December 13, 2019
FINAL

October 2019 Update to the Texas Water Quality Management Plan

TCEQ

October 2019 Update to the Texas Water Quality Management Plan

Prepared by the
Office of Water
Water Quality Division

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WQMP updates are also available on the TCEQ web site at:

< *http://www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html* >

Developed in accordance with Sections 205(j), 208,
and 303 of the Federal Clean Water Act
and applicable regulations thereto.

Jon Niermann, *Chairman*
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Texas Commission on Environmental Quality

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Introduction

The Texas Water Quality Management Plan (WQMP) is the product of a wastewater treatment facility planning process developed and updated in accordance with provisions of Sections 205(j), 208, and 303 of the federal Clean Water Act (CWA), as amended. The WQMP is an important part of the State's program for accomplishing its clean water goals.[1]

The Texas Department of Water Resources, a predecessor agency of the Texas Commission on Environmental Quality (TCEQ), prepared the initial WQMP for waste treatment management during the late 1970s. The Clean Water Act mandates that the WQMP be updated as needed to fill information gaps and revise earlier certified and approved plans. Any updates to the plan need involve only the elements of the plan that require modification. The original plan and its subsequent updates are collectively referred to as the State of Texas Water Quality Management Plan.

The WQMP is tied to the State's water quality assessments that identify priority water quality problems. The WQMPs are used to direct planning for implementation measures that control and/or prevent water quality problems. Several elements may be contained in the WQMP, such as effluent limitations of wastewater facilities, total maximum daily loads (TMDLs), nonpoint source management controls, identification of designated management agencies, and ground water and source water protection planning. Some of these elements may be contained in separate documents, which are prepared independently of the current WQMP update process but may be referenced as needed to address planning for water quality control measures.

This document, as with previous updates[2], will become part of the WQMP after completion of its public participation process, certification by the TCEQ and approval by the United States Environmental Protection Agency (EPA).

The materials presented in this document revise only the information specifically addressed in the following sections. Previously certified and approved water quality management plans remain in effect.

The October 2019 WQMP update addresses the following topics:

1. Projected Effluent Limits Updates for water quality planning purposes
2. Service Area Population for Municipal Wastewater Facilities
3. Designation of Management Agencies for Municipal Wastewater Facilities
4. Total Maximum Daily Load Update

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[1] A formal definition for a water quality management plan is found in 40 Code of Federal Regulations (CFR) 130.2(k).

[2] Fiscal Years 1974, 1975, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984/85, 1986/88, 1989, 1990, 1991, 1992, 1993/94, 1995, 1996, 1997/98, 02/1999, 05/1999, 07/1999, 10/1999, 01/2000, 04/2000, 07/2000, 10/2000, 01/2001, 04/2001, 07/2001, 10/2001, 01/2002, 04/2002, 07/2002, 10/2002, 01/2003, 04/2003, 07/2003, 10/2003, 01/2004, 04/2004, 07/2004, 10/2004, 01/2005, 04/2005, 07/2005, 10/2005, 01/2006, 04/2006, 07/2006, 10/2006, 01/2007, 04/2007, 07/2007, 10/2007, 01/2008, 04/2008, 07/2008, 10/2008, 01/2009, 04/2009, 07/2009, 10/2009, 01/2010, 04/2010, 07/2010,10/2010, 01/2011, 04/2011, 07/2011, 10/2011, BPUB 2011, 01/2012, 04/2012, 07/2012,10/2012, 01/2013, 04/2013, 07/2013,10/2013, 01/2014, 04/2014, 07/2014, 10/2014, 01/2015, 04/2015, 07/2015, 10/2015, 01/2016, 04/2016, 07/2016, 10/2016, 01/2017, 04/2017, 07/2017, 10/2017, 01/2018, 04/2018, 07/2018, 10/2018, 01/2019, Terra Verde 2019, 04/2019, and 07/2019.

The public comment period for the October WQMP update was from November 8, 2019 through December 12, 2019.

The Projected Effluent Limit Update section provides information compiled from August 1, 2019 through October 31, 2019, and is based on water quality standards, and may be used for water quality planning purposes in Texas Pollutant Discharge Elimination System (TPDES) permit actions.

The Service Area Population and Designation of Management Agency sections for municipal wastewater facilities has been developed and evaluated by the TCEQ in cooperation with the Texas Water Development Board (TWDB) and regional water quality management planning agencies.

The Total Maximum Daily Load (TMDL) Update section provides information on proposed wasteload allocations for new dischargers and revisions to existing TMDLs and has been developed by the Water Quality Planning Division, TMDL Program.

Projected Effluent Limit Updates

Table 1 reflects proposed effluent limits for new dischargers and preliminary revisions to original proposed effluent limits for preexisting dischargers (MGD-Million Gallons per Day, $CBOD_5$ – 5 Day Carbonaceous Biochemical Oxygen Demand, NH_3-N – Ammonia-Nitrogen, BOD_5 – 5 Day Biochemical Oxygen Demand and DO – Dissolved Oxygen).

Effluent flows indicated in Table 1 reflect future needs and do not reflect current permits for these facilities. These revisions may be useful for water quality management planning purposes. The effluent flows and constituent limits indicated in the table have been preliminarily determined to be appropriate to satisfy the stream standards for dissolved oxygen in their respective receiving waters. These flow volumes and effluent sets may be modified at the time of permit action. These limits are based on water quality standards (WQS) effective at the time of the TCEQ production of this update. WQS are subject to revision on a triennial basis.

Table 1. Projected Effluent Limit Updates

State Permit Number	Segment Number	EPA ID Number	Permittee Name County	Flow (MGD)	$CBOD_5$ (mg/L)	$CBOD_5$ (lbs/day)	NH_3-N (mg/L)	NH_3-N (lbs/day)	BOD_5 (mg/L)	BOD_5 (lbs/day)	DO (mg/L)	Months/ Comments
10277-003	1804	TX0103535	City of Seguin Guadalupe	5.54					20	924.07	2	
13633-001	2202	TX0057622	City of Alamo Hidalgo	2.50	10	208.50	3	62.55			4	
15306-001	1211	TX0135844	South Central Water Co. Burleson	0.30	10	25.02	2	5.00			4	
15483-001	1009	TX0137162	290 Kickapoo Development Inc. Harris	0.045	10	3.75	3	1.13			6	
15664-002	1213	TX0139289	ML DEV., L.P. & Tsakiris, Louis Bell	0.25	10	20.85	3	6.26			4	
15742-001	1010	TX0138860	Oakmont Reserve Ltd. Montgomery	0.495	7	28.90	2	8.26			4	
15766-001	1434	TX0139033	Legacy Housing Corp. Bastrop	0.288	5	12.01	2	4.80			4	
15776-001	1202	TX0139149	Waller County MUD No. 19 Waller	0.366	5	15.26	1.8	5.49			6	
15784-001	1808	TX0139238	HK Real Estate Dev., L.L.C. Hays	0.45	7	26.27	2	7.51			4	
15787-001	1908	TX0139246	Kendall West Utility, L.L.C. Kendall	0.500	5	20.85	1.9	7.92			6	

State Permit Number	Segment Number	EPA ID Number	Permittee Name County	Flow (MGD)	$CBOD_5$ (mg/L)	$CBOD_5$ (lbs/day)	NH_3-N (mg/L)	NH_3-N (lbs/day)	BOD_5 (mg/L)	BOD_5 (lbs/day)	DO (mg/L)	Months/ Comments
15798-001	1202	TX0139319	The Signorelli Co. Fort Bend	0.90	10	75.06	3	22.52			6	
15802-001	1434	TX0139343	Great Escapes Opportunity Zone Fund, L.L.C. Travis	0.025	5	1.04	2	0.42			4	
15803-001	0826	TX0139351	Denton County MUD No. 10 Denton	0.12	10	10.01	2	2.00			4	
15804-001	1434	TX0139360	Integra Water Texas, L.L.C. & Dill, Sherry Love Bastrop	0.08	5	3.34	2	1.33			4	
15810-001	1428	TX0139432	Crossroads 10445, L.P. Travis	0.010	5	0.42	2	0.17			4	
15813-001	1258	TX0139475	Guefen Development Co. Fort Bend	0.043	10	3.59	3	1.08			4	
15817-001	1808	TX0139521	Regal, L.L.C. Guadalupe	0.08	10	6.67	2	1.33			5	

Planning Information Summary

The Water Quality Planning Division of the TCEQ coordinated with the TWDB and regional planning agencies to compile the wastewater facility information in this section. Domestic facility financing decisions under the State Revolving Loan Fund (SRF) program must be consistent with the certified and approved WQMP.

The purpose of this section is to present data reflecting facility-planning needs, including previous water quality management plan needs requiring revision. Data are also presented to update other plan information for the TWDB's SRF projects. Table 2 contains the updated Service area population information. The table is organized in alphabetical order and includes the following 10 categories of information:

1. *Planning Area* – Area for which facility needs are proposed. The facility planning areas are subject to change during the facility planning process and any such changes will be documented in a later water quality management plan update. All planning areas listed are also designated management agencies (DMAs) unless otherwise noted in the "Comments" column.

2. *Service Area* – Area that receives the provided wastewater service.

3. *Needs* – A "T" indicates a need for either initial construction of a wastewater treatment plant, additional treatment capacity, or the upgrading of a wastewater treatment plant to meet existing or more stringent effluent requirements. A "C" indicates a need for improvements to, expansion of, rehabilitation of, or the initial construction of a wastewater collection system in the facility planning area. "T/C" indicates a need for both treatment and collection system facilities. More detailed facility planning conducted during a construction project may define additional needs and those needs will be reflected in a future update to the WQMP. A "F" indicates a need for flood mitigation.

4. *Needs Year* – The year in which the needs were identified for the planning area.

5. *Basin Name* – The river basin or designated planning area where the entity is located. The seven water quality management planning areas designated by the Governor are Corpus Christi [Coastal Bend Council of Governments (CBCOG)], Killeen-Temple [Central Texas Council of Governments (CTCOG)], Texarkana [Ark-Tex Council of Governments (ATCOG)], Southeast Texas [South East Texas Regional Planning Council (SETRPC)], Lower Rio Grande Valley [Lower Rio Grande Valley Development Council (LRGVDC)], Dallas-Fort Worth [North Central Texas Council of Governments (NCTCOG)] and Houston [Houston-Galveston Area Council (H-GAC)]. Basin names are shown for agencies outside one of these areas.

6. *Segment* – The classified stream segment or tributary into which any recommended facility may discharge existing or projected wastewater. In the case of no-discharge facilities, this is the classified stream segment drainage area in which the facilities are located.

7. *County* – The county in which the facility planning area is located.

8. *Date* – The date the planning information was reviewed by the TCEQ.

9. *Comments* – Additional explanation or other information concerning the facility planning area.

10. *Population* – The base year and projected populations for each facility planning area. Population projections presented are consistent with the latest available statewide population projections or represent the most current information obtained from facility planning analyses.

The facility information in this section is intended to be utilized in the preparation of facility plans and the subsequent design and construction of wastewater facilities. Design capacities of the treatment and collection systems will be based upon the population projections contained in this document plus any additional needed capacity established for commercial/industrial flows and documented infiltration/inflow volumes (treatment or rehabilitation). The probable needs shown under the "Needs" heading are preliminary findings; specific needs for an area shall be as established in the completed and certified detailed engineering studies conducted during facility planning under the SRF and other state loan programs.

Specific effluent quality for any wastewater discharges resulting from any of the facilities recommended in this document will be in accordance with the rule on the Texas Surface Water Quality Standards in effect at the time of permit issuance for the specific facility.

Table 2. Service Area Population Updates

Planning Agency	Service Area	Needs	Needs Year	Basin Name / COG	Segment	County	WQMP Date	Comments	Year	Population
Beechwood Water Supply	District boundaries	T	2019	Sabine River Basin	0504	Sabine	11/1/2019	WWTF improvements	2018	300
									2020	300
									2030	300
									2040	300
City of Austin	City limits	T	2022	Colorado River Basin	1428	Travis	11/1/2019	WWTP pumping system improvements and rehabilitation	2019	1,048,374
									2020	1,069,932
									2030	1,283,692
									2040	1,513,383
City of Cleburne	City limits	T/C	2019	Brazos River Basin/NCTCOG	1227, 1228	Johnson	11/1/2019	WWTP improvements and upgrades ***Population projections were not provided with the application.**	2019	*
									2020	*
									2030	*
									2040	*
City of Port Arthur	City limits	T	2019	Neches-Trinity Coastal Basin	0703	Jefferson	11/1/2019	WWTP improvements	2019	45,000
									2020	45,311
									2025	47,623
									2030	50,052
City of Rockdale	City limits	T/C	2018	Brazos River Basin	1212	Milam	11/1/2019	WWTP imporvements and rehabilitation	2018	5,492
									2020	5,929
									2025	6,106
									2030	6,282

Designated Management Agencies

In order to be designated as a management agency for wastewater collection or treatment, an entity must demonstrate the legal, institutional, managerial and financial capability necessary to carry out the entity's responsibilities in accordance with Section 208 (c) of the Clean Water Act (see below list of requirements). Before an entity can apply for a state revolving fund loan, it must be recommended for designation as the management agency in the approved WQMP. Designation as a management agency does not require the designated entity to provide wastewater services, but enables it to apply for grants and loans to provide the services. The facilities listed in Table 3 have submitted Designated Management Agencies (DMA) resolutions to the TCEQ. The TCEQ submits this DMA information to the EPA for approval as an update to the WQMP.

Section 208 (c) (2) Requirements for Management Agency:

208(c)(2)(A): to carry out portions of an area-wide waste treatment plan.
208(c)(2)(B): to manage waste treatment works.
208(c)(2)(C): directly or by contract to design and construct new works.
208(c)(2)(D): to accept and utilize grants.
208(c)(2)(E): to raise revenues, including assessment of waste treatment charges.
208(c)(2)(F): to incur short and long term indebtedness.
208(c)(2)(G): to assure community pays proportionate cost.
208(c)(2)(H): to refuse to receive waste from non-compliant dischargers.
208(c)(2)(I): to accept for treatment industrial wastes.

Table 3. Designated Management Agencies

Planning Agency	Service Area	DMA Needs	DMA Date	DMA Area/Comments
City of Austin	City limits	T	5/31/2019	
City of Cleburne	City limits	T/C	4/26/2019	No population projections provided with CWSRF application.
City of Rockdale	City limits	T/C	4/3/2019	

Total Maximum Daily Load Updates

The Total Maximum Daily Load (TMDL) Program works to improve water quality in impaired or threatened waters bodies in Texas. The program is authorized by and created to fulfill the requirements of Section 303(d) of the federal Clean Water Act.

The goal of a TMDL is to restore the full use of a water body that has limited quality in relation to one or more of its uses. The TMDL defines an environmental target and based on that target, the State develops an implementation plan with wasteload allocations for point source dischargers to mitigate anthropogenic (human-caused) sources of pollution within the watershed and restore full use of the water body.

The development of TMDLs is a process of intensive data collection and analysis. After adoption by the TCEQ, TMDLs are submitted to the EPA for review and approval.

The attached appendices may reflect proposed wasteload allocations for new dischargers and revisions to TMDLs. To be consistent, updates will be provided in the same units of measure used in the original TMDL document. Also, note that for bacteria TMDLs, loads may be expressed in counts per day, organisms per day, colony-forming units per day, or similar expressions. These typically reflect different lab methods, but for the purposes of the TMDL program, these terms are considered synonymous.

Appendix I. Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston For Segment Numbers 1004E, 1008, 1008H, 1009, 1009C, 1009D, 1009E, 1010 and 1011

TMDL Updates to the Water Quality Management Plan (WQMP): Watersheds Upstream of Lake Houston (1004E, 1008, 1008H, 1009, 1009C, 1009D, 1009E, 1010, and 1011)

The document *Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston For Segment Numbers 1004E, 1008, 1008H, 1009, 1009C, 1009D, 1009E, 1010, and 1011* was adopted by the TCEQ on 04/06/11 and approved by EPA on 06/29/11, and became an update to the state's WQMP. Twenty-nine subsequent WQMP updates prior to this one have updated the list of individual wasteload allocations (WLAs) found in the original TMDL document. Additionally, an addendum to the original TMDL was submitted through the October 2013 WQMP update. This addendum added six new assessment units (AUs) to the original TMDL project.

The purpose of this update is to make the following changes to the TMDL, presented in Table 1:

- add one new permit, and
- update the WLA for one facility that has increased its permitted discharge.

The changes reflected in tHis update resulted in the shifting of allocations between the sum of the individual WLAs and the allowance for future growth in five AUs. This was originally presented in Table 18 in the original TMDL document, and the affected AUs are included here as Table 2.

In Table 19 of the original TMDL, the WLAs for permitted facilities are the sum of the individual WLAs and the allowance for future growth within each AU. Therefore, these overall numbers did not change, and Table 19 of the TMDL remains the same.

Table 1 – Changes to Individual Wasteload Allocations (Updates Table 16, pp. 49-56 in the TMDL document.)

State Permit Number	Outfall	EPA Permit Number	Segment Number	Permittee Name	Flow (MGD)	Waste Load Allocation (WLA) – *E. coli* in Billion MPN/day	TMDL Comments
15742-001	001	TX0138860	1010_04	OAKMONT RESERVE, LTD	0.495	1.180	New permit
15483-001	001	TX0137162	1009E_01	290 KICKAPOO DEVELOPMENT INC.	0.045	0.107	Increased discharge

Table 2 - *E. coli* TMDL Summary Calculations for Lake Houston Assessment Units (Updates Table 18, pp. 61 in the TMDL document.)

AU	Sampling Location	Stream Name	TMDL (Billion MPN /day)	WLA_{WWTF} (Billion MPN /day)	$WLA_{StormWater}$ (Billion MPN /day)	LA (Billion MPN /day)	MOS (Billion MPN /day)	Future Growth (Billion MPN /day)
1009_02	11331	Cypress Creek	615	102.98	196	270	30.8	15.22
1009_03	11328	Cypress Creek	1340	188.43	415	574	67.0	95.57
1009_04	11324	Cypress Creek	1550	227.75	469	648	77.4	127.85
1009E_01	14159	Little Cypress Creek	91.1	18.59	16.14	48.42	4.56	3.39
1010_04	11334	Caney Creek	493	18.56	57.4	383.8	24.7	8.54

Appendix II. Addendum Two to Fifteen Total Maximum Daily Loads for 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).

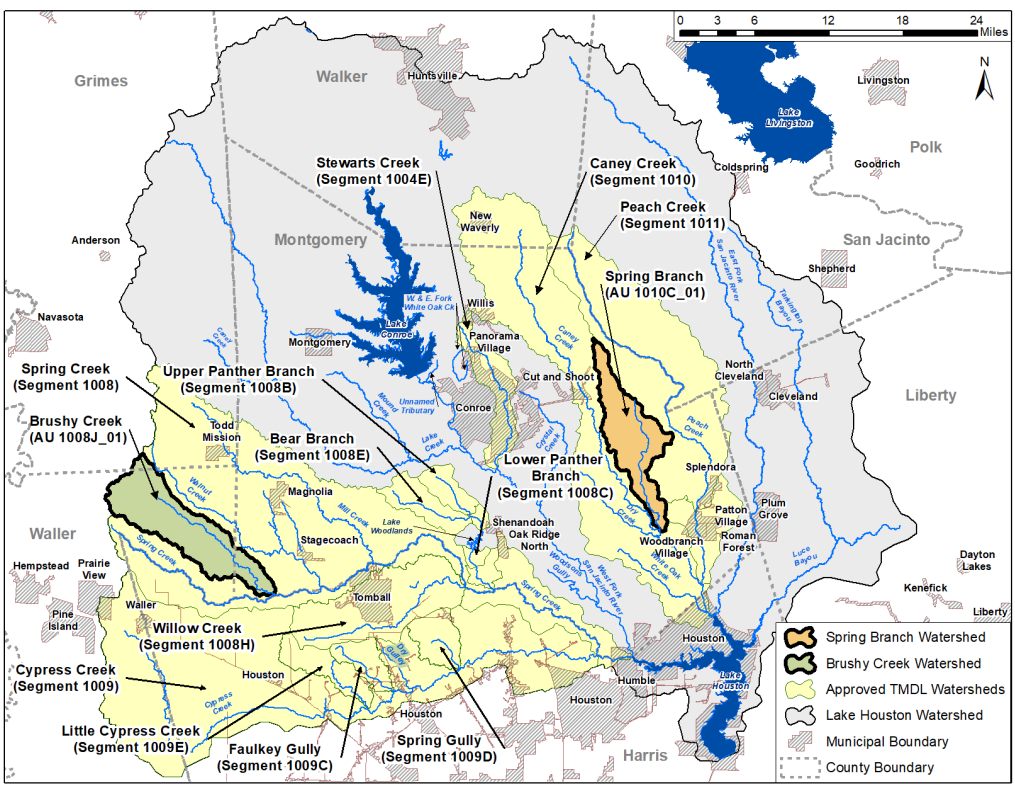

Figure 1. Approved fifteen TMDL watersheds, six addendum watersheds, and the Brushy Creek and Spring Branch watersheds.

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

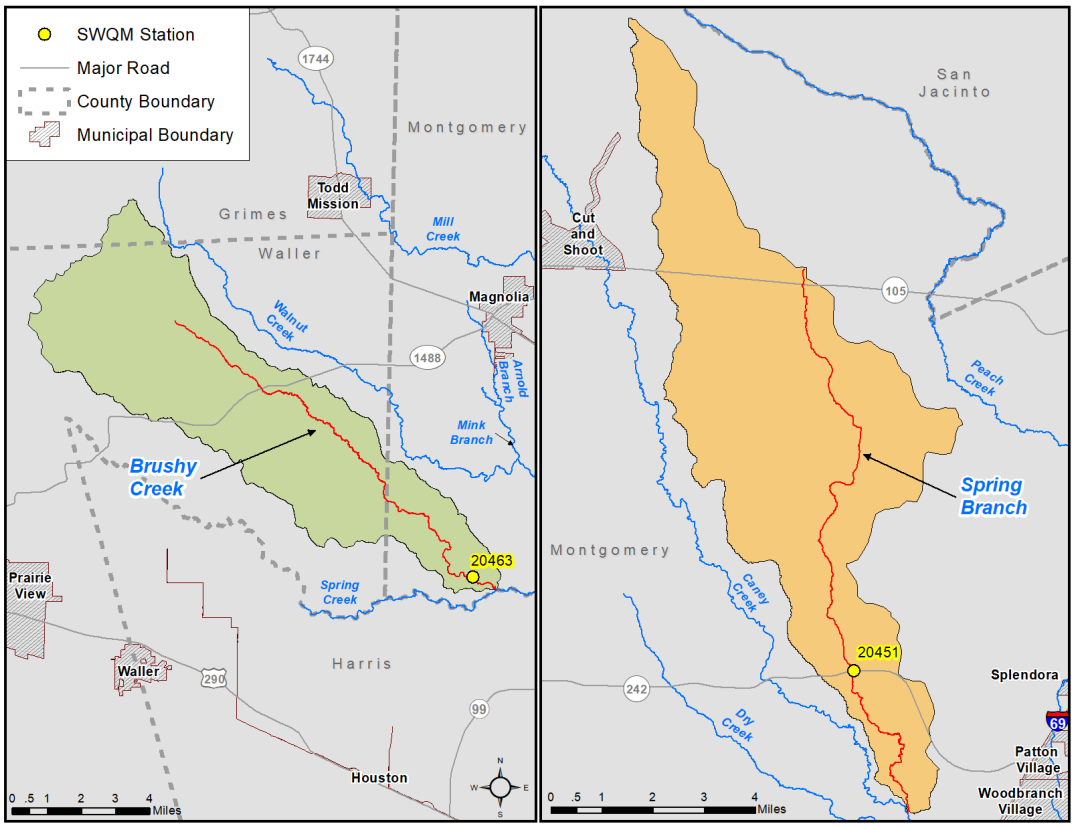

Figure 2. Brushy Creek and Spring Branch watersheds showing TCEQ SWQM stations.

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.

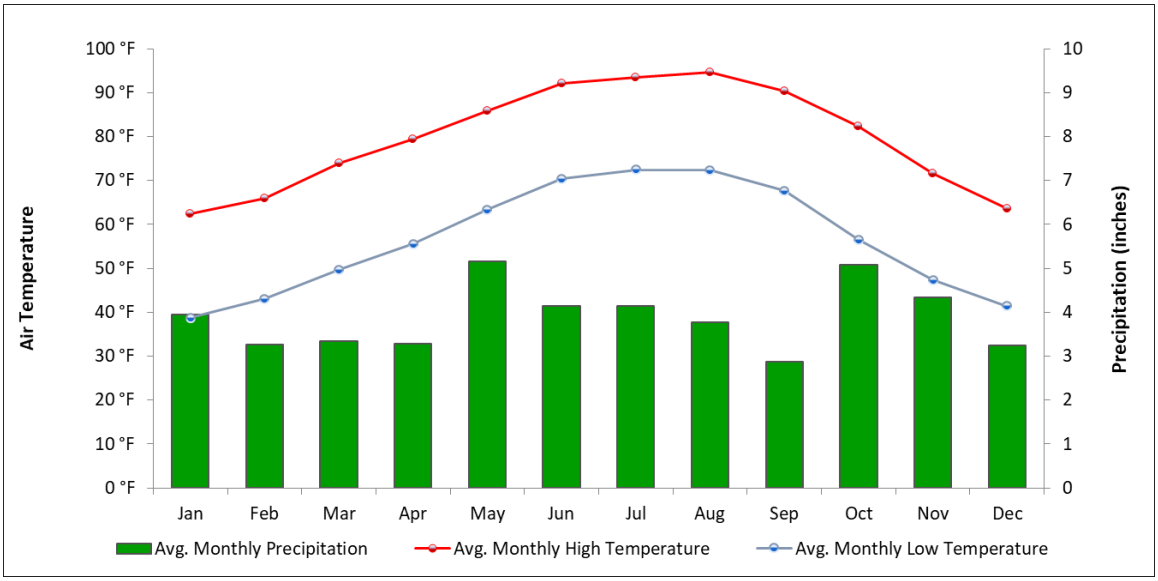

Figure 3. Average minimum and maximum air temperature and total precipitation by month from January 2004 through December 2018 for Conroe North Houston Regional Airport weather station.

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.

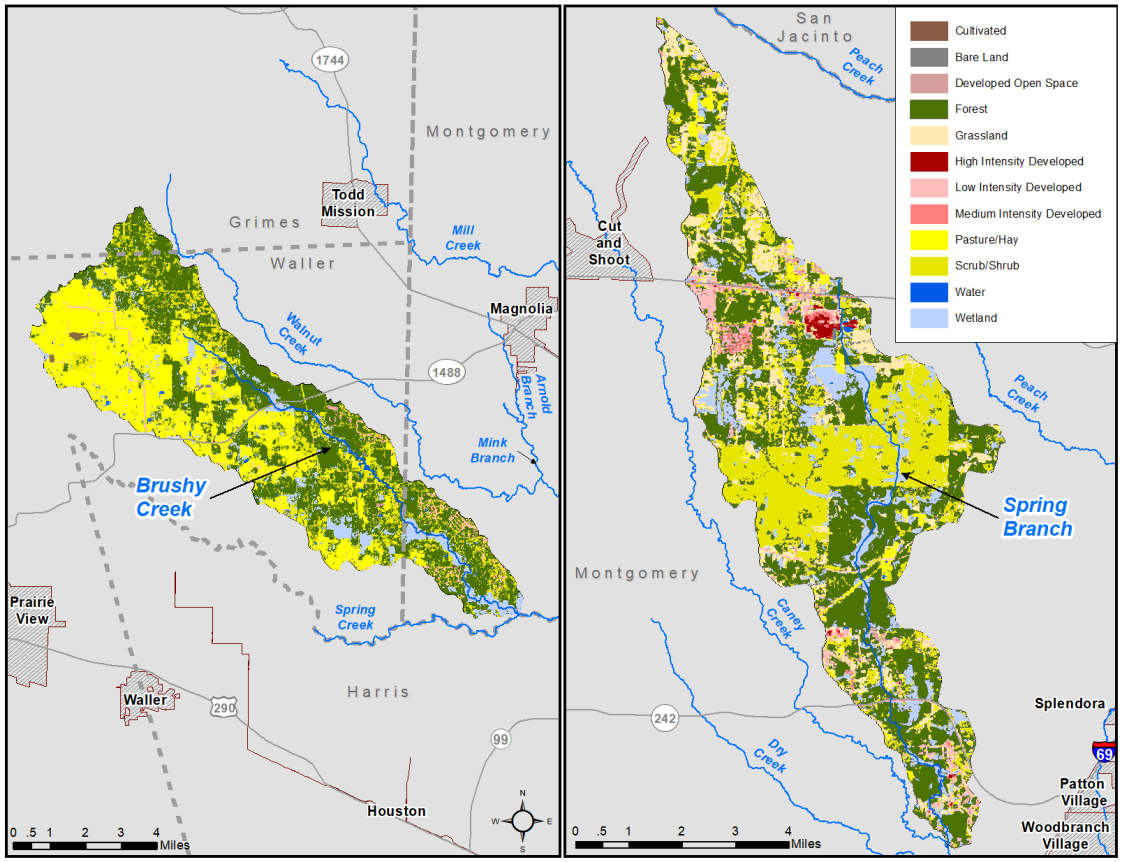

Figure 4. Land use/land cover showing categories within the Brushy Creek and Spring Branch watersheds.

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.

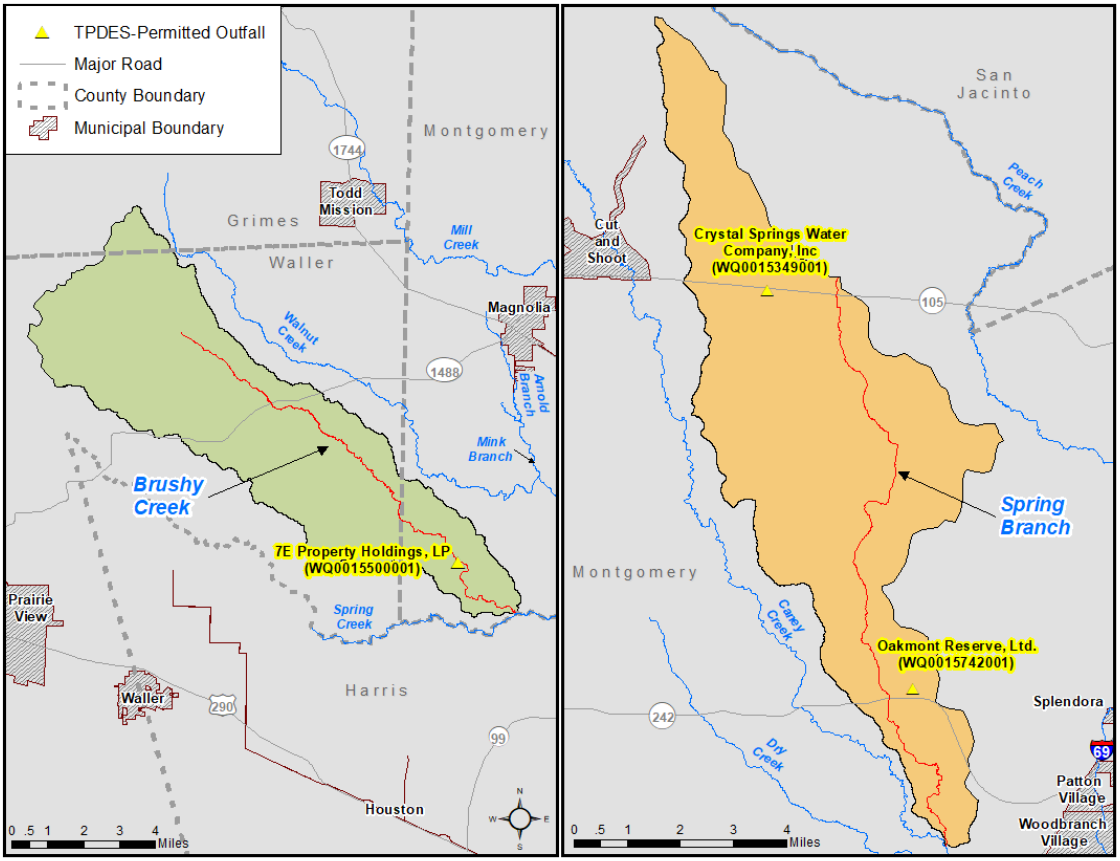

Figure 5. Brushy Creek and Spring Branch watersheds showing WWTFs.

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

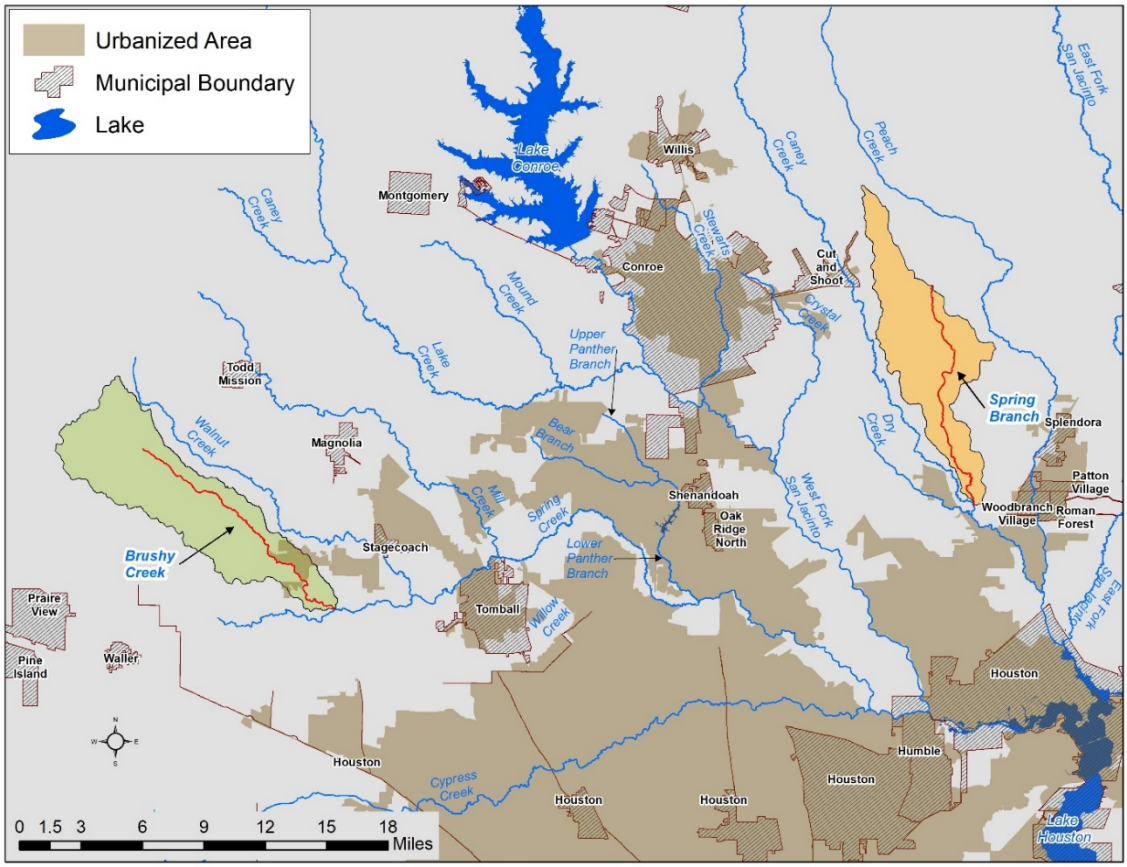

Figure 6. Regulated stormwater area based on Phase I and Phase II MS4 permits within the Brushy Creek and Spring Branch watersheds.

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.

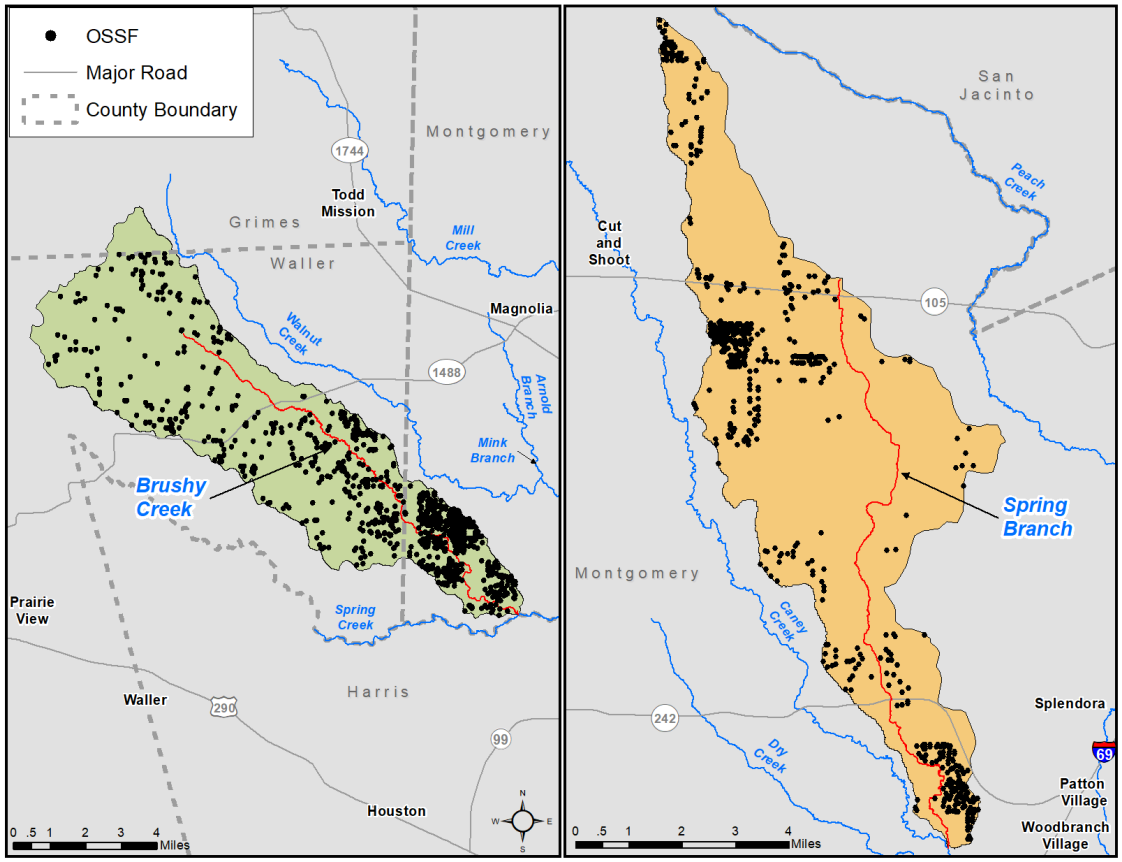

Figure 7. OSSFs located within the Brushy Creek and Spring Branch watersheds.

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.

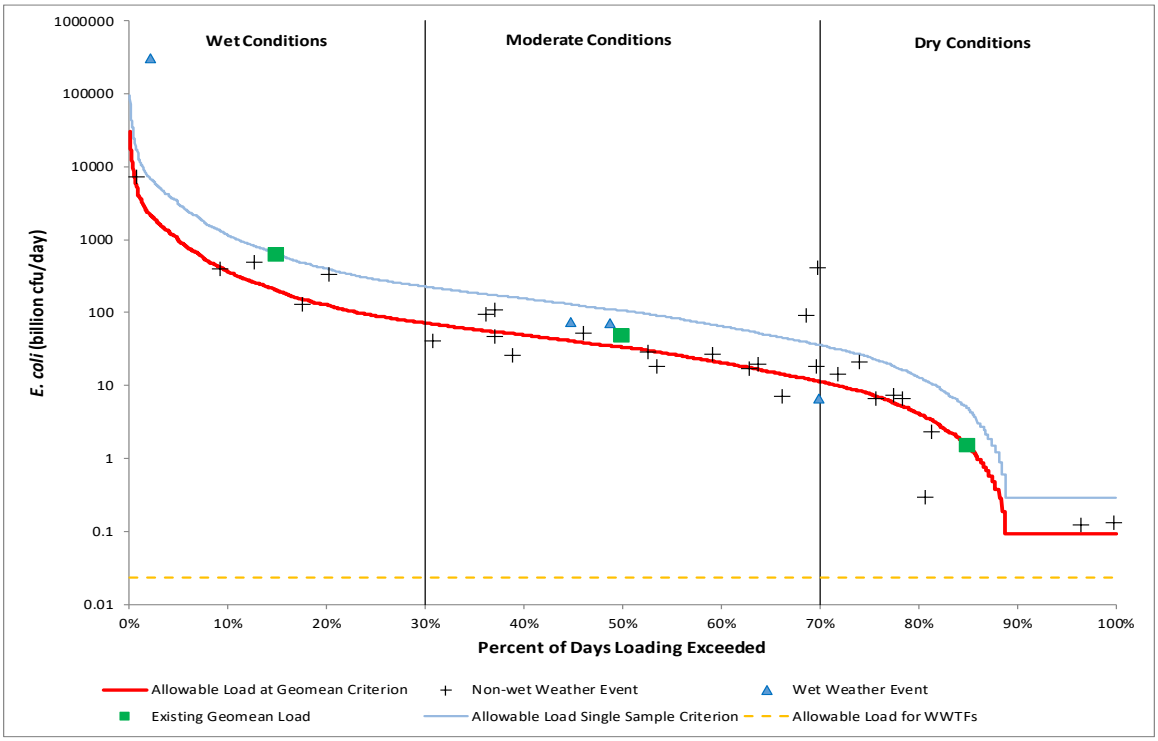

Figure 8. LDC for Brushy Creek AU 1008J_01 (Station 20463).

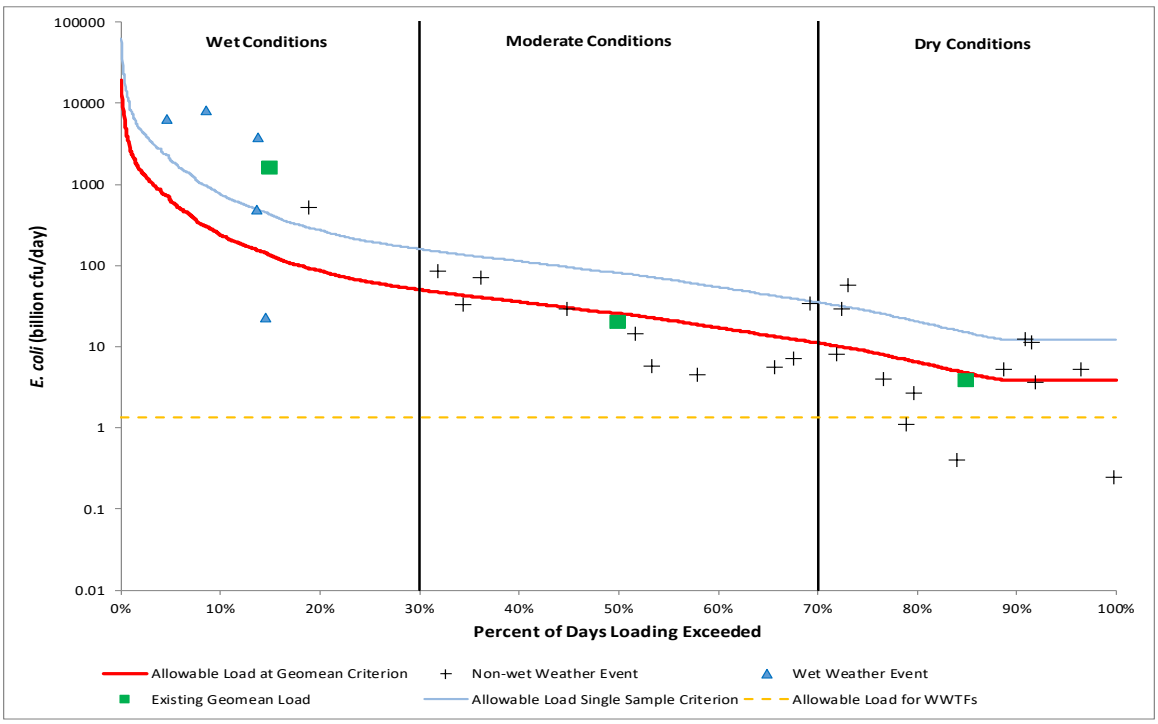

Figure 9. LDC for Spring Branch AU 1010C_01 (Station 20451).

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.

References

Adams, T. and Millican, J. 2019. *Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria for Brushy Creek and Spring Branch: Segments 1008J and 1010C*. Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas. Available online at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/82lakehouston/82-brushy-spring-tsd.pdf>.

AVMA (American Veterinary Medical Association) 2015, 2012 U.S. Pet Ownership Statistics, retrieved July 02, 2019, from website: <www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx>.

Cleland, B. 2003. TMDL Development From the "Bottom Up" - Part III: Duration Curves and Wet-Weather Assessments. Retrieved July 03, 2019, from <https://engineering.purdue.edu/mapserve/ldc/pldc/help/TMDL_Development_from_the_Bottom_UP_PartIV.pdf >.

eBird. 2019. eBird: An online database of bird distribution and abundance [web application]. Ithaca, NY. Retrieved July 2, 2019 from <www.ebird.org>.

H-GAC. 2019. 2040 Regional Growth Forecast <www.h-gac.com/rds/gis-data/gis-datasets.aspx> Accessed January 11, 2019.

IRNR. 2013. Feral hog statewide population growth and density. Retrieved July 2, 2019 from <http://feralhogs.tamu.edu/files/2011/05/FeralHogFactSheet.pdf>.

Larkin, Thomas J., G. Bomar. 1983. Climatic Atlas of Texas. LP-192. Texas Department of Water Resources. Retreived June 28, 2019 from <www.twdb.texas.gov/publications/reports/limited_printing/doc/LP192.pdf>.

NOAA. 2011. Coastal Change Analysis Program 2011 Land Cover. Obtained from the H-GAC website. <www.h-gac.com/community/socioeconomic/land-use-data/default.aspx> (Retrieved June 30, 2019).

NOAA. 2019. Station USW00053902, Conroe North Houston Regional Airport TX, US Retrieved June 26, 2019, from National Climatic Data Center: <www.ncdc.noaa.gov/cdo-web/search>.

TCEQ. 2010. *2010 Texas Surface Water Quality Standards*. Final 2010 Chapter 307 Rule Amendment. Retrieved, June 28, 2019. <https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y>.

TCEQ. 2011. Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston. Available online at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/82lakehouston/82-lakehoustontmdl_adopted.pdf> Accessed June 28, 2019.

TCEQ. 2013. Addendum One to Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston: Six Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston. Available online at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/82lakehouston/82A-LakeHoustonAddendum1.pdf > Accessed June 28, 2019.

TCEQ. 2018. *2016 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)*. Retrieved June 28, 2019. <www.tceq.texas.gov/waterquality/assessment/16twqi/16txir>.

TCEQ. 2019. Central Registry Query. Retrieved August 1, 2019, from <www15.tceq.texas.gov/crpub/index.cfm?fuseaction=home.welcome>.

TPWD. 2017. White-tailed Deer (WTD) Federal Aid Report 2017 Charts and Tables. Personal communication received February 14, 2018.

USCB (United States Census Bureau). 2019. 2010 Census Block Shapefiles. Retrieved January 11, 2019: < www.census.gov/cgi-bin/geo/shapefiles2010/main >; Tabular data from: 2010 Census Block Households and Families. Retrieved January 11, 2019, from American FactFinder: <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>.

USDA NASS (National Agricultural Statistics Service). 2019. State and County Data, Volume 1, Part43A, Inventory and Sales (2017 Census). Retrieved July 2, 2017, from <www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Census_by_State/index.php>.

Appendix III. Addendum One to Four Total Maximum Daily Loads for Indicator Bacteria in the Cottonwood Creek, Fish Creek, Kirby Creek, and Crockett Branch Watersheds Upstream of Mountain Creek Lake

One Total Maximum Daily Load for Indicator Bacteria in North Fork Fish Creek

For Segment 0841Q

Assessment Unit 0841Q_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *Four Total Maximum Daily Loads for Indicator Bacteria in the Cottonwood Creek, Fish Creek, Kirby Creek, and Crockett Branch Watersheds Upstream of Mountain Creek Lake: Segments 0841F, 0841K, 0841N, and 0841V* (TCEQ, 2016) on November 2, 2016. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency (EPA) on December 7, 2016. This document represents an addendum to the original TMDL document.

This addendum includes information specific to one additional assessment unit (AU) of one segment located within the watershed of the approved TMDL project for bacteria in segments upstream of Mountain Creek Lake. Concentrations of indicator bacteria in this additional AU 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 AU. For background or other explanatory information, please refer to the *Technical Support Document for a Total Maximum Daily Load for Indicator Bacteria for North Fork Fish Creek* (Millican, 2019). Refer to the original, approved TMDL document for details related to the overall Cottonwood Creek, Fish Creek, Kirby Creek, and Crockett Branch watersheds as well as the methods and assumptions used in developing the original TMDLs.

The addendum watershed was included in the original TMDL project area. This addendum provides the details related to developing the TMDL allocation for this additional AU, which was not specifically addressed in the original TMDL document.

Problem Definition

The TCEQ first identified the bacteria impairment for North Fork Fish Creek in the 2016 *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (2016 Integrated Report; TCEQ, 2018a). Table 1 provides a summary for the EPA-approved 2016 Integrated Report. The impaired AU is 0841Q_01, as shown in Figure 1. The impaired segment is composed of only one AU that encompasses the entire segment. The project watershed is located within Tarrant and Dallas counties. Figure 1 also shows the North Fork Fish Creek watershed in relation to the entire watershed of the original TMDLs.

Table 1. Synopsis of the 2016 Integrated Report for North Fork Fish Creek.

Integrated Report Year	Segment	AU	Parameter	Contact Recreation Use	Category
2016	0841Q	0841Q_01	*E. coli*	Nonsupport	5c

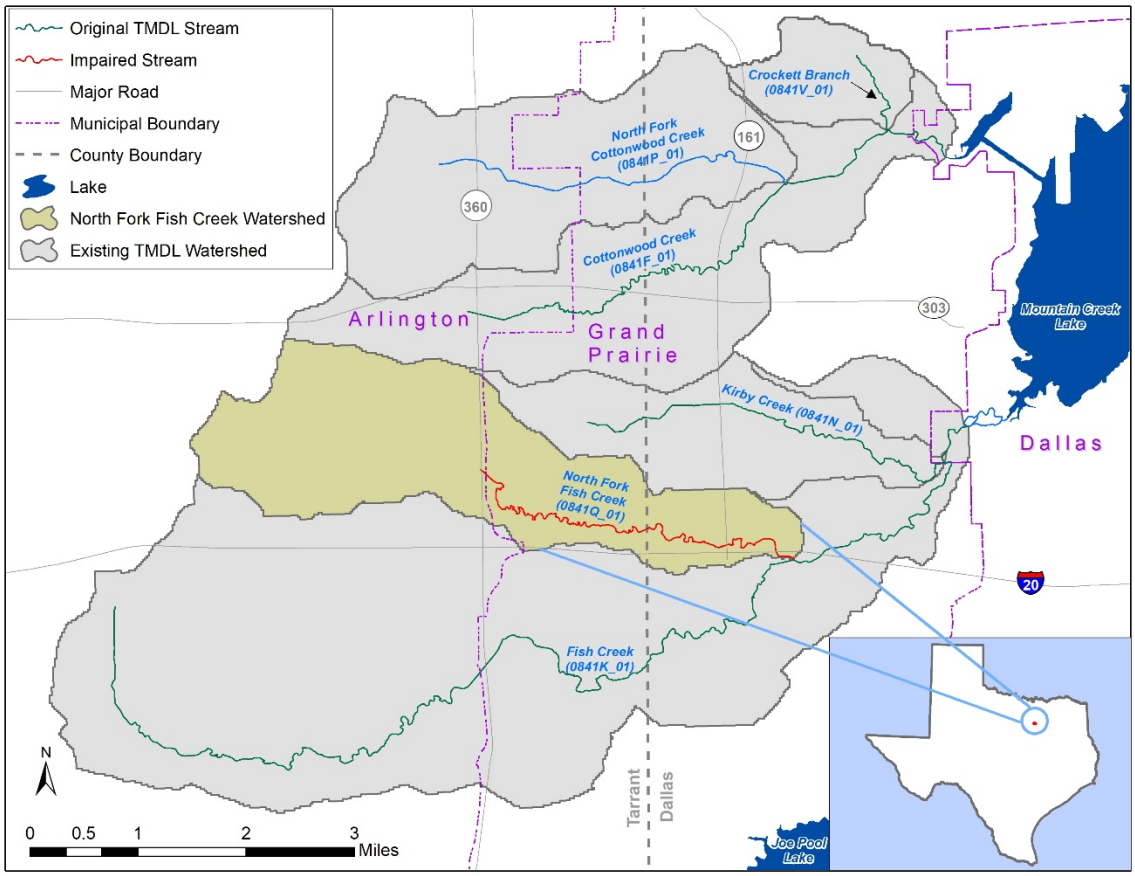

Figure 1. Approved TMDL watersheds and the North Fork Fish Creek watershed.

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 North Fork Fish Creek, as reported in the 2016 Integrated Report. The data from the assessment indicate nonsupport of the primary contact recreation use for North Fork Fish Creek, because the geometric mean concentration for *E. coli* exceeds the geometric mean criterion of 126 colony forming units (cfu)/100 milliliters (mL) of water. Surface water quality monitoring within the North Fork Fish Creek watershed has occurred at TCEQ SWQM stations 10724, 17678, and 20838 (Figure 2).

Table 2. 2016 Integrated Report summary for the North Fork Fish Creek watershed.

AU	Parameter	Stations	Number of Samples	Date Range	*E. coli* Geometric Mean (cfu/100 mL)
0841Q_01	*E. coli*	10724; 17678; 20838	84	2007-2014	183

Description of the Study Area

North Fork Fish Creek (Segment 0841Q) is a tributary to Fish Creek (Segment 0841K) and is approximately five miles in length, with portions in both Tarrant and Dallas counties (Figure 1). North Fork Fish Creek is a perennial, unclassified, freshwater stream. The North Fork Fish Creek watershed drains an area of approximately 3,663 acres.

The 2016 Integrated Report (TCEQ, 2018a) provides the following segment and AU description for North Fork Fish Creek:

- North Fork Fish Creek (AU 0841Q_01): North Fork Fish Creek from confluence with Fish Creek in Dallas County upstream to State Highway 360 in Tarrant County.

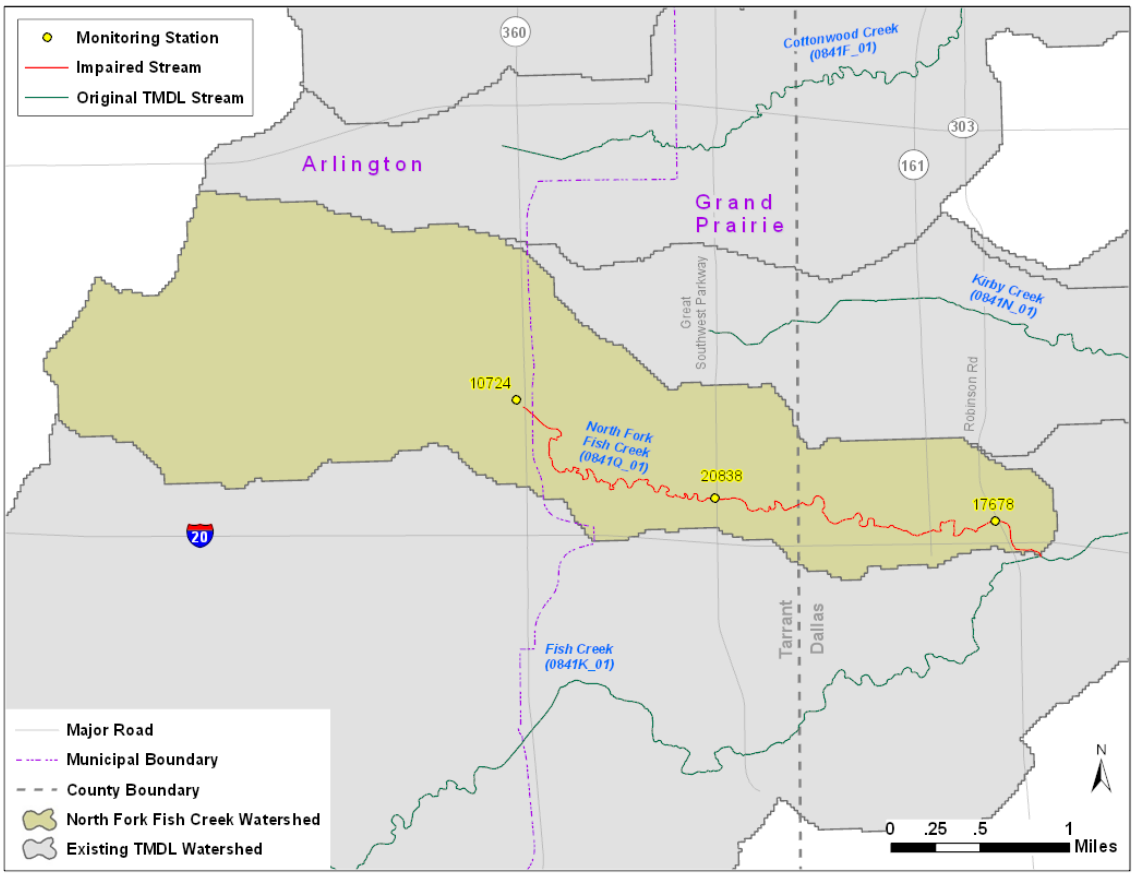

Figure 2. North Fork Fish Creek watershed showing TCEQ SWQM stations.

Watershed Climate

The North Fork Fish Creek watershed is located near the center of the Dallas/Fort Worth metroplex, which is described as having a humid subtropical climate (NOAA, 2009). Weather data spanning a period from 2003 through 2017 were obtained from the National Climatic Data Center for the Arlington Municipal Airport station located in the western portion of the Fish Creek (Segment 0841K) watershed (NOAA, 2018; Figure 3). The average annual precipitation was 34.9 inches. The wettest month is typically May (4.5 inches), while August (1.7 inches) is normally the driest month, with rainfall occurring throughout the year. The average high temperatures typically peak in August (96.5 °F) with highs above 100 °F occurring from June through August. During winter, the average low temperature reaches a minimum of 35.7 °F in January.

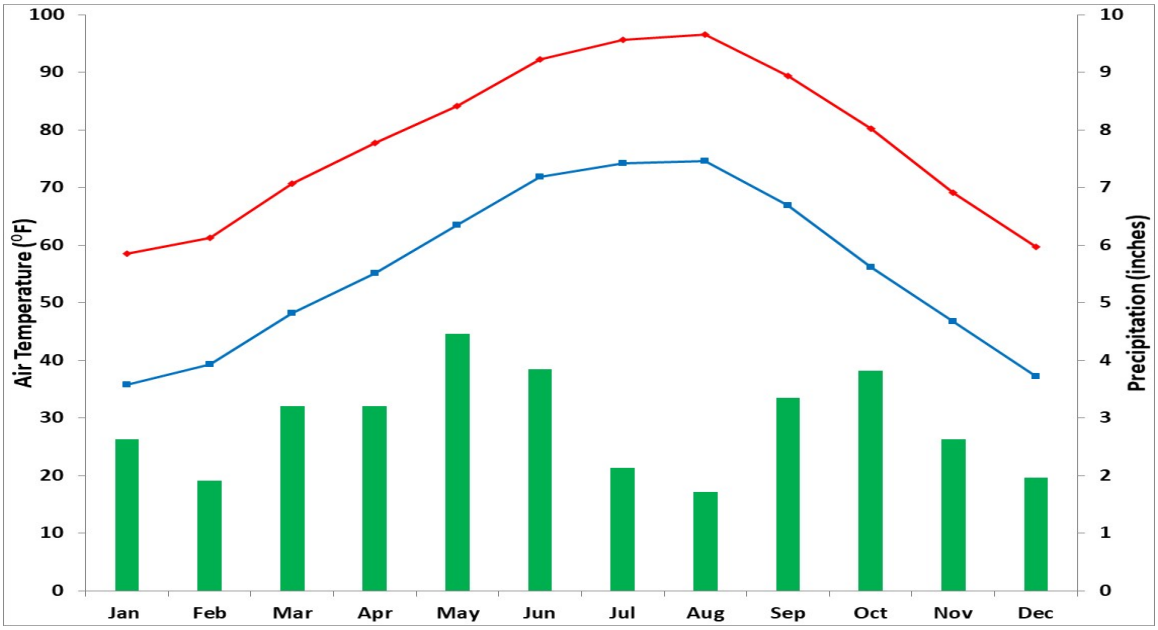

Figure 3. Average minimum and maximum air temperature and total precipitation by month from January 2003 through December 2017 for Arlington Municipal Airport.

Land Use

The land use/land cover data for the North Fork Fish Creek watershed were obtained from the North Central Texas Council of Governments (NCTCOG, 2017a) and represent land use/land cover estimates for 2015. The 2015 land use/land cover data from the NCTCOG for the North Fork Fish Creek watershed is shown in Figure 4. A summary of the land use/land cover data is provided in Table 3 and indicates that residential land use is the dominant land cover, comprising approximately 41 percent of the North Fork Fish Creek watershed.

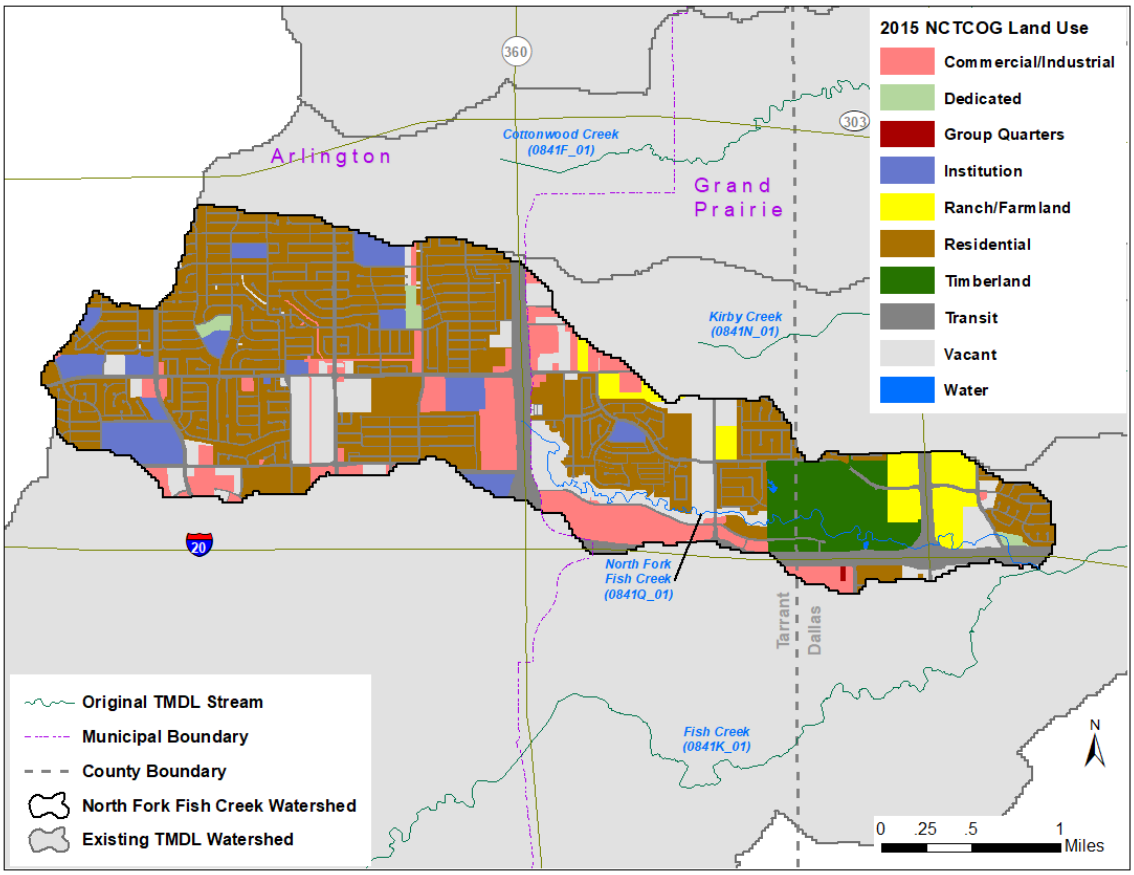

Figure 4. 2015 land use/land cover within the North Fork Fish Creek watershed.

Table 3. Land use/land cover within the North Fork Fish Creek watershed.

Classification	Area (Acres)	Percent of Total
Commercial/Industrial	369.0	10.08%
Group Quarters	1.5	0.04%
Residential	1,509.8	41.22%
Institution	216.1	5.90%
Transit	780.8	21.32%
Dedicated	26.1	0.71%
Vacant	382.8	10.45%
Ranch/Farmland	149.0	4.07%
Timberland	225.5	6.16%
Water	1.9	0.05%
Total	**3,662.5**	**100%**

Watershed Population and Population Projections

As depicted in Figure 1, the North Fork Fish Creek watershed is geographically located within the municipal incorporated boundaries of Arlington and Grand Prairie. Population estimates were developed using 2010 United States Census Bureau (USCB) Block data allocated to the area within the North Fork Fish Creek watershed. Population projections for the year 2045 were developed by the NCTCOG by utilizing traffic survey zone allocations approximated to city boundaries. The projected populations were then allocated based on proportion of the area within the North Fork Fish Creek watershed. The projected population increase was then determined based on the increase from the 2010 population to the projected 2045 population. This indicates that the population within the North Fork Fish Creek watershed is projected to increase by 62.4 percent (Table 4; USCB, 2018 and NCTCOG, 2017b).

Table 4. 2010 Population and 2045 population projection for the North Fork Fish Creek watershed.

Water Body	Segment	2010 U.S. Census Population	2045 Projected Population	Projected Population Increase	Percent Change (2010–2045)
North Fork Fish Creek	0841Q	30,749	49,926	19,177	62.4%

Endpoint Identification

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

Source Analysis

Regulated Sources

Permitted sources are regulated under the Texas Pollutant Discharge Elimination System (TPDES) and the National Pollutant Discharge Elimination System (NPDES) programs.

Domestic and Industrial Wastewater Treatment Facilities

There are no permitted domestic wastewater treatment facilities (WWTFs) or industrial dischargers within the North Fork Fish Creek watershed. Domestic wastewater is collected by and transported to the Trinity River Authority (TRA) Central Regional Wastewater System located outside the study area (Figure 5).

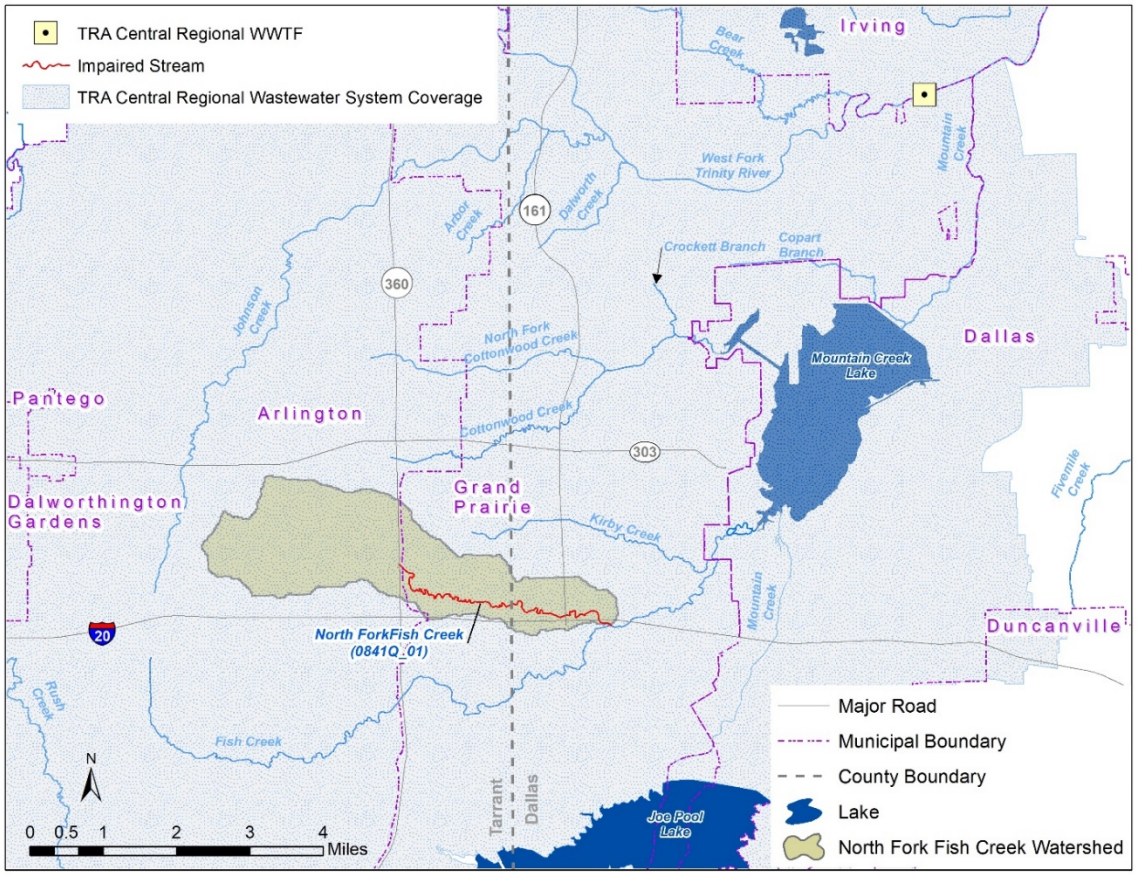

Figure 5. Coverage area of the TRA Central Regional Wastewater System in the TMDL study area.

Sanitary Sewer Overflows

Information regarding reported sanitary sewer overflow (SSO) incidents in the North Fork Fish Creek watershed was acquired through the NCTCOG and represented incidents that occurred from 2007 through 2015. Reported SSO incidents that occurred from 2007 through 2015 were refined by the NCTCOG by assigning latitude and longitude coordinates to each SSO event and plotted using Geographic Information System software in an effort to characterize the frequency and magnitude of SSO events within the North Fork Fish Creek watershed (Figure 6). A summary of the NCTCOG-refined data within the North Fork Fish Creek watershed is shown in Table 5.

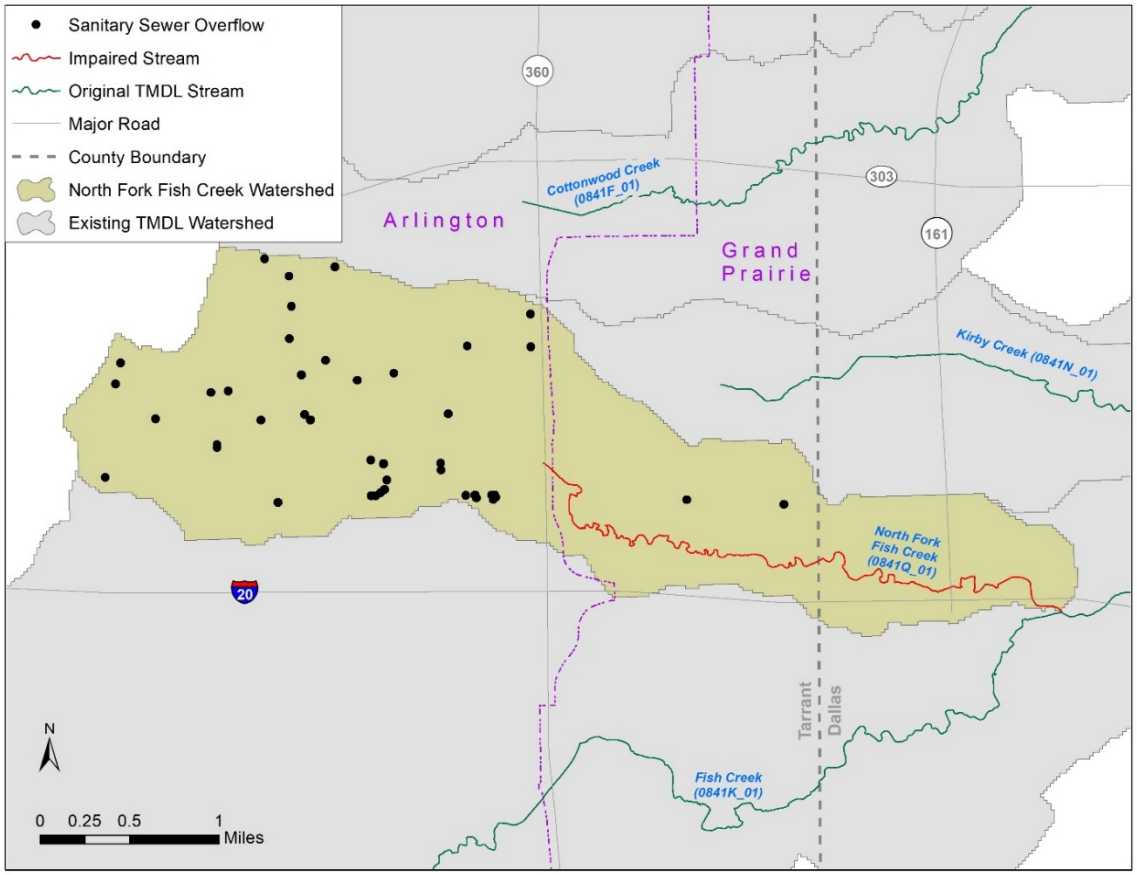

Figure 6. SSOs that occurred from 2007 through 2015 within the North Fork Fish Creek watershed.

Table 5. Summary of SSO incidences reported in the North Fork Fish Creek Watershed from 2007 through 2015.

No. of Incidents	Total Volume (gallons)	Average Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
45	22,166	493	7	6,000

TPDES-Regulated Stormwater

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

1) stormwater subject to regulation, which is any stormwater originating from TPDES/NPDES regulated municipal separate storm sewer system (MS4) entities, industrial facilities, and construction activities; and

2) stormwater runoff not subject to regulation.

The TPDES/NPDES MS4 Phase I and II rules require municipalities and certain other entities in urban areas to obtain permit coverage for their stormwater systems. A regulated MS4 is a publicly owned system of

conveyances and includes ditches, curbs, gutters, and storm sewers that do not connect to a wastewater collection system or treatment facility. Phase I 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 a little 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.

The area under the jurisdiction of Phase II general permits and Phase I individual permits was used to estimate the regulated stormwater areas for construction, industrial, and MS4 permits. In this report, the regulated area for the Phase II permits was based on the 2010 urbanized area from the U.S. Census.

A review of active stormwater general permits coverage and a review of the central registry for Phase I MS4 permit coverage (TCEQ, 2018b) in the study area revealed that existing Phase I and Phase II permits (Table 6) provide 100 percent MS4 coverage for the North Fork Fish Creek watershed (Figure 7).

Table 6. TPDES and NPDES MS4 permits associated with the North Fork Fish Creek watershed.

Entity	TPDES Permit	NPDES Permit
City of Arlington	WQ0004635000	TXS000301
Texas Department of Transportation	WQ0005011000	TXS002101
City of Grand Prairie	Phase II General Permit (TXR040000)	TXR040065

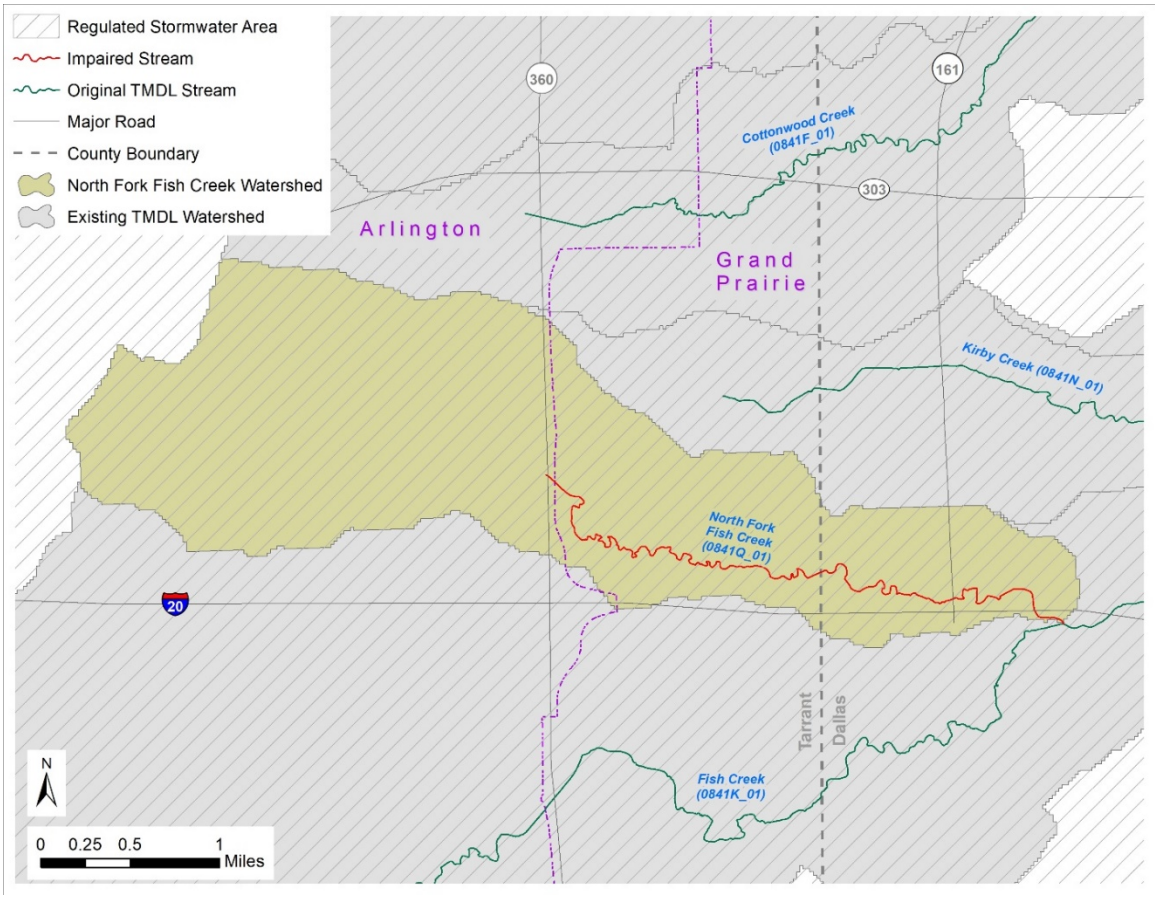

Figure 7. Regulated stormwater area based on Phase I and Phase II MS4 permits within the North Fork Fish Creek watershed.

TPDES General Wastewater Permits

Discharges of processed wastewater from certain types of facilities are required to be covered by one of several TPDES general permits:

TXG110000 – concrete production facilities
TXG130000 – aquaculture production facilities
TXG340000 – petroleum bulk stations and terminals
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, 2018b) in the North Fork Fish Creek watershed as of November 6, 2018, 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

E. coli bacteria are common inhabitants of 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. The *E. coli* contribution from feral hogs and wildlife in North Fork Fish Creek could not be determined based on existing information.

Domesticated Animals

Due to the highly urbanized nature of the North Fork Fish Creek watershed, livestock were not considered a significant source of bacteria loading. 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 7 summarizes the estimated number of dogs and cats within the North Fork Fish Creek watershed. 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 the North Fork Fish Creek watershed is unknown.

Table 7. Estimated households and pet populations for the North Fork Fish Creek watershed.

Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
9,962	5,818	6,356

On-site Sewage Facilities

Failing OSSFs were not considered a major source of bacteria loading in the North Fork Fish Creek watershed, because the entire watershed area is served by TRA. Areas serviced by centralized treatment and collection systems typically contain very few OSSFs, and this is the situation for the TMDL watershed. NCTCOG information indicates that only two OSSFs exist in the North Fork Fish Creek watershed.

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 allocation. 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 (Millican, 2019) provides details about the linkage analysis and the LDC method and its application.

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 TMDL for North Fork Fish Creek was derived using the median flow within the high flow regime (or five percent flow) of the LDC developed for Station 17678, the most downstream station in the watershed (Figure 8).

With historical *E. coli* data added to this LDC, the following broad linkage statements can be made. For the North Fork Fish Creek watershed, the historical *E. coli* data indicate that elevated bacteria loadings occur under all three flow regimes. However, the geometric means of the measured data for each flow regime generally indicate decreasing concentration with decreasing flow. The allowable load at the single sample criterion (399 cfu/100 mL) is included on the LDC for comparison with individual *E. coli* samples, although it is not used for assessment or allocation purposes.

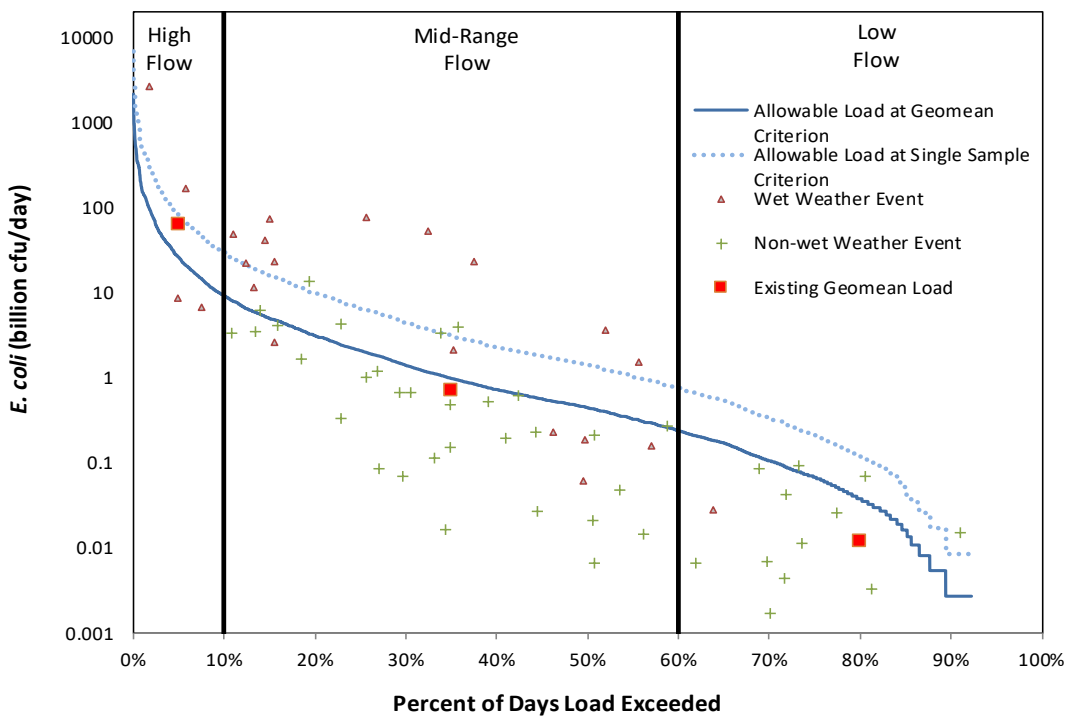

Figure 8. LDC for North Fork Fish Creek (Station 17678).

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 would be 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/100 mL *E. coli*) is used as the WWTF target to provide instream and downstream load capacity and to be consistent with previously developed TMDLs. Due to the absence of any permitted dischargers in the North Fork Fish Creek watershed, and to remain consistent with the previous TMDLs, the WLA_{WWTF} component is zero.

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 (defined as the area designated as urbanized area in the 2010 U.S. Census) 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. As noted earlier, Phase I and Phase II permits provide 100 percent MS4 coverage for the North Fork Fish Creek watershed.

However, even in highly urbanized areas such as the North Fork Fish Creek watershed, there remain small areas of streams within each watershed that are not strictly regulated, and which may receive bacteria loadings from unregulated sources such as wildlife. To account for these small unregulated areas, the stream length based on the TCEQ description of Segment 0841Q and a stream width estimated from measurements recorded as part of a recreational use attainability analysis on North Fork Fish Creek (TIAER, 2010) were used to calculate an area of unregulated stormwater contribution, totaling 4.2 acres. The resulting percentage of land under the jurisdiction of stormwater permits in the North Fork Fish Creek watershed was 99.9 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).

As noted previously, the North Fork Fish Creek watershed is entirely within the collection system area of the TRA Central Regional Wastewater System. Additionally, there are no WWTFs within the North Fork Fish Creek watershed and there are no plans to build a new WWTF within the watershed (TRA, 2019). Due to 100 percent coverage of wastewater collection by the TRA Central Regional Wastewater System and the absence

of WWTFs in the North Fork Fish Creek watershed, the FG component for impaired AU 0841Q_01 is zero. This approach for FG also remains consistent with the previous TMDLs.

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 8 summarizes the TMDL calculation for North Fork Fish Creek AU 0841Q_01. The TMDL was calculated based on the median flow in the 0-10 percentile range (five percent exceedance, high flow regime) for flow exceedance from the LDC developed for the monitoring station 17678. Allocations are based on the current geometric mean criterion for *E. coli* of 126 cfu/100 mL for each component of the TMDL (although one-half the criterion would have been used to calculate the WLA_{WWTF} and FG terms, had these terms not been zero).

Table 8. TMDL allocation summary for North Fork Fish Creek.

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	FG	MOS
North Fork Fish Creek	0841Q_01	26.08	0	24.75	0.03	0	1.30

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

The final TMDL allocations (Table 9) 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 9. Final TMDL allocations for North Fork Fish Creek.

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
North Fork Fish Creek	0841Q_01	26.08	0	24.75	0.03	1.30

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 seventeen years (2001 through 2017) 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 a significant difference (α=0.05) in indicator bacteria between cool and warm weather seasons for North Fork Fish Creek (α=0.008), with the warm season having higher concentrations. 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 (Millican, 2019) was posted on the TCEQ website on July 17, 2019. A presentation on this addendum was given at the annual meeting of the Greater Trinity River Bacteria TMDL Implementation Plan Coordination Committee in Arlington on June 13, 2019. The public will have an opportunity to comment on this addendum during the official Water Quality Management Plan 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 May 27 through June 27, 2016. No comments were submitted related to North Fork Fish Creek.

Implementation and Reasonable Assurance

The segment covered by this addendum is within the existing bacteria TMDL watersheds of Cottonwood Creek, Fish Creek, Kirby Creek, and Crockett Branch. Those TMDL watersheds including North Fork Fish Creek are within the area covered by the implementation plan developed by the NCTCOG (in collaboration with the Coordination Committee of the Greater Trinity River Bacteria TMDL Implementation Project) for bacteria TMDLs throughout the greater Dallas/Fort Worth area, approved by the TCEQ on December 11, 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.

References

AVMA (American Veterinary Medical Association). 2015, *2012 U.S. Pet Ownership Statistics*. Retrieved May 17, 2019, from: <www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx>.

Cleland, B. 2003. *TMDL Development From the "Bottom Up" - Part III: Duration Curves and Wet-Weather Assessments.* Retrieved February 20, 2019, from: <engineering.purdue.edu/mapserve/ldc/pldc/help/TMDL_Development_from_the_Bottom_UP_PartIV.pdf>.

Millican, J. 2019. *Technical Support Document for a Total Maximum Daily Load for Indicator Bacteria for North Fork Fish Creek: Segment 0841Q*. Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas. Available online at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/66trinitybact/66h-north-fork-fish-creek-tsd.pdf>.

NCTCOG. 2017a. *2015 Land Use*. Retrieved November 15, 2018, from Regional Data Center: <data-nctcoggis.opendata.arcgis.com/datasets/933a1ca8ded44fe89f3189fa5445eb9c_6>.

NCTCOG. 2017b. *Traffic Survey Zones*. Retrieved November 15, 2018, from Regional Data Center: <http://data-nctcoggis.opendata.arcgis.com/datasets/2045-nctcog-demographic-forecast-tsz>.

NOAA (National Oceanic and Atmospheric Administration). 2009. *Dallas/Fort Worth Climate Narrative.* Retrieved February 20, 2019, from National Weather Service Forecast Office: <www.weather.gov/fwd/dnarrative>.

NOAA. 2018. *Station USW00053907, Arlington Municipal Airport, Arlington, TX, US.* Retrieved November 15, 2018, from National Climatic Data Center: <www.ncdc.noaa.gov/cdo-web/search>.

TCEQ. 2010. *2010 Texas Surface Water Quality Standards*. Final 2010 Chapter 307 Rule Amendment. Retrieved February 20, 2019 from: < https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y>

TCEQ. 2016. *Four TMDLs for Indicator Bacteria in the Cottonwood Creek, Fish Creek, Kirby Creek, and Crockett Branch Watersheds Upstream of Mountain Creek Lake.* Retrieved February 20, 2019, from: <www.tceq.texas.gov/assets/public/waterquality/tmdl/66trinitybact/66F-MtCreekLakeTMDL-Adopted.pdf>.

TCEQ. 2018a. *2016 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)*. Retrieved February 20, 2019, from: <www.tceq.texas.gov/waterquality/assessment/16twqi/16basinlist>.

TCEQ. 2018b. *Central Registry Query*. Retrieved November 6, 2018, from: <www15.tceq.texas.gov/crpub/index.cfm?fuseaction=home.welcome>.

TIAER. 2010. *Dallas-Fort Worth Metroplex Urban Creeks Trinity River Bacteria TMDL Project Recreational Use-Attainablitlity Analysis Report*. Retrieved February 20, 2019, from: <www.tceq.texas.gov/assets/public/permitting/waterquality/standards/ruaas/Trininty/Trinity_River_D-FW_streams/RUAA_Urban_Creeks_full.pdf>

TRA. 2019. Communication via emails with Glenn Clingenpeel (Manager, Technical Services and Basin Planning) on future growth for WWTFs within the North Fork Fish Creek watershed, June 6-7, 2019.

USCB. 2018. 2010 *Census Block Shapefiles*. Retrieved Nov. 15, 2018 from: <www.census.gov/cgi-bin/geo/shapefiles2010/main>; Tabular data from: *2010 Census Block Households and Families.* Retrieved Nov. 15, 2018, from American FactFinder: <factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>.

Appendix IV. Addendum Two to Three Total Maximum Daily Loads for Bacteria in the San Antonio Area

One Total Maximum Daily Load for Indicator Bacteria in Martinez Creek

For Segment 1911I

Assessment Unit 1911I_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *Three Total Maximum Daily Loads for Bacteria in the San Antonio Area: Segments 1910, 1910A, and 1911* (TCEQ, 2007) on July 25, 2007. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency (EPA) on September 25, 2007. Additionally, an addendum to the original TMDL was submitted to EPA through the April 2016 Water Quality Management Plan (WQMP) update (TCEQ, 2016). That addendum added seven additional assessment units (AUs) in five segments (1910D, 1911B, 1911C, 1911D, and 1911E). This document represents a second addendum to the original TMDL document.

This addendum includes information specific to one additional AU. The AU is in Segment 1911I located within the watershed of the approved TMDL project for bacteria in the San Antonio area. Concentrations of indicator bacteria in this additional AU 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 AU. For background or other explanatory information, please refer to the *Technical Support Document for a Total Maximum Daily Load for Indicator Bacteria in Martinez Creek* (Brady et al., 2019). Refer to the original, approved TMDL document for details related to the Salado Creek, Walzem Creek, and Upper San Antonio River watersheds as well as the methods and assumptions used in developing the original TMDLs.

The watershed for Segment 1911I was included in the original TMDL project area. This addendum provides the details related to developing the TMDL allocation for this additional AU, which was not specifically addressed in the original TMDL document.

Problem Definition

The TCEQ first identified the bacteria impairment for Martinez Creek in the 2014 *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (2014 Integrated Report; TCEQ, 2015). Martinez Creek was also included in the 2016 Integrated Report (TCEQ, 2018; the most recent EPA-approved version). Table 1 provides a synopsis of the 2014 and 2016 Integrated Reports. The impaired AU is 1911I_01, as shown in Figure 1. The segment has two AUs, with the impairment in the most downstream AU (Figure 2). The project watershed is located within Bexar County. Figure 1 also shows the Martinez Creek watershed in relation to the entire watershed of the original TMDLs as well as the watersheds addressed in the first addendum.

Table 1. Synopsis of the 2014 and 2016 Integrated Reports for Martinez Creek.

Integrated Report Year	Segment	AU	Parameter	Contact Recreation Use Level of Support	Category
2014	1911I	1911I_01	*E. coli*	Nonsupport	5c
2016	1911I	1911I_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 Martinez Creek, as reported in the 2014 and 2016 Integrated Reports. The data from these assessments indicate nonsupport of the primary contact recreation use for Martinez Creek, because the geometric mean concentration for *E. coli* exceeds the geometric mean criterion of 126 colony forming units (cfu)/100 milliliters (mL) of water. Surface water quality monitoring within the Martinez Creek watershed has occurred at TCEQ SWQM station 12751 (Figure 2).

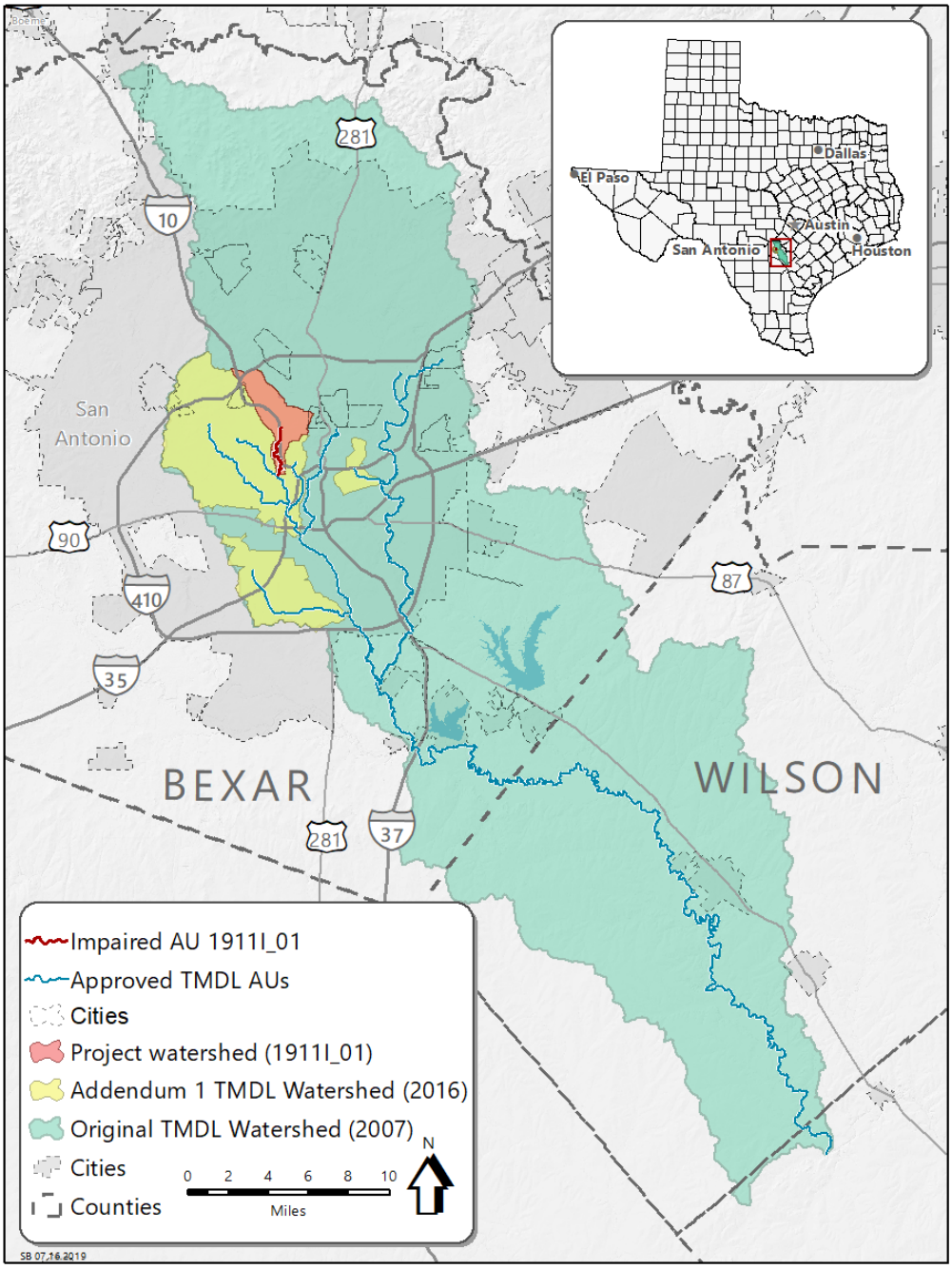

Figure 1. Approved TMDL and first addendum watersheds, and the Martinez Creek project watershed.

Table 2. 2014 and 2016 Integrated Report summary for the Martinez Creek watershed.

Integrated Report Year	AU	Parameter	Station	Number of Samples	Date Range	*E. coli* Geometric Mean (cfu/100 mL)
2014	1911I_01	*E. coli*	12751	41	2005-2012	268
2016	1911I_01	*E. coli*	12751	50	2007-2014	238

Description of the Study Area

Martinez Creek (Segment 1911I) is a tributary of the Upper San Antonio River (Segment 1911). Martinez Creek is an unclassified, freshwater stream composed of two AUs – the downstream AU (1911I_01) has a flow type of "Intermittent with pools"; the upstream AU (1911I_02) has a flow type of "Intermittent" (TCEQ, 2018). Martinez Creek (Segment 1911I) flows into Alazan Creek (1911C) in San Antonio and is approximately 6 miles in length. At its mouth, Martinez Creek drains an area of 7.29 square miles in Bexar County. Martinez Creek is located within the San Antonio city limits and is largely channelized within concrete banks.

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

- Segment 1911I (Martinez Creek) – Martinez Creek from the confluence of Alazan Creek in central San Antonio upstream to the terminus at Vance Jackson Rd in north San Antonio
    - 1911I_01 – Martinez Creek from the confluence of Alazan Creek in central San Antonio upstream to the concrete channel portion at San Francisco St in north San Antonio
    - 1911I_02 – Martinez Creek from the concrete channel portion at San Francisco St upstream to the terminus at Vance Jackson Rd in north San Antonio

Using a watershed-based approach and because the impaired AU 1911I_01 is downstream of the non-impaired AU 1911I_02, the entire watershed of Martinez Creek will be considered in this document.

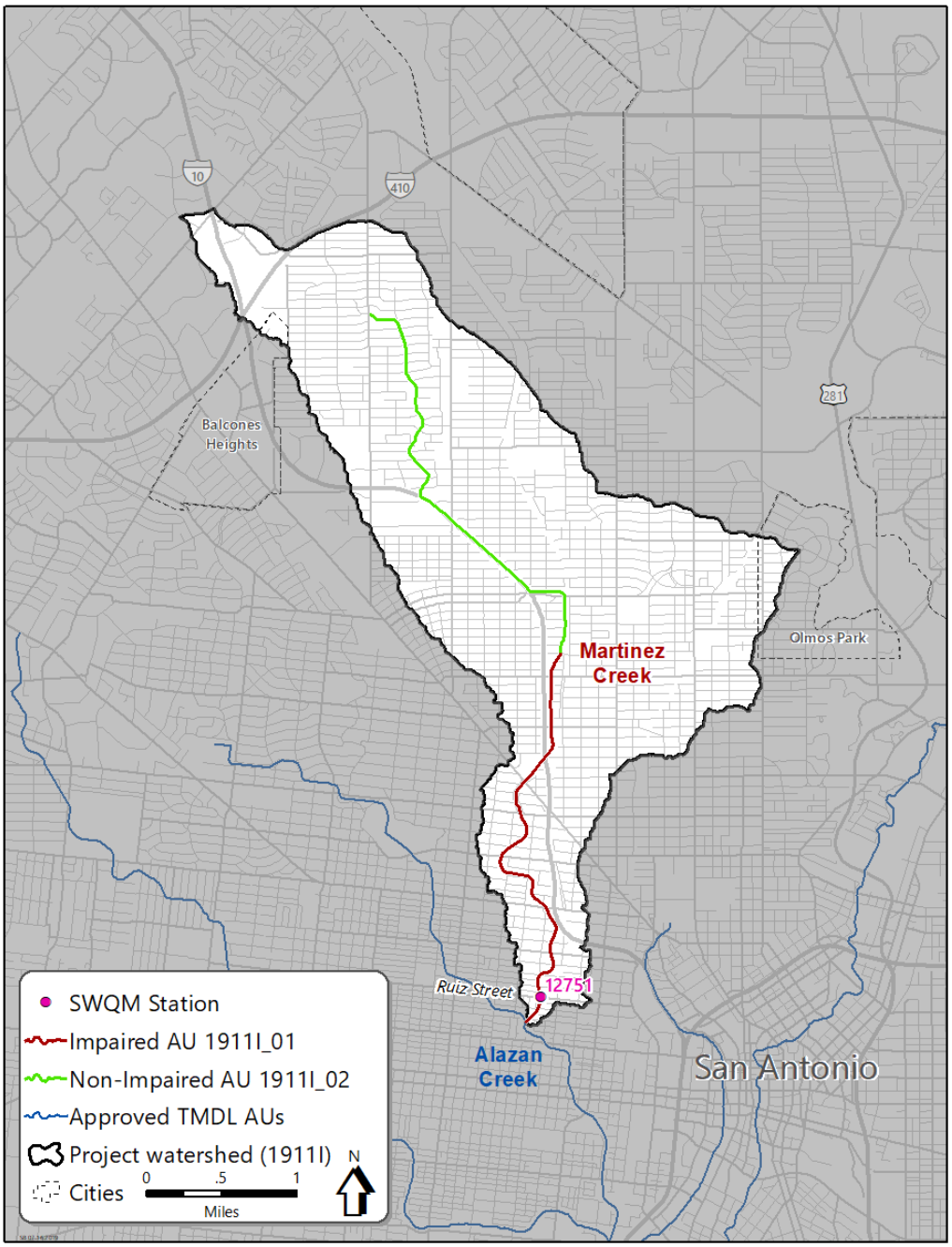

Figure 2. Martinez Creek watershed showing impairment status of AUs and TCEQ SWQM station.

Watershed Climate

The Martinez Creek watershed is located within the central portion of Texas, described as having a subtropical subhumid climate (Larkin and Bomar, 1983). As in much of the state, the region's subtropical climate is caused by the "predominant onshore flow of tropical maritime air from the Gulf of Mexico," while the increasing moisture content (from west to east) reflects variations in "intermittent seasonal intrusions of continental air" (Larkin and Bomar, 1983).

Climate data from 2004 through 2018 for the San Antonio International Airport weather station (USW00012921) indicate a bimodal precipitation pattern (NOAA, 2019a; Figure 3). Annual rainfall in the San Antonio area averages 32.4 inches. The wettest months are typically May and September (4.5 and 4.6 inches) while February and August (1.6 and 2.0 inches) are normally the driest months (NOAA, 2019b). Average high temperatures generally reach their peak of 96° F in August, while the average low temperature reaches a minimum of 41° F in January.

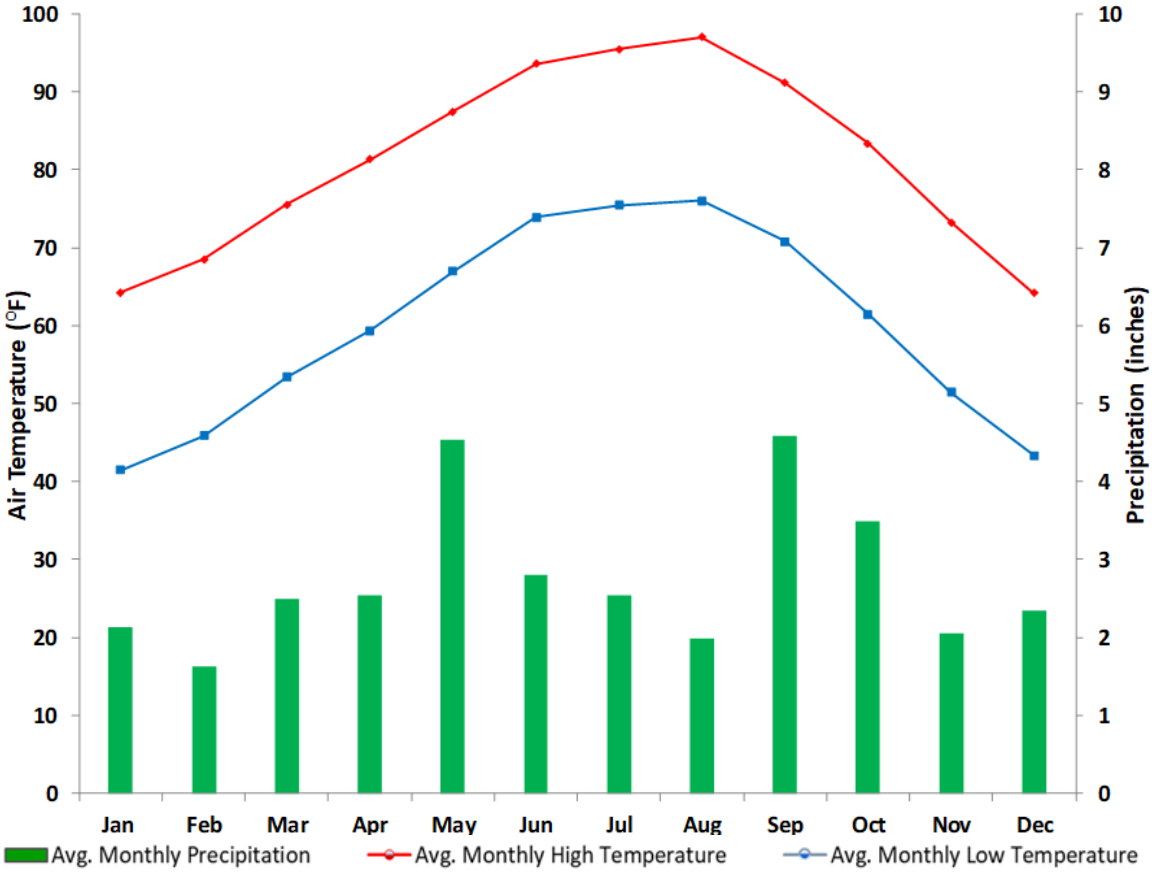

Figure 3. Average minimum and maximum air temperature and total precipitation by month from January 2004 through December 2018 for San Antonio International Airport weather station.

Land Use

The land use/land cover data for the Martinez Creek watershed was obtained from the 2016 National Land Cover Database (NLCD) (MRLC, 2019) and are displayed in Figure 4. A summary of the land use/land cover data is shown in Table 3 and indicates that the Martinez Creek watershed is almost completely developed (over 99 percent).

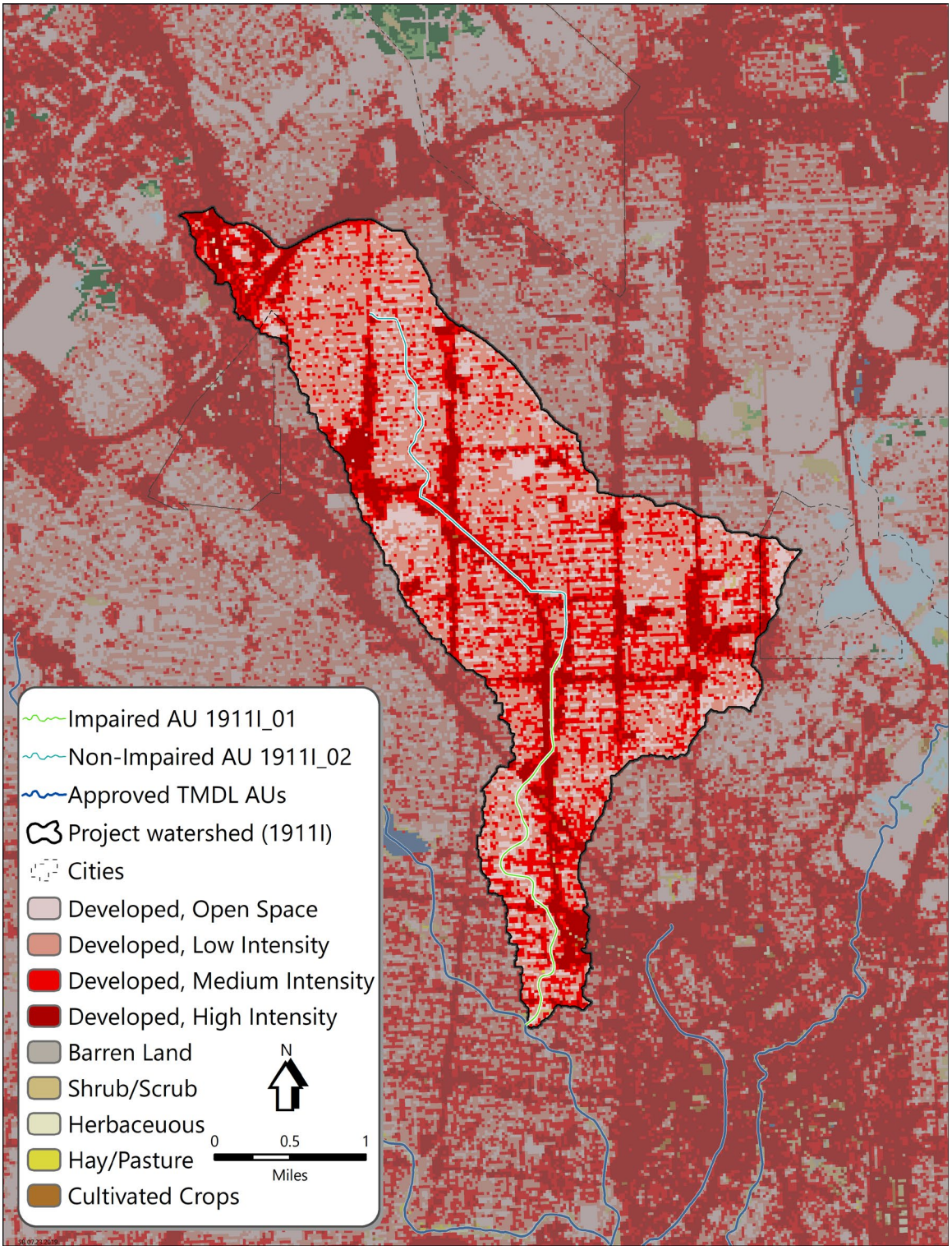

Figure 4. Land use/land cover map showing categories within the Martinez Creek watershed.

Table 3. Land use/land cover within the Martinez Creek watershed.

Classification	Area (Acres)	Percent of Total
Developed, Open Space	636.8	13.7%
Developed, Low Intensity	2065.2	44.3%
Developed, Medium Intensity	1307	28.0%
Developed High Intensity	643.6	13.8%
Barren Land	0.4	0.01%
Shrub/Scrub	8.7	0.19%
Grassland/Herbaceous	1.8	0.04%
Pasture/Hay	0.2	0.004%
Cultivated Crops	1.8	0.04%
Total	**4,665.5**	**100.0%**

Watershed Population and Population Projections

According to the United States Census Bureau (USCB) 2010 Census (USCB, 2011), there are an estimated 47,010 people in the Martinez Creek watershed, indicating a population density of 6,449 people/ square mile.

Geospatial analysis based on water user groups (WUGs), which allows a refinement of county and city-level projections developed by the Office of the State Demographer and the Texas Water Development Board (TWDB, 2019), reveals that the population is projected to increase by 82.6 percent in the Martinez Creek watershed between 2010 and 2070 (Table 4).

Table 4. 2010 Population and 2070 population projection for the Martinez Creek watershed.

Water Body	Segment	2010 U.S. Census Population	2070 Projected Population	Projected Population Increase	Percent Change (2010─2070)
Martinez Creek	1911I	47,010	85,858	38,848	82.64

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

There are no permitted domestic wastewater treatment facilities (WWTFs) or industrial dischargers within the Martinez Creek watershed. The entire watershed is included within the San Antonio Water System (SAWS) service area.

Sanitary Sewer Overflows

The TCEQ Region 13 Office maintains a database of sanitary sewer overflow (SSO) data reported by municipalities. These SSO data typically contain estimates of the total gallons spilled, responsible entity and a general location of the spill. A summary of the reports of SSO events that were determined to have occurred within the Martinez Creek watershed between January 2012 and December 2017 is shown in Table 5, as well as in Figure 5.

Table 5. Summary of SSO incidences reported within the Martinez Creek Watershed from 2012 through 2017.

No. of Incidents	Total Volume (gallons)	Average Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
69	196,037	2,841	5	75,600

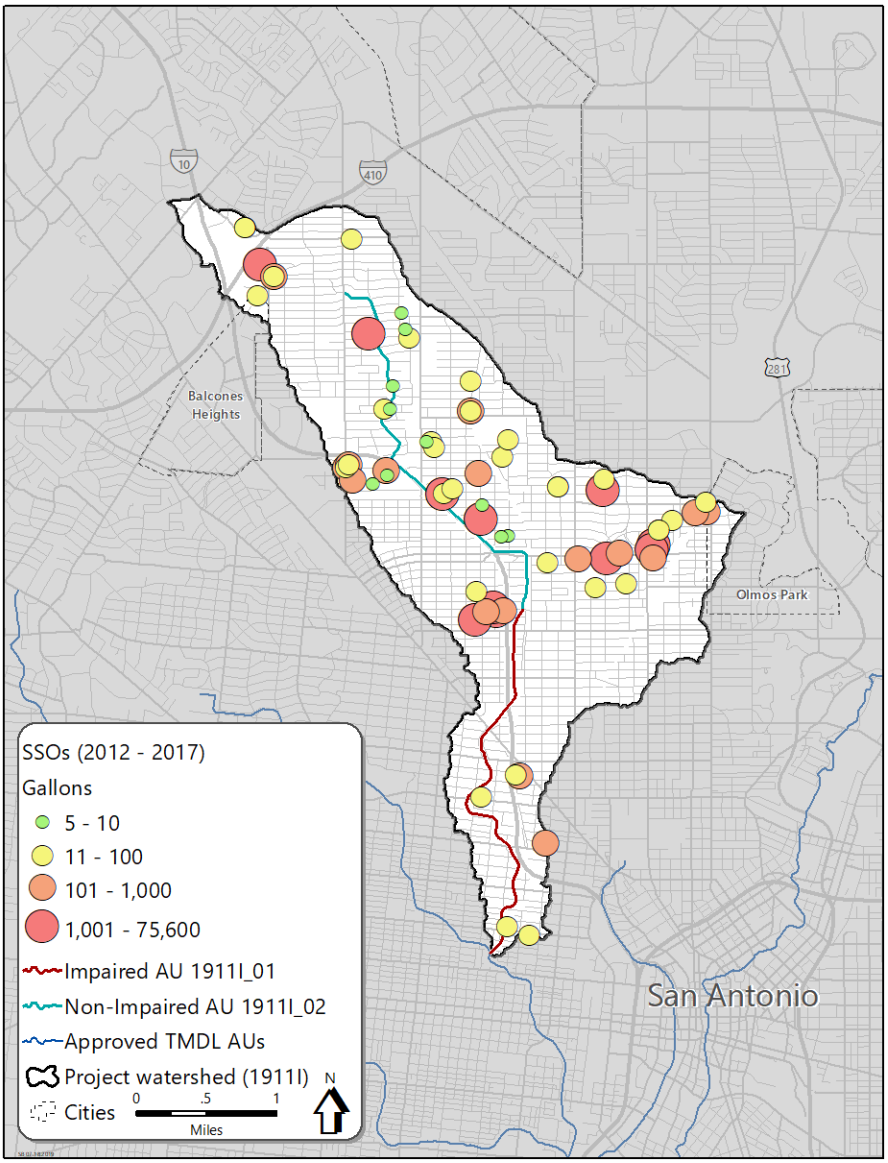

Figure 5. SSOs incidences reported from 2012 through 2017 within the Martinez Creek watershed.

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.

The area under the jurisdiction of Phase II general permits and Phase I individual permits was used to estimate the regulated stormwater areas for construction, industrial, and MS4 permits. In this report, the regulated area for the Phase II permits was based on the 2010 urbanized area from the U.S. Census (Figure 6).

A review of active stormwater general permits coverage and a review of the central registry for Phase I MS4 permit coverage (TCEQ, 2019) in the study area revealed that existing Phase I and Phase II permits (Table 6) provide 100 percent MS4 coverage for the Martinez Creek watershed.

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

Entity/ Permittee	Permitted Area	TPDES Permit	NPDES[a] Permit
City of San Antonio/ San Antonio Water System/Texas Department of Transportation	San Antonio	WQ0004284000	TXS001901
Texas Department of Transportation	Statewide	WQ0005011000	TXS002101
City of Balcones Heights	Balcones Heights	Phase II General Permit (TXR040000)	TXR040156
City of Olmos Park	Olmos Park	Phase II General Permit (TXR040000)	TXR040026

[a] National Pollutant Discharge Elimination System (NPDES)

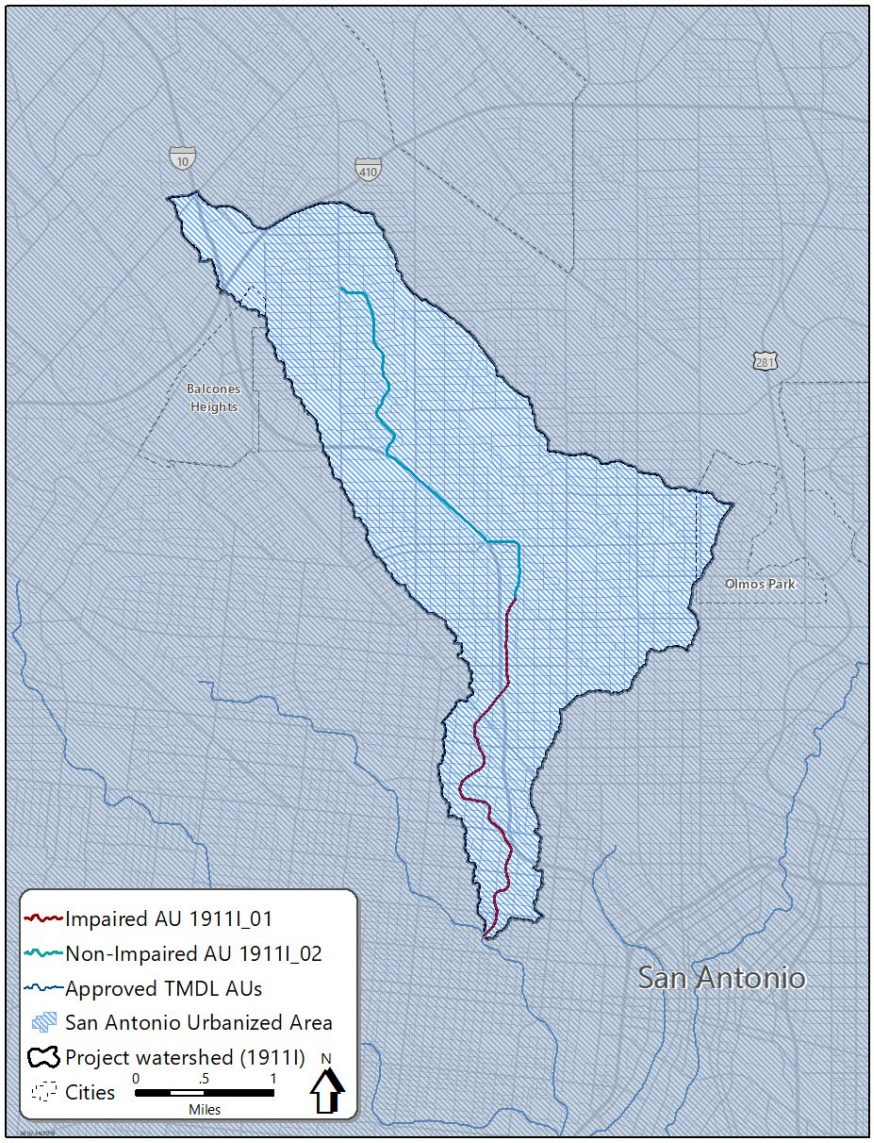

Figure 6. Regulated stormwater area based on Phase I and Phase II MS4 permits within the Martinez Creek watershed.

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 Martinez Creek watershed as of June 14, 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. The *E. coli* contribution from feral hogs and wildlife in Martinez Creek could not be determined based on existing information. However, due to the urbanized nature of the watershed, it is assumed that the contribution would be minimal.

Domesticated Animals

Due to the highly urbanized nature of the Martinez Creek watershed, livestock were not considered a significant source of bacteria loading. 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 7 summarizes the estimated number of dogs and cats within the Martinez Creek watershed. 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, 2010). The actual contribution and significance of bacteria loads from pets in the Martinez Creek watershed is unknown.

Table 7. Estimated households and pet populations for the Martinez Creek watershed.

Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
17,620	10,290	11,242

On-site Sewage Facilities

Estimates of the number of OSSFs in the Martinez Creek watershed were determined using spatial data supplied by the Bexar County Public Works Department (BCPW). The BCPW data indicate that there are 14 OSSFs located within the project watershed (Table 8 and Figure 7).

Table 8. OSSF permits for the Martinez Creek watershed.

Watershed	Segment/AU Number	Permitted OSSFs
Martinez Creek	1911I	14

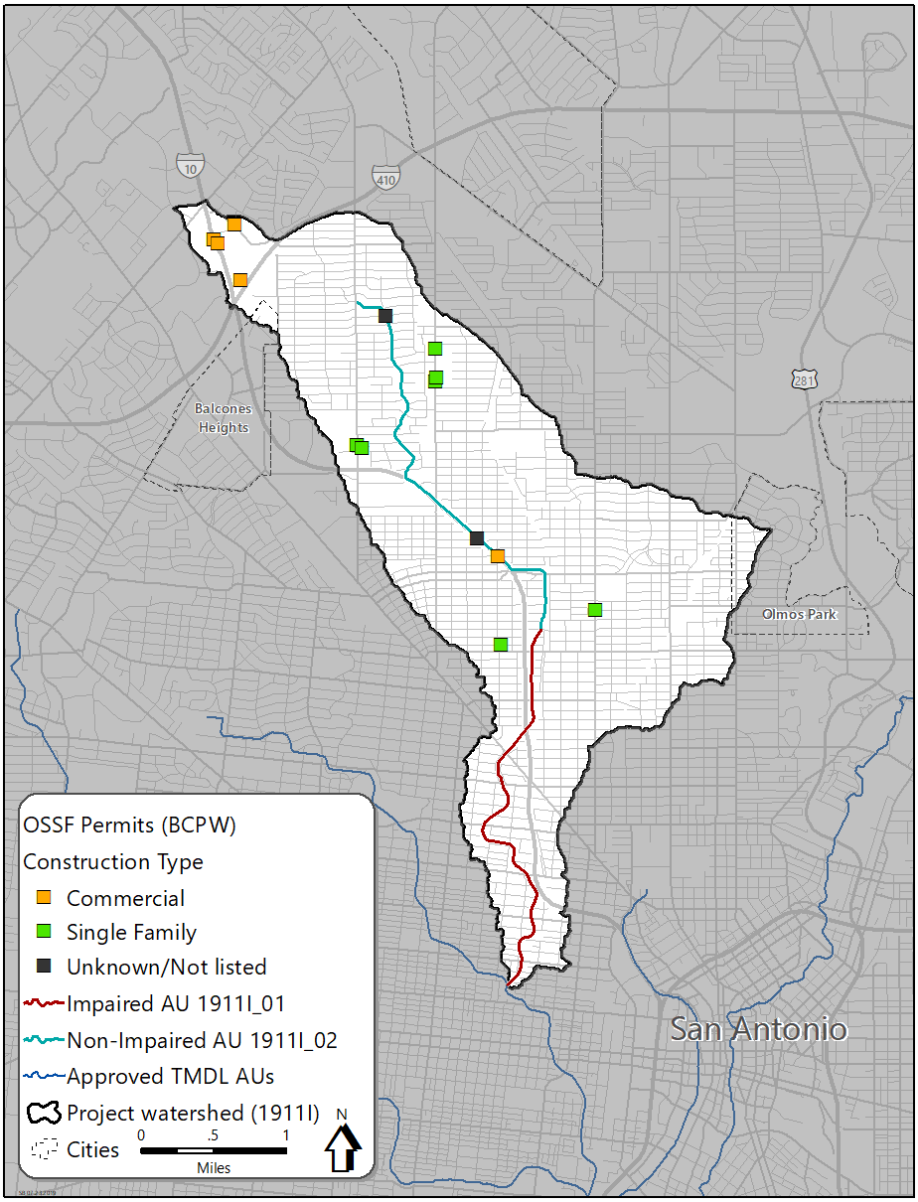

Figure 7. Map showing OSSFs located within the Martinez Creek watershed.

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 allocation. 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 (Brady et al., 2019) provides details about the linkage analysis and the LDC method and its application.

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 TMDL for Martinez Creek was derived using the median flow within the high flows regime (or 10 percent flow) of the LDC developed for SWQM Station 12751, the most downstream station in the watershed (Figure 8).

For the Martinez Creek LDC, the wet weather data points occurred predominately under the higher flow regimes and consistently exceeded the geometric mean criterion. Wet weather data points in the lowest flow regime typically represent bacteria data collected after a small rainfall-runoff event when conditions up to the event were very dry. Often the non-wet weather event data points also exceed the geometric mean criterion for Martinez Creek. The geometric means of existing data for all three flow regimes show that *E. coli* levels are consistently greater than the geometric mean criterion for the waterbody. The allowable load at the single sample criterion (399 cfu/100 mL) is included on the LDC for comparison with individual *E. coli* samples, although it is not used for assessment or allocation purposes.

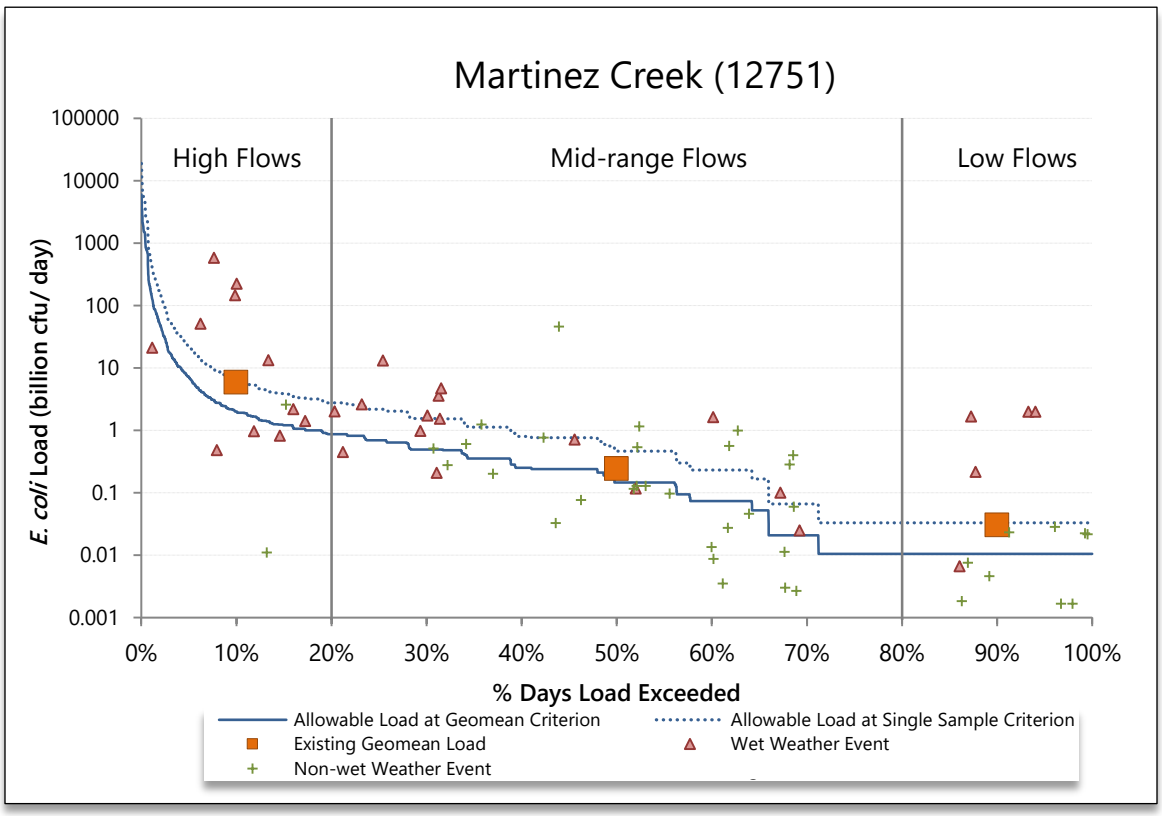

Figure 8. LDC for Martinez Creek (Station 12751).

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 would be 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/100 mL *E. coli*) is used as the WWTF target to provide instream and downstream load capacity and to be consistent with previously developed TMDLs. Due to the absence of any permitted dischargers in the Martinez Creek watershed and to remain consistent with the previous TMDLs, the WLA_{WWTF} component is zero.

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 (defined as the area designated as urbanized area in the 2010 U.S. Census) 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. As noted earlier, Phase I and Phase II permits provide 100 percent MS4 coverage for the Martinez Creek watershed.

However, even in highly urbanized areas such as the Martinez Creek watershed, there remain small areas of streams within each watershed that are not strictly regulated, and which may receive bacteria loadings from unregulated sources such as wildlife. To account for these small unregulated areas, the stream length based on the TCEQ description of AU 1911I_01 was multiplied by the average channel width as calculated based on recent aerial imagery, and the results were used to compute an area of unregulated stormwater contribution, totaling 37.6 acres. Therefore, the percentage of land under the jurisdiction of stormwater permits in the Martinez Creek watershed was 99.19 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).

As noted previously, the Martinez Creek watershed is entirely within the collection system area of the SAWS. Additionally, there are no WWTFs within the Martinez Creek watershed and there are no plans to build a new WWTF within the watershed (SAWS, 2019). Due to 100 percent coverage of wastewater collection by the SAWS collection system and the absence of WWTFs in the Martinez Creek watershed, the FG component for impaired AU 1911I_01 is zero. This approach for FG also remains consistent with the previous TMDLs.

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 9 summarizes the TMDL calculation for Martinez Creek AU 1911I_01. The TMDL was calculated based on the median flow in the 0-20 percentile range (10 percent exceedance, high flows regime) for flow exceedance from the LDC developed for the monitoring station 12751. Allocations are based on the current geometric mean criterion for *E. coli* of 126 cfu/100 mL for each component of the TMDL (although one-half the criterion would have been used to calculate the WLA_{WWTF} and FG terms, had these terms been non-zero).

Table 9. TMDL allocation summary for Martinez Creek.

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	FG	MOS
Martinez Creek	1911I_01	2.0031	0	1.8875	0.0154	0	0.1002

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

The final TMDL allocations (Table 10) 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 10. Final TMDL allocations for Martinez Creek.

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
Martinez Creek	1911I_01	2.0031	0	1.8875	0.0154	0.1002

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 11 years (2008 through 2018) of routine monitoring collected in the warmer months (May through September) against those collected during the cooler months (October through April). 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 Martinez Creek at station 12751. 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 (Brady et al., 2019) was posted on the TMDL project webpage on July 30, 2019. A presentation on this addendum was given at an annual status meeting for

the *Implementation Plan for Three Total Maximum Daily Loads for Bacteria in the Upper San Antonio Watersheds* in San Antonio on September 5, 2019. The public will have an opportunity to comment on this addendum during the official Water Quality Management Plan 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 March 23 through April 23, 2007. No comments were submitted related to Martinez Creek.

Implementation and Reasonable Assurance

The segment covered by this addendum is within the existing bacteria TMDL watersheds of Salado Creek, Walzem Creek, and Upper San Antonio River. Those TMDL watersheds including Martinez Creek are addressed by the implementation plan developed by the Upper San Antonio River Watershed Stakeholder Coordination Committee, which was approved by the commission on April 6, 2016. 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.

References

AVMA (American Veterinary Medical Association). 2015. 2012 U.S. Pet Ownership Statistics. Retrieved June 26, 2019, from: <www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx>.

Brady, S., Millican, J., and Hauck, L. 2019. *Technical Support Document for a Total Maximum Daily Load for Indicator Bacteria in Martinez Creek: Segment 1911I.* Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas. Available online at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/34uppersa/34-martinez-creek-tsd.pdf>.

Cleland, B. 2003. *TMDL Development from the "Bottom Up" -- Part III: Duration Curves and Wet-Weather Assessments*. Retrieved June 27, 2019, from: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.566.9879&rep=rep1&type=pdf>.

Larkin, T. J., and Bomar, G. W. 1983. *Climatic Atlas of Texas*. Retrieved June 26, 2019, from: <www.twdb.texas.gov/publications/reports/limited_printing/doc/LP192.pdf>.

MRLC. 2019. *NLCD 2016 Land Cover Conterminous United States.* Retrieved June 25, 2019 from: <www.mrlc.gov/data/nlcd-2016-land-cover-conus>.

NOAA. 2019a. *Daily Summaries – San Antonio International Airport, TX US USW00012921.* Retrieved November 28, 2018, from: <www.ncdc.noaa.gov/cdo-web/>.

NOAA. 2019b. Summary of Monthly Normals 2004-2018 San Antonio International Airport, TX US USW00012921. Retrieved July 10, 2019, from: <www.ncdc.noaa.gov/cdo-web/>.

SAWS. 2019. Communications via emails with Ken Diehl (Environmental Protection Specialist) on future growth for WWTFs within the Martinez Creek watershed, June 25 through July 2, 2019.

TCEQ. 2007. *Three Total Maximum Daily Loads for Bacteria in the San Antonio Area*. Retrieved July 10, 2019, from: <www.tceq.texas.gov/assets/public/waterquality/tmdl/34uppersa/34-uppersanantoniotmdl-adopted.pdf>.

TCEQ. 2010. *2010 Texas Surface Water Quality Standards*. Final 2010 Chapter 307 Rule Amendment. Retrieved June 26, 2019, from: <https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y>.

TCEQ. 2015. *2014 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)*. Retrieved June 20, 2019, from: <www.tceq.texas.gov/waterquality/assessment/14twqi/14txir>.

TCEQ. 2016. Addendum One to Three Total Maximum Daily Loads for the Upper San Antonio Watershed. Seven Total Maximum Daily Loads for Bacteria in the Upper San Antonio Watershed. Retrieved June 26, 2019, from: <www.tceq.texas.gov/assets/public/waterquality/tmdl/34uppersa/34-usar_addendum_2016-04.pdf>.

TCEQ. 2018. *2016 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)*. Retrieved June 20, 2019, from: <www.tceq.texas.gov/waterquality/assessment/16twqi/16txir>.

TCEQ. 2019. *Water Quality General Permits & Registration Search - Advanced Search*. Retrieved May 30, 2019, from: <www2.tceq.texas.gov/wq_dpa/index.cfm>.

TWDB. 2019. *2021 Regional and 2022 State Water Plan Projections Data*. Retrieved October 29, 2019, from: <www.twdb.texas.gov/waterplanning/ data/projections/index.asp>.

USCB. 2011. *Census Blocks - Population & Housing Unit Counts*. Retrieved December 4, 2018, from: <www.census.gov/geo/maps-data/data/tiger-data.html>.