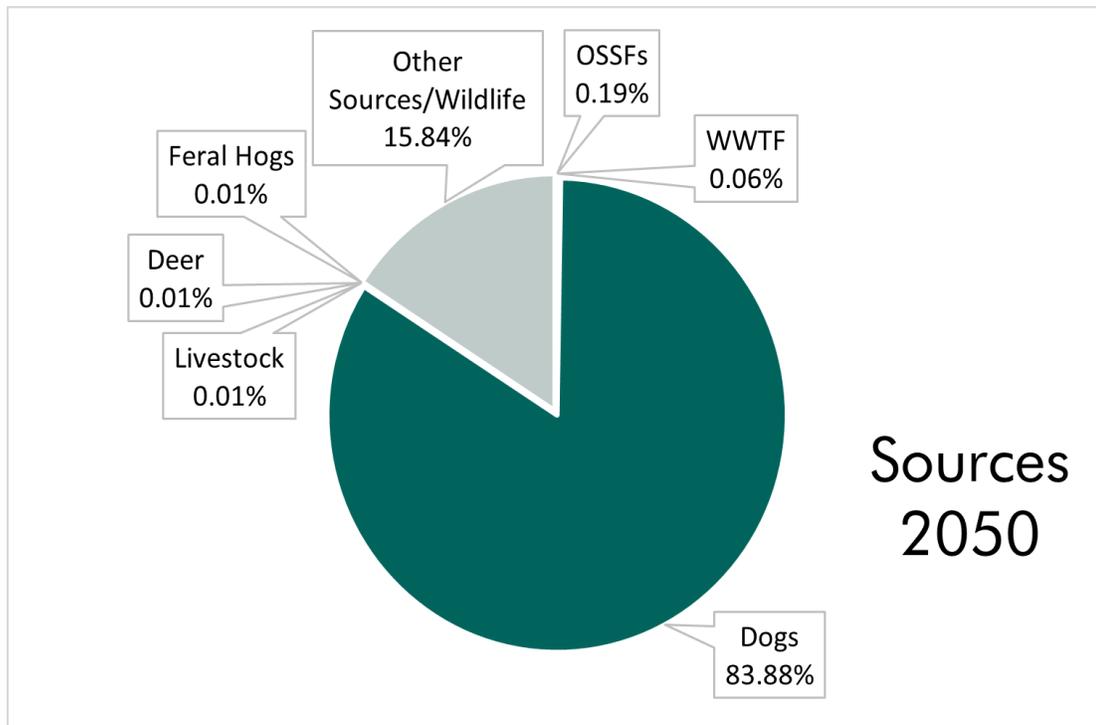**Figure 31.** Fecal indicator bacteria source profile, 2022

Figure 32. Fecal indicator bacteria source profile, 2050

SECTION 6: OUTCOMES AND IMPLICATIONS

6.1 Overview of Outcomes

The results of LDC and SELECT models generated for this report indicate different fecal bacteria reduction needs for different areas of the watershed dictated by a complex mix of sources which are predicted to shift in coming years. Among these sources, pet waste was determined to be the dominant pollutant in both current and projected scenarios. The methodologies implemented in the design of these model results may be refined by stakeholder feedback as the partnership progresses through the stages of WPP development. From these data, fecal bacteria reduction targets and implementation timelines may be established by linking the results of LDC and SELECT models.

The LDC and SELECT results discussed in this report satisfy Element A: Identify Causes/Sources of Pollution, Element B: Expected Load Reductions, and Element C: Nonpoint Source Management Measures of EPA's Nine Minimum Elements to be Included in a Watershed Plan for Impaired Waters[15]. Specifically, with the LDC results, H-GAC staff were able to determine where bacteria sources were most likely coming from by plotting water quality data against flow regimes. Estimated load reductions were determined, and the results will be used to justify the selection of management measures best suited for each watershed. With SELECT results, the estimated fecal indicator bacteria loads were used to identify primary pollutant sources. These estimates, along with LDC load reduction results, were used to calculate the 2022 and 2040 source load reduction targets provided in Table 22. The SELECT model was also the basis for identifying the subwatersheds and attainment areas described in this report, which will be used for determining the most appropriate locations for Best Management Practices and other implementation strategies.

6.2 Model Linkage

LDC analyses helped to determine fecal bacteria reduction targets at different rates of stream flow for different sites throughout the watershed area. These models also helped identify similar spatial trends that will aid in the selection of target areas for implementing specific fecal bacteria reduction strategies. SELECT models helped to spatially visualize potential fecal bacteria loads contributed by known sources and characterize the proportion of those loads to each other and to the overall total. This is important for determining how to approach fecal bacteria reduction throughout the watershed most effectively. The methods used to generate both LDC and SELECT models were developed with H-GAC and TCEQ project staff for quality assurance. Fate and transport relationships of fecal bacteria loads were not captured in these analyses. However, modifications were made to the base SELECT model to infer generalized linear relationships between source loading instream and in the watershed area at large. Most importantly, a buffer zone was established around the stream network which led to the distinction between sources directly impacting waterways and those with more indirect effects delivered via runoff and other high flow events. The level of precision achieved with more complex models does not produce an appreciably more useful level of information for stakeholders determining best management practices for their watershed. Other WPPs in the region have used similarly modified SELECT models with success as an efficient, accessible method of answering the needs of a project of this scale. Though a certain level of uncertainty is acknowledged in this approach, the general outcomes of these assessments will be defensible and suitable for guiding implementation.

---

[15]Handbook for Developing Watershed Plans to Restore and Protect Our Waters, March 2008

6.3 Fecal Indicator Bacteria Reduction Targets

Three main points help to guide the decision-making process for determining fecal bacteria reduction targets. First, a checkpoint must be determined for gaging the progress of actions taken to improve water quality in the watershed. This checkpoint is referred to as a milestone year. Secondly, managers must decide the scope of reduction targets and whether they will apply to specific target areas or if they will be more effective on a larger scale. Finally, reduction targets should be allocated proportional to the known sources contributing to fecal bacteria loading in the watershed.

Milestone Year
Typically, WPPs are written to provide a guideline for making improvements to water quality within a period of five to 15 years. By incorporating five-year intervals into future projections of fecal bacteria loading with the SELECT models used in this report, stakeholders will be able to target any year on the timeline between the present day and 2050 as a milestone year. While intervals closer to the present-day present challenges for organizing and implementing water quality improvement strategies, estimates for fecal bacteria loading further along the timeline are subject to higher levels of uncertainty. Therefore, a balance must be reached between selecting a milestone year that effectively addresses fecal bacteria loading for a long-term outlook while working within an acceptable margin of error regarding uncertainty. As a compromise, project staff recommend targeting the year 2040 as a milestone for this watershed project. With a WPP approval planned in 2027, this would cover a period between 10 and 15 years.

Target Areas
In both LDC and SELECT model results, different fecal bacteria source pressures are indicated in different areas of the watershed. To streamline the process of determining load reduction targets while recognizing different loading pressures affecting different areas of the watershed, project staff recommend using attainment areas as the base level target areas for determining fecal bacteria reductions. Attainment areas are groupings of similar geographical areas such as subwatersheds which share similar characteristics including land cover or pollutant loading pressures. The Brays and Sims Bayou subwatersheds were grouped into eight attainment areas (**Table 21**).

By designating these eight generalized attainment areas (**Figure 33**), overall reduction targets compromising between over-generalization of the total watershed and overly conservative reduction targets for individual subwatersheds at different rates of flow can be applied in the development of a WPP. Overall reduction targets for each attainment area were determined using the representative LDC station for the area and taking a weighted average of the LDC reduction targets produced for that station based on rates of flow. Therefore, where W represents the weighting factor (percent of flows) at high flow (h), moist (m), mid-range (mr), dry (d), and low flow (l) conditions, and R represents the reduction value required at each rate of flow, the weighted average reduction can be calculated as follows:

$$\text{Weighted Average Reduction} = \frac{W_h R_h + W_{mm} R_{mm} + W_{mmm} R_{mmm} + W_{dd} R_{dd} + W_{ll} R_{ll}}{W_h + W_{mm} + W_{mmm} + W_{dd} + W_{ll}}$$

For example, Station 11140 represents the Brays Above Tidal-Headwaters attainment area. At the high flow category which represents the top 10% of flows, an *E. coli* reduction of 99% is recommended. *E. coli* observed in the next 30% of flows (moist conditions) require a reduction of 97% and *E. coli* observed in the following 20% of flows (mid-range conditions) require a 94% reduction. Finally, *E. coli* observed in dry conditions comprising the following 30% of flows require a 93% reduction and *E. coli* observed in the lowest 10% of flows (low flow conditions) require a 92% reduction. For stations with negative reductions indicated in the low flow category, no values are factored into the calculation for the last weighted average category. The calculation for the weighted average reduction for Station 11140 is shown below:

$$\text{Weighted Average Reduction} = \frac{(10 \times 99) + (30 \times 97) + (20 \times 94) + (30 \times 93) + (10 \times 92)}{10 + 30 + 20 + 30 + 10}$$

$$\text{Weighted Average Reduction} = \frac{990 + 2{,}910 + 1{,}880 + 2{,}790 + 920}{100}$$

$$\text{Weighted Average Reduction} = \frac{9{,}490}{100} = 94.9$$

Table 21. Attainment Areas and Fecal Indicator Bacteria Load Reduction Goals

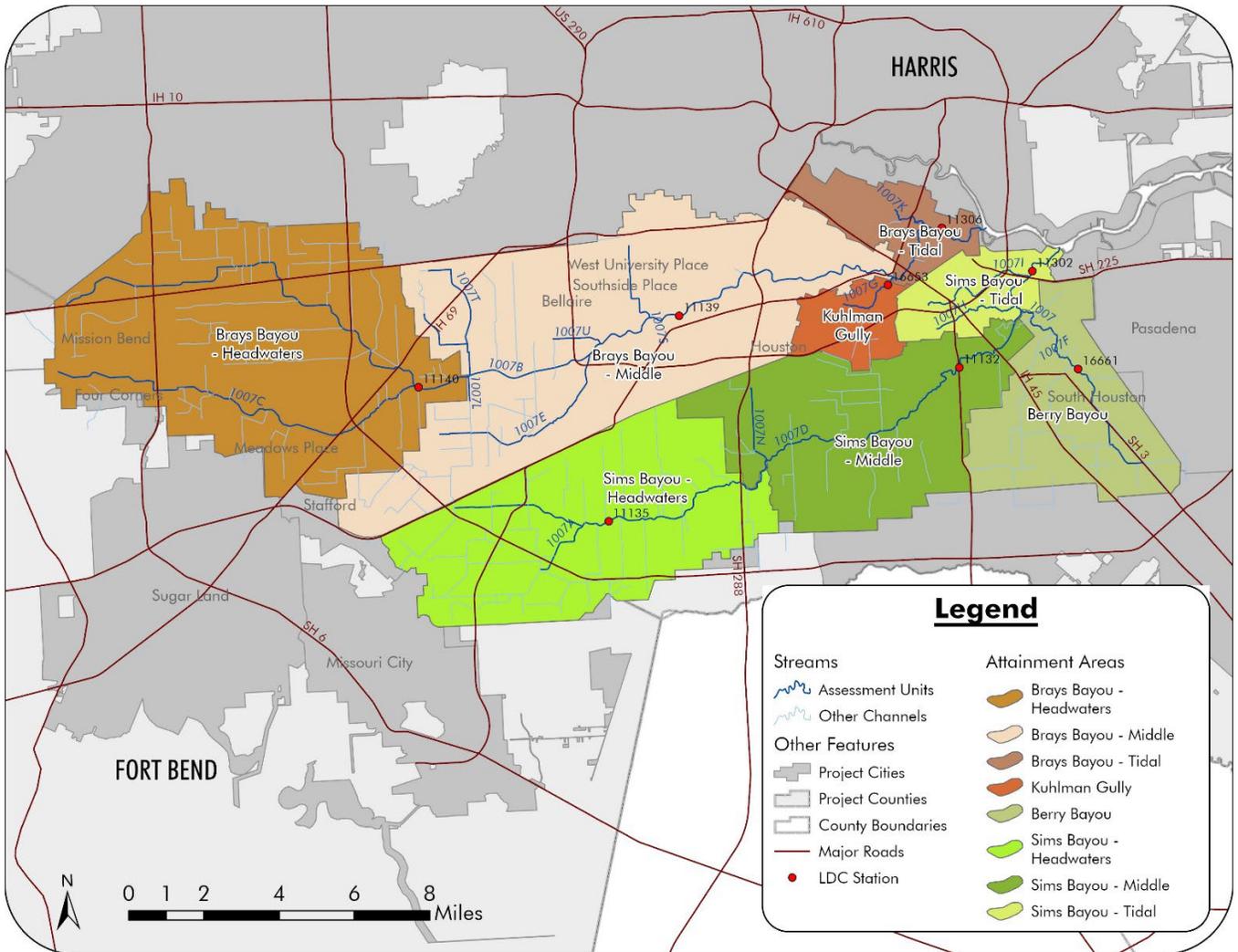| Attainment Area	LDC Station	Subwatersheds	Weighted Average *E. coli* Reduction Target
Brays Above Tidal-Headwaters	11140	B1	95%
Brays Above Tidal-Middle	11139	B2, B3, B4, B5, B6, B7, B9	95%
Brays Tidal	11306	B8	93%
Kuhlman Gully	16653	B10	82%
Sims Above Tidal-Headwaters	11135	S1	81%
Sims Above Tidal-Middle	11132	S2, S3	77%
Sims Tidal	11302	S4	56%
Berry Bayou	16661	S5	95%

Figure 33. Fecal Indicator Bacteria Attainment Areas

Allocating Reductions

Many methods can be implemented to determine the most appropriate course for allocating reductions to different fecal bacteria loading sources in a watershed area. Among them are:

1) Allocating reduction targets relative to source contributions estimated for the milestone year
2) Allocating reduction targets subjectively based on implementation strategies deemed most feasible and effective by area stakeholders
3) Allocating reduction targets relative to source contributions estimated for current conditions

For the needs of this watershed, project staff recommend the first option as it allows stakeholders some flexibility in focusing short-term efforts on sources indicated as greater pressures in current conditions relative to the milestone year. While proportional allocations are modeled at the subwatershed level and for the total watershed area, project staff further propose targeting results from the subwatersheds. According to these recommendations, both overall reduction targets for each of the subwatersheds and the linkage of the reduction target percentages to the source loadings to generate the target source load reductions for current and 2040 milestone years were calculated (**Table 22**). The allocation of reduction loads by source for each of the eight attainment areas were also calculated (**Table 23**, **Table 24**, **Table 25**, **Table 26**, **Table 27**, **Table 28**, **Table 29,** and **Table 30**).

Table 22. 2022 and 2040 source load reduction targets

Attainment Area	Subwatersheds	Weighted Average Bacteria Reduction Target	2022 Total Source Load in Billion cfu/day[15]	2022 Source Load Reduction Target in Billion cfu/day	Incremental Load, 2022 to 2040 in Billion cfu/day[16]	2040 Total Source Load Reduction Target in Billion cfu/day[17]
Brays Above Tidal-Headwaters	B1	95%	172,747.88	164,110.49	14,114.27	178,224.75
Brays Above Tidal-Middle	B2, B3, B4, B5, B6, B7, B9	95%	177,790.17	168,900.67	22,682.28	191,582.95
Brays Tidal	B8	93%	16,033.17	14,910.85	1,891.55	16,802.39
Kuhlman Gully	B10	82%	9,813.92	8,047.42	687.77	8,735.18
Sims Above Tidal-Headwaters	S1	81%	52,033.00	42,146.73	19,134.04	61,280.77
Sims Above Tidal-Middle	S2, S3	77%	45,675.24	35,169.93	9,470.26	44,640.20
Sims Tidal	S4	56%	13,650.33	7,644.18	111.68	7,755.87
Berry Bayou	S5	95%	31,209.15	29,648.69	3,110.07	32,758.76

---

[15]Current source load is generated by summing the source loads for the subwatersheds within the attainment area.

[16] The incremental load represents the difference between the 2040 load and the 2022 load. See the next footnote for explanation of its use in generating 2040 source reduction load target.

[17] The 2040 reduction target is generated by through the equation $C_r+(F_l-C_l)$; where C_r= current source reduction load, F_l = future total source load, and C_l = current total source load. In essence, the incremental load generated between 2022 and 2040 is added to whatever existing reduction load exists in 2022. This approach is used because LDCs cannot estimate future reduction percentages, and because it is assumed the waterway will not have additional assimilative capacity in 2040.

Table 23. Load reduction targets by source, Brays Above Tidal-Headwaters

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.3%	495.60
WWTFs	0.0%	22.54
Dogs	79.7%	142,034.75
Cattle	0.0%	6.31
Horses	0.0%	0.06
Sheep and Goats	0.0%	0.08
Deer	0.0%	10.95
Other Wildlife	20.0%	35,644.93
Feral Hogs	0.0%	9.53
Total	**100.0%**	**178,224.75**

Table 24. Load reduction targets by source, Brays Above Tidal-Middle

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.2%	437.76
WWTFs	0.1%	145.45
Dogs	79.7%	152,691.05
Cattle	0.0%	1.98
Horses	0.0%	0.01
Sheep and Goats	0.0%	0.57
Deer	0.0%	10.61
Other Wildlife	20.0%	38,233.38
Feral Hogs	0.0%	62.14
Total	**100.0%**	**191,582.95**

Table 25. Load reduction targets by source, Brays Tidal

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.0%	0.00
WWTFs	0.0%	0.00
Dogs	80.0%	13,441.09
Cattle	0.0%	0.00
Horses	0.0%	0.00
Sheep and Goats	0.0%	0.00
Deer	0.0%	0.82
Other Wildlife	20.0%	3,360.48
Feral Hogs	0.0%	0.00
Total	**100.0%**	**16,802.39**

Table 26. Load reduction targets by source, Kuhlman Gully

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.0%	0.00
WWTFs	0.0%	0.00
Dogs	80.0%	6,987.36
Cattle	0.0%	0.00
Horses	0.0%	0.00
Sheep and Goats	0.0%	0.00
Deer	0.0%	0.79
Other Wildlife	20.0%	1,747.04
Feral Hogs	0.0%	0.00
Total	**100.0%**	**8,735.18**

Table 27. Load reduction targets by source, Sims Above Tidal-Headwaters

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.4%	228.36
WWTFs	0.0%	17.88
Dogs	79.2%	48,523.02
Cattle	0.2%	114.13
Horses	0.0%	1.01
Sheep and Goats	0.1%	33.62
Deer	0.0%	11.52
Other Wildlife	20.0%	12,256.15
Feral Hogs	0.2%	95.06
Total	**100.0%**	**61,280.77**

Table 28. Load reduction targets by source, Sims Above Tidal-Middle

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.1%	45.02
WWTFs	0.2%	74.58
Dogs	79.5%	35,489.87
Cattle	0.1%	58.10
Horses	0.0%	0.51
Sheep and Goats	0.0%	17.12
Deer	0.0%	7.17
Other Wildlife	20.0%	8,928.04
Feral Hogs	0.0%	19.79
Total	**100.0%**	**44,640.20**

Table 29. Load reduction targets by source, Sims Tidal

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.0%	0.00
WWTFs	0.3%	20.92
Dogs	79.7%	6,182.81
Cattle	0.0%	0.00
Horses	0.0%	0.00
Sheep and Goats	0.0%	0.00
Deer	0.0%	0.70
Other Wildlife	20.0%	1,551.17
Feral Hogs	0.0%	0.26
Total	**100.0%**	**7,755.87**

Table 30. Load reduction targets by source, Berry Bayou

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.0%	0.00
WWTFs	0.0%	16.05
Dogs	79.8%	26,157.60
Cattle	0.0%	12.30
Horses	0.0%	0.10
Sheep and Goats	0.0%	3.42
Deer	0.0%	4.61
Other Wildlife	20.0%	6,551.75
Feral Hogs	0.0%	12.94
Total	**100.0%**	**32,758.76**

6.4 Implications of Findings

Models characterizing fecal bacteria loads and sources in the Brays and Sims Bayou watershed reinforce the concept of a watershed beset by a diverse range of pressures impacting water quality. Future projections indicate worsening trends in bacteria load without intervention.

Action must be taken to reduce fecal bacteria loading and improve overall water quality in Brays and Sims Bayou and their tributaries to ensure the waterways are safe for recreation, aquatic life, and myriad other uses. Without executing appropriate management strategies, current water quality issues will be compounded by future loads, leading to degrading water quality in the coming years.

Models generated for this report are intended to provide the best available information to stakeholders hoping to take such action in the watershed. As with all models, a certain level of uncertainty is acknowledged. However, by combining quality assured methods with stakeholder feedback, project staff will work to minimize uncertainty wherever possible. Further refinement of results may be needed in the future considering changing conditions. By assessing current and predicted trends in water quality presented in this report and understanding the impacts of sources influencing fecal bacteria loads, stakeholders can form effective plans specific to their watershed to make positive changes in water quality that will benefit their communities today and in the future.