Watersheds Upstream of Lake Houston: Bacteria in Waters Used for Contact Recreation

- **Fifteen TMDLs Adopted April 6, 2011**
  Approved by EPA June 29, 2011

- **Six TMDLs Added by Addendum October 2013**
  Approved by EPA February 14, 2014

- **Two TMDLs Added by Addendum October 2019**
  Approved by EPA March 11, 2020 (scroll to view or print this addendum)

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

Addendum Two to
Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston

Two Total Maximum Daily Loads for Indicator Bacteria in Brushy Creek and Spring Branch

For Segments 1008J and 1010C

Assessment Units 1008J_01 and 1010C_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston* (TCEQ, 2011) on April 6, 2011. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency (EPA) on June 29, 2011. Additionally, an addendum to the original TMDL was submitted to EPA through the October 2013 Water Quality Management Plan (WQMP) update (TCEQ, 2013). That addendum added six additional assessment units (AUs) in four segments (1008B, 1008C, 1008E, and 1011). This document represents a second addendum to the original TMDL document.

This addendum includes information specific to two additional AUs of two segments located within the watershed of the approved TMDL project for bacteria in segments upstream of Lake Houston. Concentrations of indicator bacteria in these additional AUs exceed the geometric mean criterion used to evaluate attainment of the water quality standard for contact recreation. This addendum presents the new information associated with the additional AUs. For background or other explanatory information, please refer to the Technical Support Document for *Two Total Maximum Daily Loads for Indicator Bacteria for Brushy Creek and Spring Branch* (Adams and Millican, 2019). Refer to the original, approved TMDL document for details related to the overall project watershed as well as the methods and assumptions used in developing the original TMDLs.

The watersheds for Segments 1008J and 1010C_01 were included in the original TMDL project area. This addendum provides the details related to developing the TMDL allocations for these additional AUs, which were not specifically addressed in the original TMDL document.

Problem Definition

The TCEQ first identified the bacteria impairments for Brushy Creek and Spring Branch in the 2016 *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (2016 Integrated Report; TCEQ, 2018). Table 1 provides a synopsis of the EPA-approved 2016 Integrated Report. The impaired AUs are 1008J_01 and 1010C_01, as shown in Figure 1. The impaired segments are each composed of only one AU that encompasses the entire segment. The Brushy Creek watershed is located within portions of Grimes, Waller, and Montgomery counties, while the Spring Branch watershed is located entirely within Montgomery County. Figure 1 also shows the Brushy Creek and Spring Branch watersheds in relation to the entire watershed of the original TMDLs, which also includes the watersheds from the first addendum.

Table 1. Synopsis of the 2016 Integrated Report for Brushy Creek and Spring Branch.

Integrated Report Year	Segment	AU	Parameter	Contact Recreation Use Level of Support	Category
2016	1008J	1008J_01	*E. coli*	Nonsupport	5c
2016	1010C	1010C_01	*E. coli*	Nonsupport	5c

The Texas Surface Water Quality Standards (TSWQS; TCEQ, 2010) identify uses for surface waters and numeric and narrative criteria to evaluate attainment of those uses. The basis for the water quality target for the TMDL developed in this report is the numeric criterion for indicator bacteria from the 2010 TSWQS. *Escherichia coli* (*E. coli*) is the indicator bacteria for assessing primary contact recreation use in freshwater.

Table 2 summarizes the ambient water quality data for the TCEQ surface water quality monitoring (SWQM) stations on Brushy Creek and Spring Branch, as reported in the 2016 Integrated Report. The data from the assessment indicate nonsupport of the primary contact recreation use for both segments, because the geometric mean concentrations for *E. coli* exceed the geometric mean criterion of 126 colony forming units (cfu)/100 milliliters (mL) of water. Surface water quality monitoring within the Brushy Creek watershed and Spring Branch watershed has occurred at TCEQ SWQM stations 20463 and 20451 respectively (Figure 2).

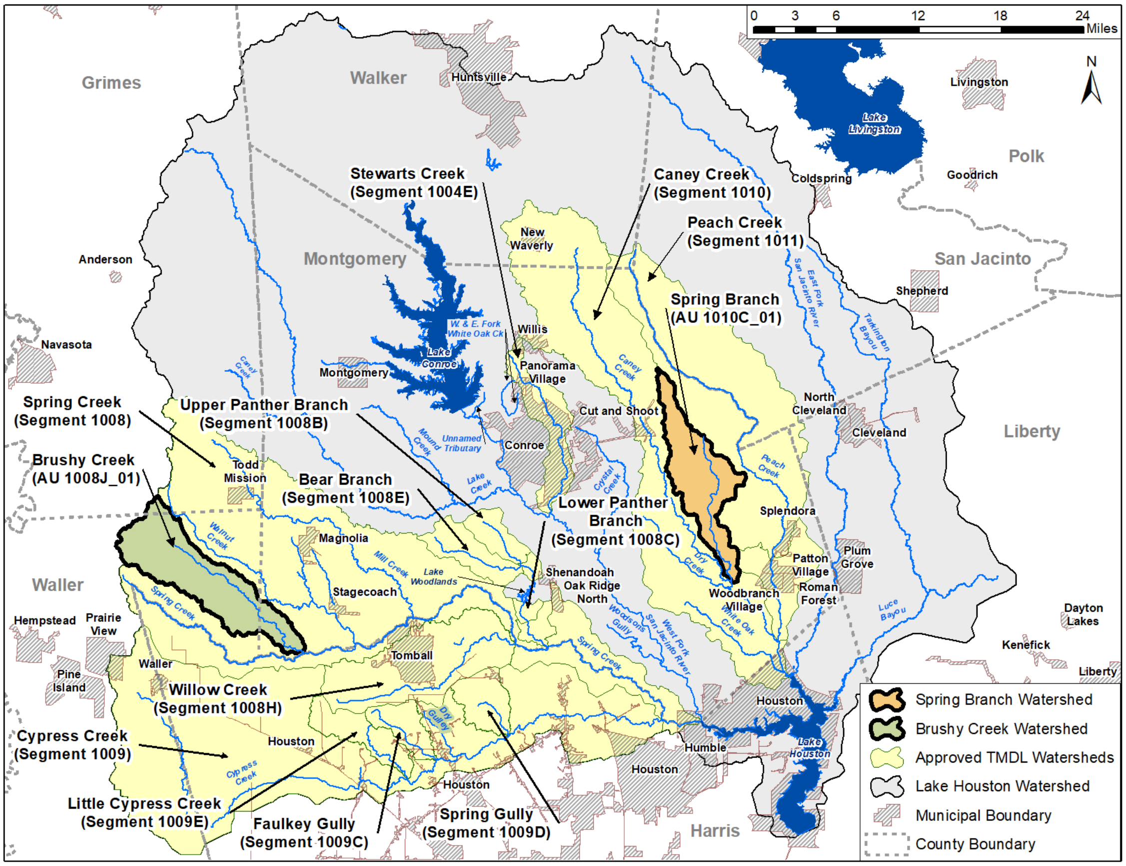

Figure 1. Approved fifteen TMDL watersheds, six addendum watersheds, and the Brushy Creek and Spring Branch watersheds.

Table 2. 2016 Integrated Report summary for the Brushy Creek and Spring Branch watersheds.

Integrated Report Year	AU	Station	Parameter	Number of Samples	Date Range	*E. coli* Geometric Mean (cfu/100 mL)
2016	1008J_01	20463	*E. coli*	22	2007-2014	221
2016	1010C_01	20451	*E. coli*	20	2007-2014	384

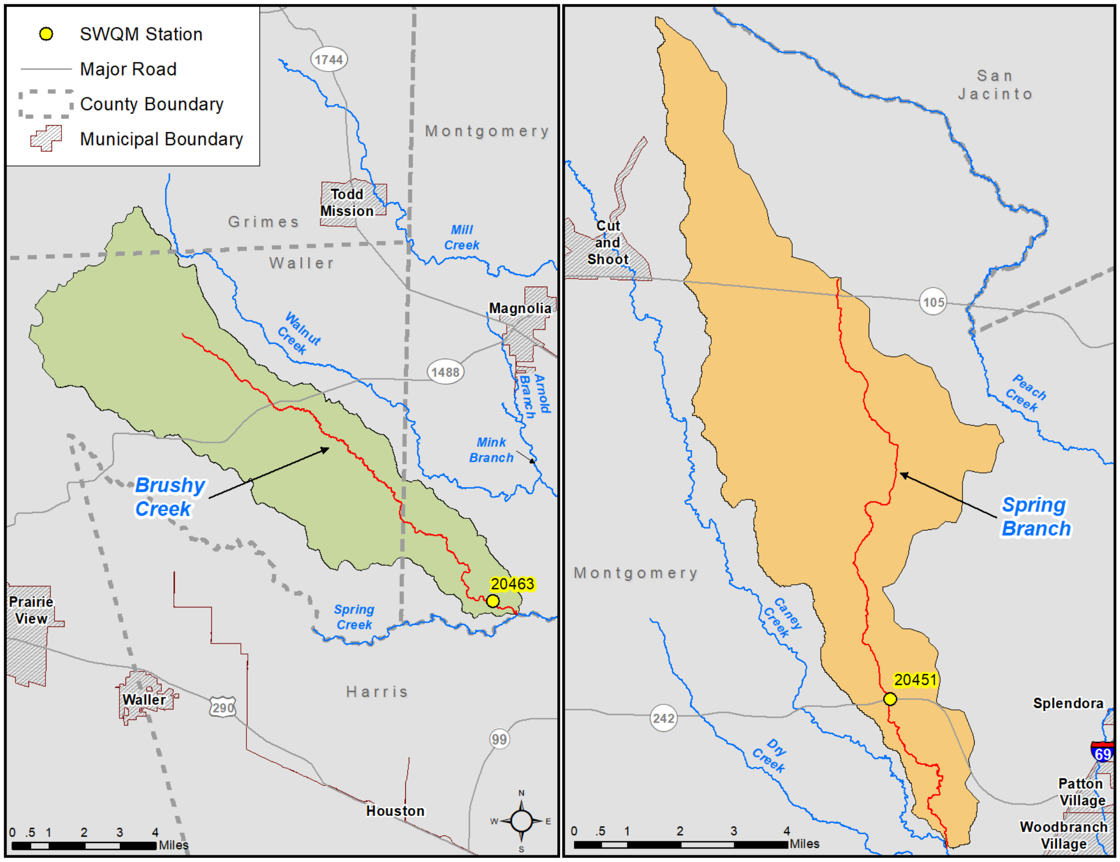

Figure 2. Brushy Creek and Spring Branch watersheds showing TCEQ SWQM stations.

Description of the Study Area

Brushy Creek (Segment 1008J) is a tributary to Spring Creek (Segment 1008) and is approximately 16.3 miles in length, with portions in both Waller and Montgomery counties. The Brushy Creek watershed drains an area of approximately 31,508 acres. Spring Branch (Segment 1010C) is a tributary to Caney Creek (Segment 1010) and is approximately 14 miles in length, entirely within Montgomery County. The Spring Branch watershed drains an area of approximately 22,969 acres. Both segments are perennial, unclassified, freshwater streams.

The 2016 Integrated Report (TCEQ, 2018) provides the following segment and AU descriptions:

- Brushy Creek (AU 1008J_01): From the Spring Creek confluence upstream to a point 5.6 km (3.5 mi) upstream of FM 1488.
- Spring Branch (AU 1010C_01): From the Caney Creek confluence to a point 0.54 km (0.34 mi) upstream of SH 105.

Watershed Climate

The Brushy Creek and Spring Branch watersheds are within the Upper Coast and East Texas climatic divisions categorized as subtropical humid (Larkin and Bomar, 1983). The Gulf of Mexico is the principal source of moisture that drives precipitation in the region. For the 15-year period from 2004-2018 weather data were obtained from the National Climatic Data Center for the Conroe North Houston Regional Airport (NOAA, 2019). Data from this 15-year period indicates that the average high temperatures typically peak in August (94.7 ˚F). During winter, the average low temperature generally reaches a minimum of 38.8 ˚F in January (Figure 3). Annual rainfall averages 50.5 inches. The wettest month was May (5.2 inches) while September (2.9 inches) was the driest month, with rainfall occurring throughout the year.

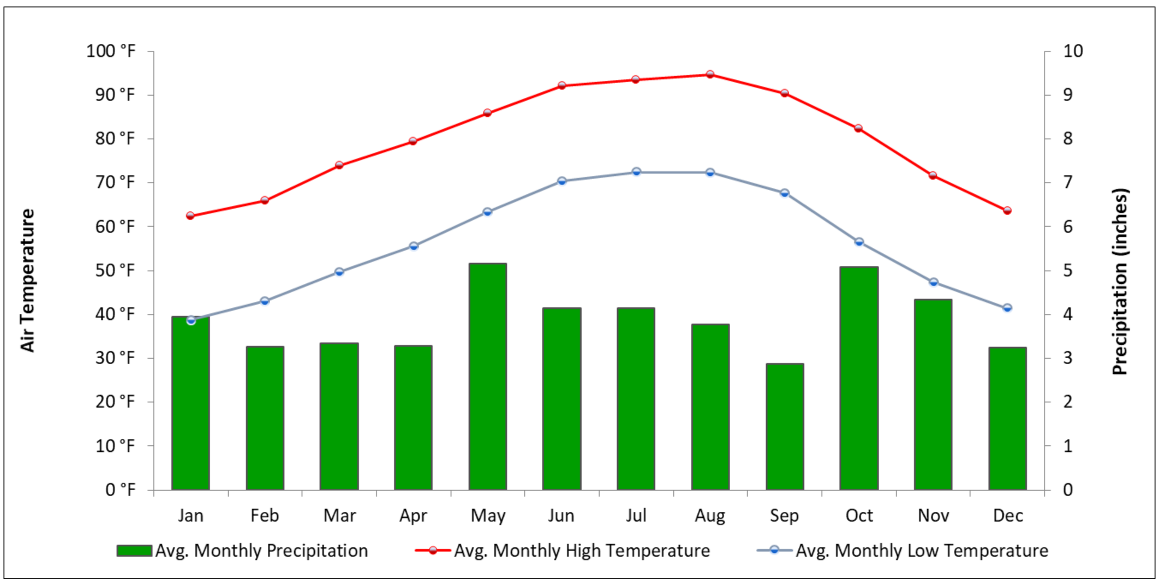

Figure 3. Average minimum and maximum air temperature and total precipitation by month from January 2004 through December 2018 for Conroe North Houston Regional Airport weather station.

Land Use

The land use/land cover data for the project watersheds were obtained from the National Oceanic and Atmospheric Administration Coastal Change Analysis Program (via the Houston-Galveston Area Council (H-GAC)) and indicated to be for the year 2011 (NOAA, 2011). The land use/land cover data for the Brushy Creek and Spring Branch watersheds is shown in Figure 4. A summary of the land use/land cover data is provided in Table 3 and indicates that for the Brushy Creek watershed, forest (40.4 percent) and pasture/hay (34.0 percent) are the dominant land covers comprising approximately 74.4 percent of the total land cover. Forest (39.9 percent) and scrub/shrub (28.1 percent) are the dominant land covers of the Spring Branch watershed comprising approximately 68 percent of the total land cover.

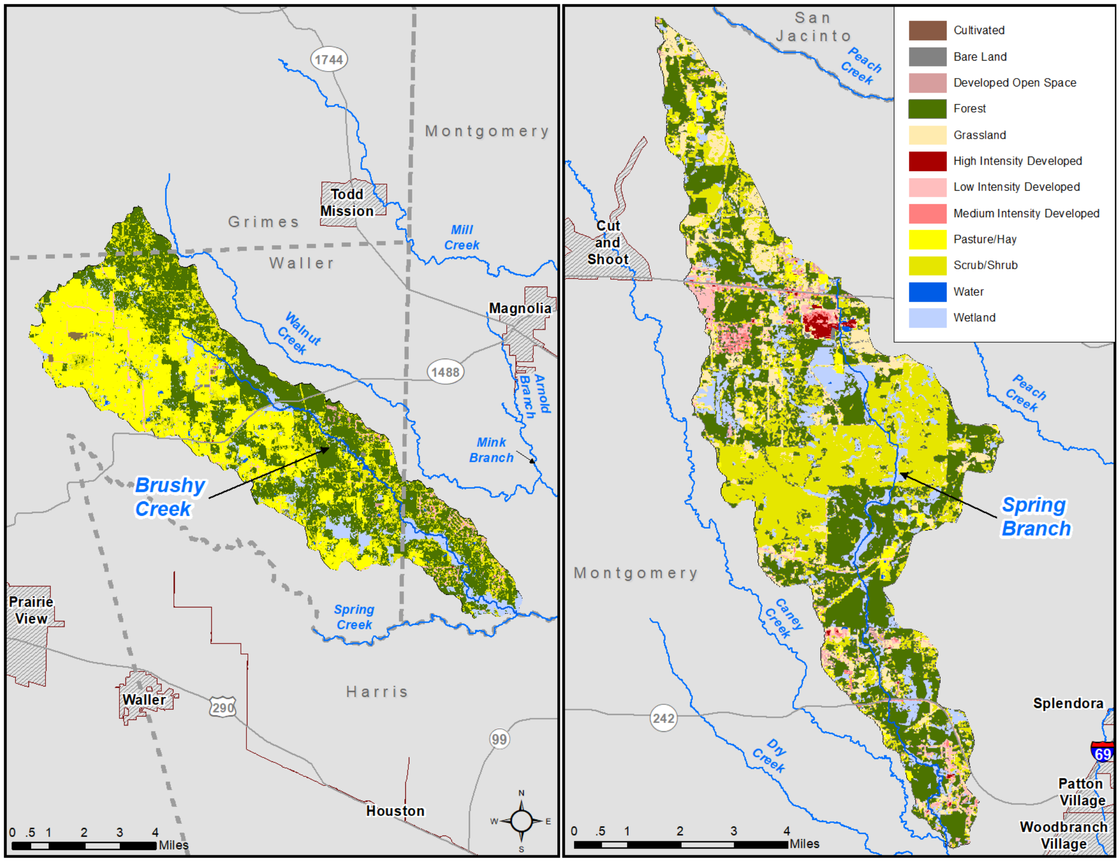

Figure 4. Land use/land cover showing categories within the Brushy Creek and Spring Branch watersheds.

Watershed Population and Population Projections

As depicted in Figure 2, the Brushy Creek watershed is geographically located within portions of Grimes, Montgomery, and Waller counties and outside of any municipal boundaries. The rural nature of the watershed is evident in that the predominant current population density found throughout the watershed is zero to two people per acre. According to the United States Census Bureau (USCB) 2010 Census (USCB, 2019), the Brushy Creek watershed has an estimated population of 6,755 people.

Spring Branch is located entirely within Montgomery County and outside of any municipal boundaries. Indicative of a mostly rural watershed, current predominant population density for this watershed is zero to two people per acre. The 2010 Census data (USCB, 2019) indicates there are an estimated 6,531 people in the Spring Branch watershed.

Table 3. Land use/land cover within the Brushy Creek and Spring Branch watersheds.

Classification	Brushy Creek (1008J)		Spring Branch (1010C)	
	Area (Acres)	% of Total	Area (Acres)	% of Total[a]
Cultivated	82.9	0.3%	NA	NA
Bare Land	86.4	0.3%	56.3	0.2%
Developed Open Space	94.5	0.3%	142.7	0.6%
Forest	12,744.2	40.4%	9,168.5	39.9%
Grassland	NA[b]	NA	2,821.4	12.3%
High Intensity Developed	6.6	0.0%	153.0	0.7%
Low Intensity Developed	772.3	2.5%	858.6	3.7%
Medium Intensity Developed	27.6	0.1%	224.1	1.0%
Pasture/Hay	10,725.2	34.0%	534.0	2.3%
Scrub/Shrub	4,337.5	13.8%	6,463.5	28.1%
Water	104.9	0.3%	25.6	0.1%
Wetland	2,525.5	8.0%	2,521.3	11.0%
Total	**31,507.6**	**100%**	**22,969.0**	**99.9%**

[a] Due to rounding the column does not add to exactly 100.0%
[b] NA is Not Applicable

Population projections from 2010 through 2040 were developed by utilizing data from the 2010 U.S. Census and H-GAC 2040 regional growth forecast (H-GAC, 2019). The 2010 and projected 2040 populations were allocated based on the proportion of the area within each of the TMDL watersheds. According to the growth projections, a population increase of 202.6 percent is expected in the Brushy Creek watershed and 83.1 percent in the Spring Branch watershed by 2040. Table 4 provides a summary of the 2010 populations and 2040 population projections for the Brushy Creek and Spring Branch watersheds.

Table 4. 2010 Population and 2040 population projection for the Brushy Creek and Spring Branch watersheds.

Water Body	Segment	2010 U.S. Census Population	2040 Projected Population	Projected Population Increase	Percent Change (2010−2040)
Brushy Creek	1008J	6,755	20,441	13,686	202.6%
Spring Branch	1010C	6,531	11,958	5,427	83.1%

Endpoint Identification

The endpoint for the TMDL is to maintain the concentration of *E. coli* below the geometric mean criterion of 126 cfu/100mL identified in the 2010 TSWQS.

Source Analysis

Regulated Sources

Permitted sources are regulated under the Texas Pollutant Discharge Elimination System (TPDES) program.

Domestic and Industrial Wastewater Treatment Facilities

As of June 30, 2019, there was one domestic WWTF with a TPDES permit within the Brushy Creek watershed (Table 5 and Figure 5). There is one domestic WWTF with a TPDES permit located within the Spring Branch watershed, and another pending TPDES permit application (Oakmont Reserve WWTF). An additional facility—C & R Water Supply Inc. (WQ0014285001)—is located within the Spring Branch watershed but discharges effluent outside of the watershed into Caney Creek. This facility is excluded from the Spring Branch TMDL development and is not illustrated in Figure 5.

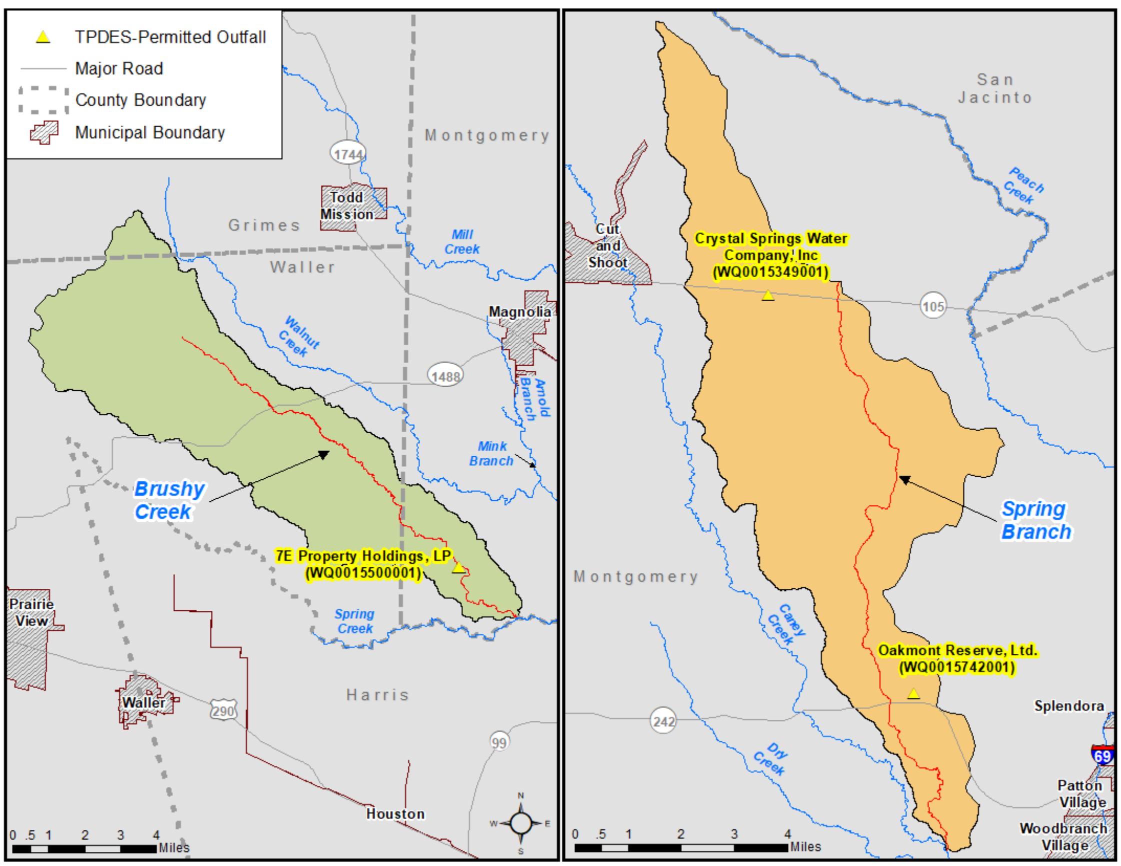

Figure 5. Brushy Creek and Spring Branch watersheds showing WWTFs.

Table 5. Permitted domestic WWTFs in the Brushy Creek and Spring Branch watersheds.

Water-shed	Permittee	Facility	TPDES No.	NPDES[a] No.	Daily Average Flow - Permitted Discharge (MGD)	Daily Average Flow - Recent Discharge (MGD)
Brushy Creek	7E Property Holdings, LP	Mike Emmons Development WWTF	WQ0015500001	TX0137251	0.0095	0.0045[b]
Spring Branch	Crystal Springs Water Company, Inc.	Ponderosa Pines WWTF	WQ0015349001	TX0136263	0.075	-------[c]
Spring Branch	Oakmont Reserve, Ltd	Oakmont Reserve WWTF	WQ0015742001[d]	TX0138860	0.495	-------[c]

[a] National Pollutant Discharge Elimination System (NPDES)
[b] Reflects daily average flow discharges available from March 1, 2019 through May 31, 2019.
[c] No available records as of August 31, 2019.
[d] Pending permit application as of May 31, 2019.

Sanitary Sewer Overflows

A summary of sanitary sewer overflow (SSO) incidents that occurred during a three-year period from 2016 through 2018 in the project counties (Grimes, Montgomery, and Waller) was obtained from the TCEQ Central Office in Austin. The summary data indicated no SSO incidents were reported for any locations within the Brushy Creek or Spring Branch watersheds.

TPDES-Regulated Stormwater

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

1) stormwater subject to regulation, which is any stormwater originating from TPDES regulated municipal separate storm sewer system (MS4) entities, industrial facilities, and construction activities; and
2) stormwater runoff not subject to regulation.

The TPDES MS4 Phase I and II rules require municipalities and certain other entities in urban areas to obtain permit coverage for their stormwater systems. A regulated MS4 is a publicly owned system of conveyances that includes ditches, curbs, gutters, and storm sewers that do not connect to a wastewater collection system or treatment facility. Phase I permits are individual permits for large and medium-sized communities with populations of 100,000 or more based on the 1990 U.S. Census, whereas the Phase II general permit regulates smaller communities within a USCB-defined urbanized area. The purpose of an

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

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

Phase I MS4 individual permits have similar MCMs organized differently and are further required to perform water quality monitoring.

The geographic region of the TMDL watershed covered by Phase I and II MS4 permits is that portion of the area within the jurisdictional boundaries of the regulated entities. For Phase I permits the jurisdictional area is defined by the city limits and for Phase II permits the jurisdictional area is defined as the intersection or overlapping areas of the city limits and the 2000 or 2010 USCB urbanized area.

There is currently one Phase I MS4 permit within the urbanized area of the Brushy Creek watershed (Table 6). A review of active MS4 general permit coverage (TCEQ, 2019) in the Brushy Creek watershed as of January 24, 2019, found one active Phase II MS4 permit (Table 6 and Figure 6). The same review revealed that there are currently no Phase I or Phase II MS4s in the Spring Branch watershed.

Table 6. TPDES MS4 permits associated with the Brushy Creek watershed.

Watershed	Entity	TPDES Permit	NPDES Permit
Brushy Creek	Texas Department of Transportation	WQ0005011000	TXS002101
Brushy Creek	Montgomery County	Phase II General Permit (TXR040000)	TXR040348

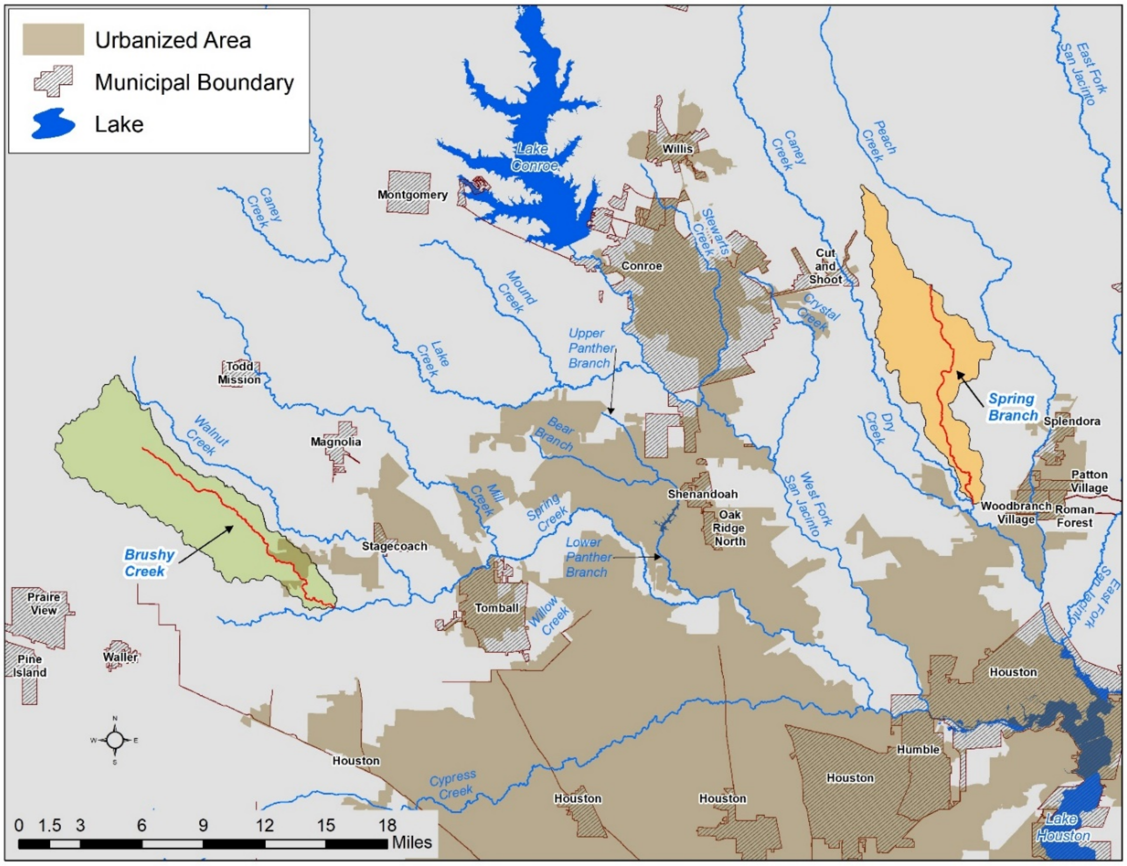

Figure 6. Regulated stormwater area based on Phase I and Phase II MS4 permits within the Brushy Creek and Spring Branch watersheds.

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

- TXR050000 – stormwater multi-sector general permit (MSGP) for industrial facilities
- TXR150000 – stormwater from construction activities disturbing more than one acre

A review of active stormwater general permit coverage (TCEQ, 2019) in the Brushy Creek watershed as of January 24, 2019, found no active MSGPs or construction permits within the Brushy Creek watershed. The same review revealed two industrial MSGP facilities located in the Spring Branch watershed and five construction permits.

TPDES Water Quality General Permits

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

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production facilities
- TXG340000 – petroleum bulk stations and terminals
- TXG500000 – quarries in John Graves Scenic Riverway
- TXG670000 – hydrostatic test water
- TXG830000 – petroleum fuel or petroleum substances
- TXG870000 – pesticides
- TXG920000 – concentrated animal feeding operations
- TXG100000 – wastewater evaporation
- WQG20000 – livestock manure compost operations (irrigation only)

A review of active general permit coverage (TCEQ, 2019) in the Brushy Creek and Spring Branch watersheds as of January 24, 2019, found no operations or facilities of the types described above.

Unregulated Sources

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

Wildlife and Unmanaged Animal Contributions

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

Quantitative estimates of wildlife are inexact and often limited to discrete taxa groups or geographical areas of interest so that even county-wide approximations of wildlife numbers are difficult or impossible to acquire. Bird diversity is high in the counties where the TMDL watersheds are located (eBird, 2019), but population sizes for individual species are not known. However, population estimates for feral hogs and deer are readily available for the TMDL watersheds, although the *E. coli* contribution from them could not be determined based on existing information.

For feral hogs, the Institute of Renewable Natural Resources (IRNR, 2013) estimated a range of feral hog densities within Texas (1.33 to 2.45 hogs/square mile). The average hog density (1.89 hogs/square mile) was multiplied by the hog-habitat area in the Brushy Creek (47.5 square miles) and Spring Branch (33.6

square miles) watersheds. Habitat deemed suitable for hogs followed as closely as possible to the land use selections of the IRNR study and include from the H-GAC 2015 land use: forest, cultivated crops, wetlands, pasture/hay, scrub/shrub, and grasslands. Using this methodology, there are an estimated 90 feral hogs in the Brushy Creek watershed and 64 feral hogs in the Spring Branch watershed.

For deer, the Texas Parks and Wildlife Department (TPWD) published data showing deer population-density estimates by Deer Management Unit (DMU) and Ecoregion in the state (TPWD, 2017). The Brushy Creek watershed is located entirely within the Urban Houston DMU for which there is no deer density data. Spring Branch falls mainly within the Urban Houston DMU with partial coverage (19 percent) by DMU 14. Due to the close proximity of the Brushy Creek watershed to DMU 14 and partial coverage of Spring Branch by DMU 14, density data from this DMU was used to estimate deer populations for both watersheds. For the 2016 TPWD survey year, the estimated deer population density for DMU 14 was 21.4 deer/1000 acres. Applying this value to the entire area of both watersheds returns an estimated 674 deer within the Brushy Creek watershed and 492 deer within the Spring Branch watershed.

Domesticated Animals

Livestock are a potential source of bacteria in the project watershed. The number of livestock within the TMDL watersheds was estimated from county-level data obtained from the 2017 Census of Agriculture (USDA NASS, 2019). The county-level data were refined to better reflect actual numbers within the Brushy Creek and Spring Branch watersheds. The refinement was performed by dividing the total area of each watershed by the total area of each of the counties within the watershed area. This ratio was then applied to the county-level livestock data (Table 7). The livestock numbers in Table 7 are provided to demonstrate that livestock are a potential source of bacteria in the TMDL watersheds. These livestock numbers are not used to develop an allocation of allowable bacteria loading to livestock.

Table 7. Estimated distributed domesticated animal populations within the Brushy Creek and Spring Branch watersheds, based on proportional area.

Watershed	Cattle and Calves	Hogs and Pigs	Sheep and Lambs	Goats	Horses and Ponies	Mules, Burros, and Donkeys	Poultry	Deer (captive)
Brushy Creek	3,985	34	147	22	428	58	688	130
Spring Branch	599	50	36	75	113	22	415	16

Fecal bacteria from dogs and cats are transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 8 summarizes the estimated number of dogs and cats within the project watersheds. Pet population estimates were calculated as the estimated number of dogs (0.584) and cats (0.638) per household according to data from the American Veterinary Medical Association 2012 U.S Pet Statistics (AVMA, 2015). The number of households in the watershed was estimated using 2010 USCB data (USCB, 2018). The actual contribution and significance of bacteria loads from pets in either watershed is unknown.

Table 8. Estimated households and pet populations for the Brushy Creek and Spring Branch watersheds.

Watershed	Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
Brushy Creek	2,392	1,397	1,526
Spring Branch	2,007	1,172	1,280

On-site Sewage Facilities

Estimates of the number of OSSFs in the Brushy Creek and Spring Branch watersheds were determined using H-GAC supplied data for Grimes, Montgomery, and Waller counties. The H-GAC data indicate that there are 1,240 OSSFs located within the Brushy Creek watershed and 662 OSSFs in the Spring Branch watershed. (Figure 7).

Linkage Analysis

The load duration curve (LDC) method was used to examine the relationship between instream water quality and the source of indicator bacteria loads. Inherent to the use of LDCs as the mechanism of linkage analysis is the assumption of a one-to-one relationship between instream loadings and loadings originating from point sources and the landscape as regulated and non-regulated sources. Further, this one-to-one relationship was also inherently assumed when using LDCs to define the TMDL pollutant load allocations. The LDC method allows for estimation of TMDL loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). In addition to estimating stream loads, this method allows for the determination of the hydrologic conditions under which impairments are typically occurring, can give indications of the broad origins of the bacteria (i.e., point source and stormwater), and provides a means to allocate allowable loadings. The technical support document (Adams and Millican, 2019) provides details about the linkage analysis and the LDC method and its application.

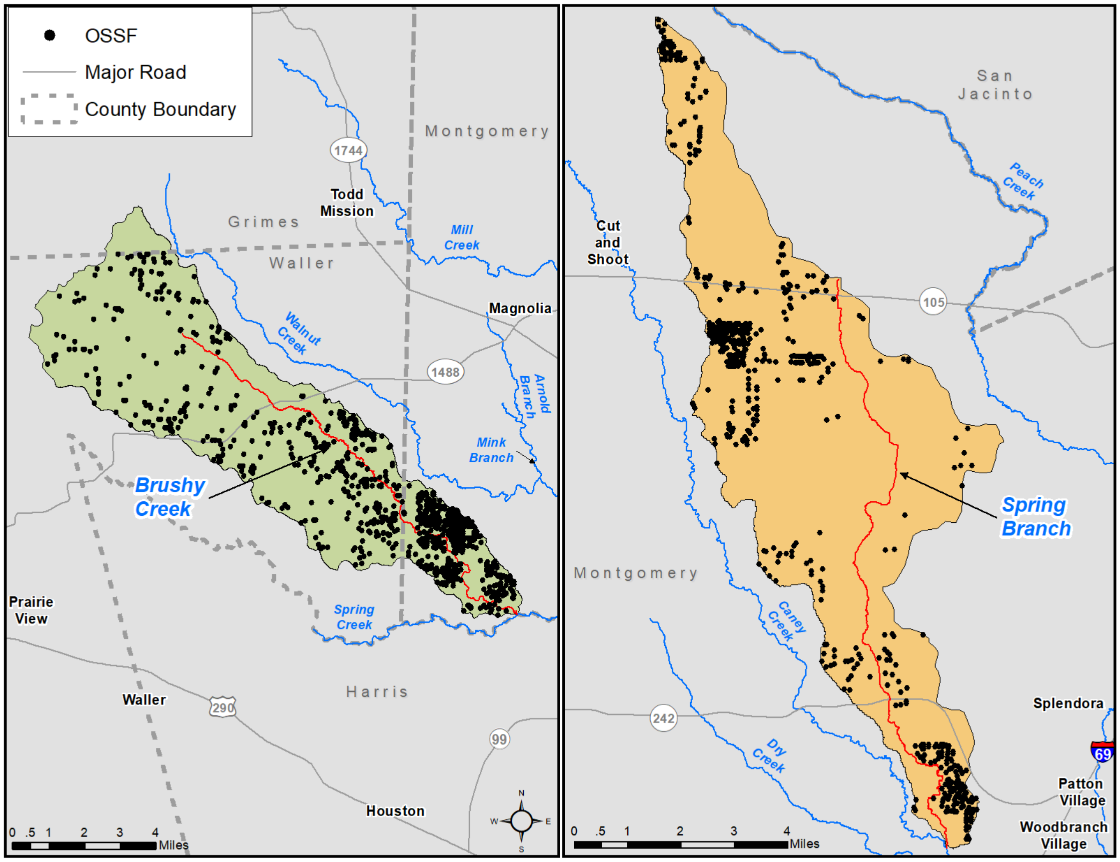

Figure 7. OSSFs located within the Brushy Creek and Spring Branch watersheds.

Margin of Safety

The margin of safety (MOS) is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning an MOS. The TMDL incorporates an explicit MOS of five percent of the total TMDL allocation.

Pollutant Load Allocation

The TMDLs for Brushy Creek and Spring Branch were derived using the median flow within the wet conditions flow regime (or 15 percent flow) of the LDCs developed for SWQM stations 20463 (Brushy Creek) and 20451 (Spring Branch). These stations are the only locations within Brushy Creek and Spring Branch where an adequate number of *E. coli* samples have been collected. (Figures 8 and 9).

The flow regime geomeans for the *E. coli* event data plotted on the LDC for station 20463 (Brushy Creek) in Figure 8 show a subtle pattern of increasing tendency to plot near the geometric mean criterion allowable loading curve as flows decrease, which is indicated in a left to right direction along the graph. This pattern is more noticeable for station 20451 (Spring Branch) as revealed in Figure 9. The allowable load at the single sample criterion (399 cfu/100 mL) is included on the LDCs for comparison with individual *E. coli* samples, although it is not used for assessment or allocation purposes.

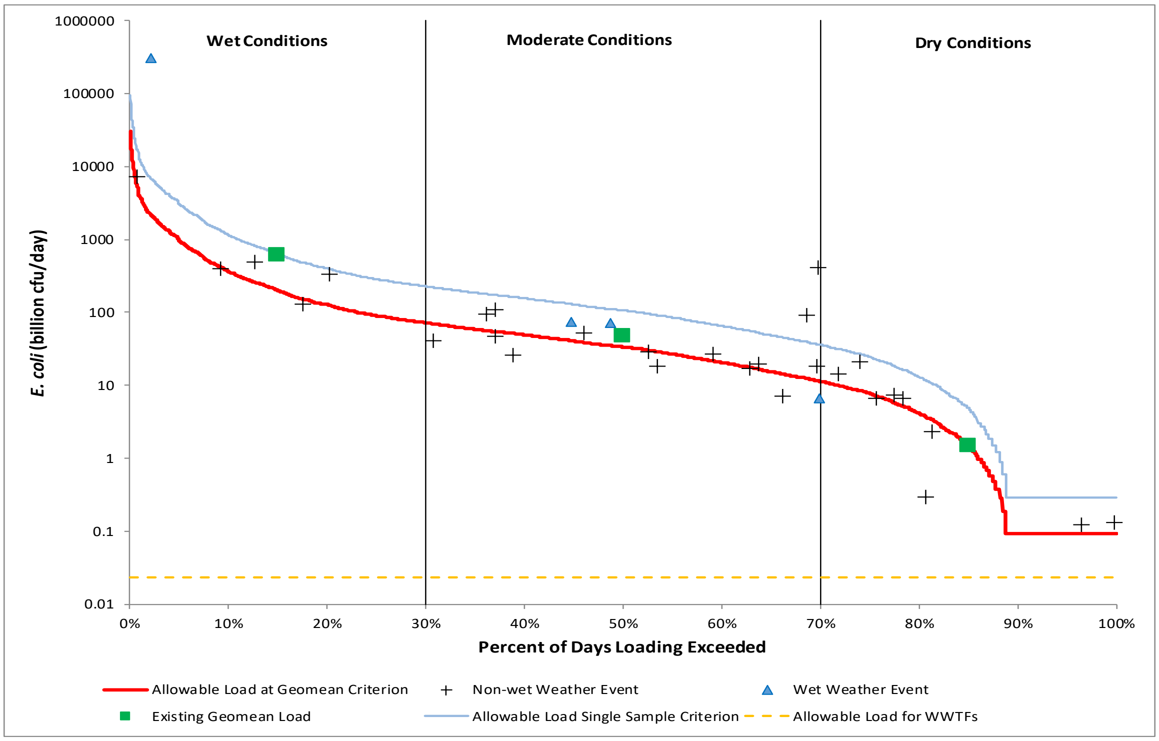

Figure 8. LDC for Brushy Creek AU 1008J_01 (Station 20463).

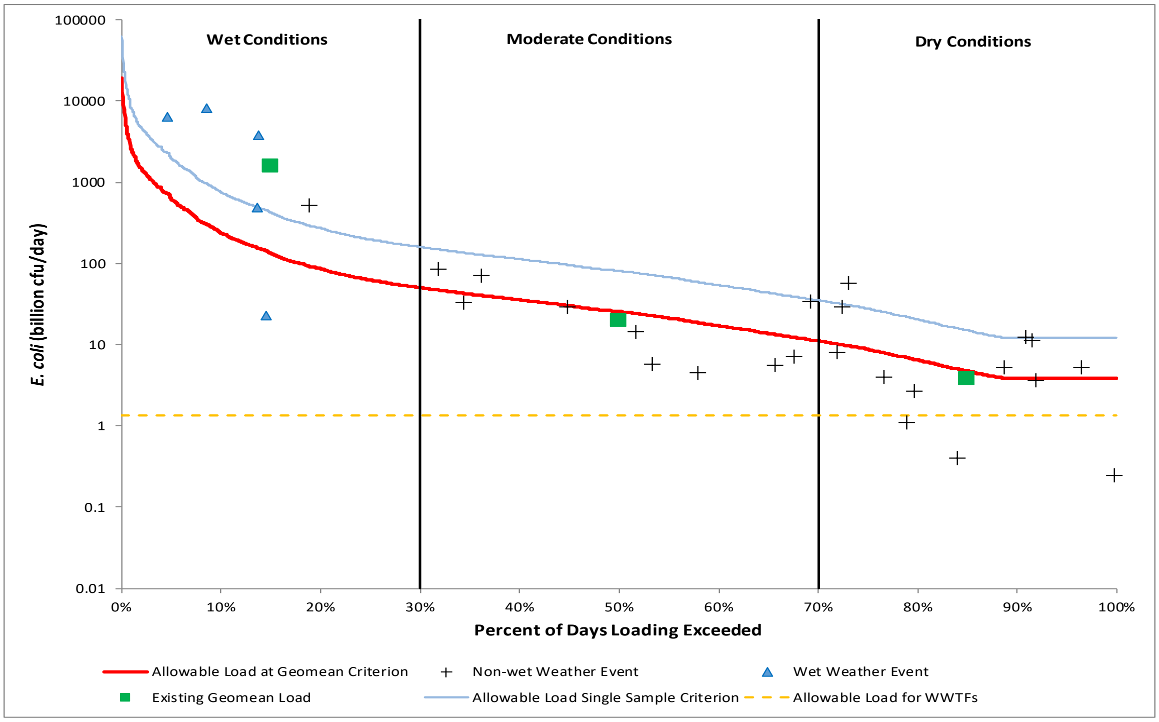

Figure 9. LDC for Spring Branch AU 1010C_01 (Station 20451).

Wasteload Allocation

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

Wastewater Treatment Facilities

TPDES-permitted WWTFs are allocated a daily wasteload (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by one-half the instream geometric mean criterion. One-half of the water quality criterion (63 cfu/100mL *E. coli*) is used as the WWTF target to provide instream and downstream load capacity and to be consistent with previously completed TMDLs. Table 9 presents the WLA for each WWTF in the project watersheds.

Table 9. Wasteload allocations (in billion cfu/day *E. coli*) for TPDES-permitted facilities in the Brushy Creek and Spring Branch watersheds.

Watershed (AU)	TPDES Permit No.	NPDES Permit No.	Permittee	Full Permitted Flow (MGD)[a]	*E. coli* WLA_{WWTF}
Brushy Creek (1008J_01)	WQ0015500001	TX0137251	7E Property Holdings, LP	0.0095	0.023
Spring Branch (1010C_01)	WQ0015349001	TX0136263	Crystal Springs Water Company, Inc.	0.075	0.179
Spring Branch (1010C_01)	WQ0015742001[b]	TX0138860	Oakmont Reserve, Ltd	0.495	1.180

[a] Full permitted flow from Table 5.
[b] Pending permit as of May 31, 2019.

Regulated Stormwater

Stormwater discharges from MS4, industrial, and construction sites are also considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). The percentage of the land area included in the project watershed that is under the jurisdiction of stormwater permits is used to estimate the amount of the overall runoff load that should be allocated as the permitted stormwater contribution in the WLA_{SW} component of the TMDL.

A portion of the Brushy Creek watershed lies within the jurisdiction of one MS4 Phase II permit. The area associated with the 2010 Houston urbanized area located within the Brushy Creek watershed provides a surrogate for stormwater coverage for Brushy Creek. Two multi-sector general permits and five construction permits exist within the Spring Branch watershed. The acreage associated with the two industrial storm water permits was estimated by importing the location information associated with the facility into a Geographic Information System, and measuring the estimated disturbed area based on the most recently available aerial imagery. Additionally, the disturbed areas associated with each of the five construction permits within the Spring Branch watershed were summed. Stormwater coverage for Spring Branch is provided by the combined areas of the industrial and construction stormwater permits. The percentage of land under the jurisdiction of stormwater permits in the Brushy Creek watershed is 4.23 percent, and in the Spring Branch watershed it is 3.74 percent.

Load Allocation

The load allocation (LA) component of the TMDL corresponds to runoff from unregulated sources. It is calculated by subtracting the sum of the WLA_{WWTF}, WLA_{SW}, MOS, and future growth (FG) allocations from the total TMDL allocation.

Future Growth

The FG component of the TMDL equation addresses the requirement of TMDLs to account for future loadings that might occur as a result of population growth, changes in community infrastructure, and development. The assimilative capacity of streams increases as the amount of flow increases. Increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the primary contact recreation standard (126 cfu/100 mL).

The future growth component of the TMDL watersheds was based on population projections and current permitted wastewater dischargers for the entire TMDL watersheds. Recent population and projected population growth between 2010 and 2040 for the TMDL watersheds are provided in Table 4. The projected population percentage increase within the watershed was multiplied by the corresponding WLA_{WWTF} to calculate future WLA_{WWTF}. The permitted flows were increased by the expected population growth per AU between 2010 and 2040 to determine the estimated future flows.

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

TMDL Calculations

Table 10 summarizes the TMDL calculations for the Brushy Creek and Spring Branch watersheds. The TMDLs were calculated based on the median flow in the 0-30 percentile range (15 percent exceedance, wet conditions flow regime) for flow exceedances from the LDCs developed for the monitoring stations 20463 (Brushy Creek) and 20451 (Spring Branch). Allocations are based on the current geometric mean criterion for *E. coli* of 126 cfu/100 mL for each component of the TMDL (with the exception of the WLA_{WWTF} and FG terms, which used one-half the criterion).

Table 10. TMDL allocation summary for Brushy Creek and Spring Branch.

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	FG	MOS
Brushy Creek	1008J_01	200.615	0.023	8.059	182.457	0.045	10.031
Spring Branch	1010C_01	134.408	1.359	4.682	120.517	1.130	6.720

All loads expressed as billion cfu/day *E. coli*

The final TMDL allocations (Table 11) needed to comply with the requirements of 40 Code of Federal Regulations (CFR) Section 103.7 include the FG component within the WLA_{WWTF}.

Table 11. Final TMDL allocations for Brushy Creek and Spring Branch.

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
Brushy Creek	1008J_01	200.615	0.068	8.059	182.457	10.031
Spring Branch	1010C_01	134.408	2.489	4.682	120.517	6.720

All loads expressed as billion cfu/day *E. coli*

Seasonal Variation

Federal regulations in 40 CFR Section 130.7(c)(1) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* concentrations obtained from ten years (2009 through 2018) of routine monitoring collected in the warmer months (April through September) against those collected during the cooler months (October through

March). Differences in *E. coli* concentrations obtained in warmer versus cooler months were then evaluated by performing a t-test on the natural log transformed dataset. This analysis of *E. coli* data indicated that there was no significant difference (α=0.05) in indicator bacteria between cool and warm weather seasons for either Brushy Creek AU 1008J_01 (α=0.1674) or Spring Branch AU 1010C_01 (α=0.3029). Seasonal variation was also addressed by using all available flow and bacteria records (covering all seasons) from the period of record used in LDC development for this project.

Public Participation

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

The technical support document for this TMDL addendum (Adams and Millican, 2019) was posted on the TCEQ website on August 22, 2019. A presentation on this addendum was given at the annual spring meeting of the Bacteria Implementation Group (BIG) in Houston on June 4, 2019. The public will have an opportunity to comment on this addendum during the official WQMP update public comment period (November 8 through December 12, 2019). This is an ongoing process, so notice of the public comment period for this addendum will be sent to the stakeholders and posted on the TCEQ's TMDL Program News webpage, and the document will be posted on the WQMP Updates webpage. TCEQ accepted public comments on the original TMDL from November 19 through December 20, 2010. Two comments were submitted, and neither of them referred directly to the AUs in this TMDL addendum.

Implementation and Reasonable Assurance

The segments covered by this addendum are within the existing bacteria TMDL watersheds upstream of Lake Houston. Those TMDL watersheds including Brushy Creek and Spring Branch are within the area covered by the Implementation Plan developed by the BIG for bacteria TMDLs throughout the greater Houston area, which was approved by the commission on January 30, 2013. It outlines an adaptive management approach in which measures are periodically assessed for efficiency and effectiveness. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals, and expresses stakeholder commitment to the process. Please refer to the original TMDL document for additional information regarding implementation and reasonable assurance.

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