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Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek

Assessment Units 0603A_01 and 0603B_01

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

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This total maximum daily load report is based in large part on the report titled:
"Technical Support Document for Two Total Maximum Daily Loads
for Indicator Bacteria in Sandy Creek and Wolf Creek"
by Michael Schramm and Achla Jha of the Texas Water Resources Institute.

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

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Abbreviations

AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfu	colony forming units
CGP	construction general permit
DAR	drainage area ratio
E. coli	Escherichia coli
EPA	Environmental Protection Agency (United States)
FDC	flow duration curve
FG	future growth
ft^3	cubic feet
I/I	inflow and infiltration
I-Plan	implementation plan
LA	load allocation
LDC	load duration curve
MCM	minimum control measure
mL	milliliter
MGD	million gallons per day
MOS	margin of safety
MS4	municipal separate storm sewer system

MSGP	multi-sector general permit
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
OSSF	on-site sewage facility
PUC	Public Utility Commission of Texas
RMU	Resource Management Unit
s/d	seconds per day
SSO	sanitary sewer overflow
SSURGO	Soil Survey Geographic Database
SWMP	Stormwater Management Program
SWQM	surface water quality monitoring
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
U.S.	United States
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WLA	wasteload allocation
WQBEL	water quality-based effluent limits
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek

Executive Summary

This document describes two total maximum daily loads (TMDLs) for Sandy Creek and Wolf Creek, where concentrations of indicator bacteria exceed the criterion used to determine attainment of the primary contact recreation 1 use. The Texas Commission on Environmental Quality (TCEQ) first identified the bacteria impairment of Sandy Creek in the *2000 Texas Surface Water Quality Inventory and 303(d) List* (Texas Integrated Report, TCEQ, 2002). The bacteria impairment of Wolf Creek was first identified in the 2006 Texas Integrated Report (TCEQ, 2007). The impaired water bodies and identifying assessment units (AUs) are:

- Sandy Creek (AU 0603A_01)
- Wolf Creek (AU 0603B_01)

Sandy Creek and Wolf Creek are in southeast Texas in the Neches River Basin. Both creeks flow into B. A. Steinhagen Lake. Sandy Creek is located entirely in Jasper County, flowing through the city of Jasper to its confluence with B. A. Steinhagen Lake. Wolf Creek is located entirely in Tyler County, with headwaters located roughly halfway between Woodville and Colmesneil, then flowing easterly to its confluence with B. A. Steinhagen Lake.

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

The Sandy Creek watershed is a primarily rural, forested watershed that includes the City of Jasper and is approximately 57 square miles. There is one domestic wastewater treatment facility (WWTF) within the Sandy Creek watershed. Regulated stormwater comprises less than 1% of the Sandy Creek watershed.

The Wolf Creek watershed is also a primarily rural, forested watershed that includes the town of Colmesneil and is approximately 83 square miles. No WWTFs discharge within the Wolf Creek watershed. Although the City of Colmesneil WWTF is in the Wolf Creek watershed, it discharges outside of the

watershed to an unclassified stream with no TCEQ Segment ID. Regulated stormwater accounts for less than 1% of the Wolf Creek watershed.

A load duration curve (LDC) analysis was used to quantify allowable pollutant loads and specific TMDL allocations for point and nonpoint sources of indicator bacteria.

For Sandy Creek, the wasteload allocation (WLA) for WWTFs was established as the permitted discharge flow rate multiplied by the instream geometric mean criterion for the indicator bacteria. Future growth (FG) of existing or new domestic point sources in the Sandy Creek watershed was determined using population projections.

No WLA for WWTFs was established for Wolf Creek because there are no permitted discharges within the watershed. However, an FG allowance was allocated to account for future loadings that might occur due to population growth, changes in community infrastructure, and development. FG of new domestic point sources in the Wolf Creek watershed was established as the current permitted discharge flow rate for the City of Colmesneil WWTF.

The TMDL calculations in this report will guide determination of the assimilative capacity of each water body under changing conditions, including FG. WWTF discharges will be evaluated case by case.

Compliance with these TMDLs is based on keeping indicator bacteria concentrations in Sandy Creek and Wolf Creek below the geometric mean criterion of 126 cfu/100 mL for attainment of the primary contact recreation 1 use.

Introduction

Section 303(d) of the federal Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a TMDL for each pollutant that contributes to the impairment of a water body included on a state's 303(d) list of impaired waters. TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

A TMDL is like a budget—it determines the amount of a particular pollutant that a water body can receive and still meet applicable water quality standards. TMDLs are the best possible estimates of the assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load with units of mass per period of time but may be expressed in other ways.

The TMDL Program is a major component of Texas' overall process for managing the quality of its surface waters. The program addresses impaired or threatened streams, reservoirs, lakes, bays, and estuaries (water bodies) in, or bordering on, the state of Texas. The program's primary objective is to restore and maintain water quality uses—such as drinking water supply, recreation, support of aquatic life, or fishing—of impaired or threatened water bodies.

This TMDL document addresses impairment of the primary contact recreation 1 use due to exceedances of indicator bacteria criteria in Sandy Creek (AU 0603A_01) and Wolf Creek (AU 0603B_01). This TMDL takes a watershed approach to address the bacteria impairments. While TMDL allocations were developed only for the impaired AUs identified in this report, the entire project watersheds (Figure 1) and all WWTFs that discharge within them are included within the scope of this TMDL. Information in this TMDL document was derived from the *Technical Support Document for Two Total Maximum Daily Load for Indicator Bacteria in Sandy Creek and Wolf Creek*[1] (Schramm and Jha, 2020).

Section 303(d) of the Clean Water Act and the implementing regulations of the United States (U.S.) Environmental Protection Agency (EPA) in Title 40 of the Code of Federal Regulations (CFR), Part 130 (40 CFR 130) describe the statutory and regulatory requirements for acceptable TMDLs. EPA provides further direction in its *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA, 1991). This TMDL document has been prepared in accordance with those regulations and guidelines.

TCEQ must consider certain elements in developing a TMDL. They are described in the following sections of this report:

- Problem Definition
- Endpoint Identification
- Source Analysis
- Linkage Analysis
- Margin of Safety
- Pollutant Load Allocation
- Seasonal Variation
- Public Participation
- Implementation and Reasonable Assurance

Upon adoption of the TMDL report by TCEQ and subsequent EPA approval, these TMDLs will become an update to the state's Water Quality Management Plan (WQMP).

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

Problem Definition

TCEQ first identified the impairment of the primary contact recreation 1 use within Sandy Creek in the 2000 Texas Integrated Report (TCEQ, 2002), and again in each subsequent edition through the EPA-approved 2020 Texas Integrated Report (TCEQ 2020). The impairment of the primary contact recreation 1 use in Wolf Creek was first identified in the 2006 Texas Integrated Report (TCEQ, 2007), and then in each subsequent edition through the EPA-approved 2020 Texas Integrated Report (TCEQ, 2020).

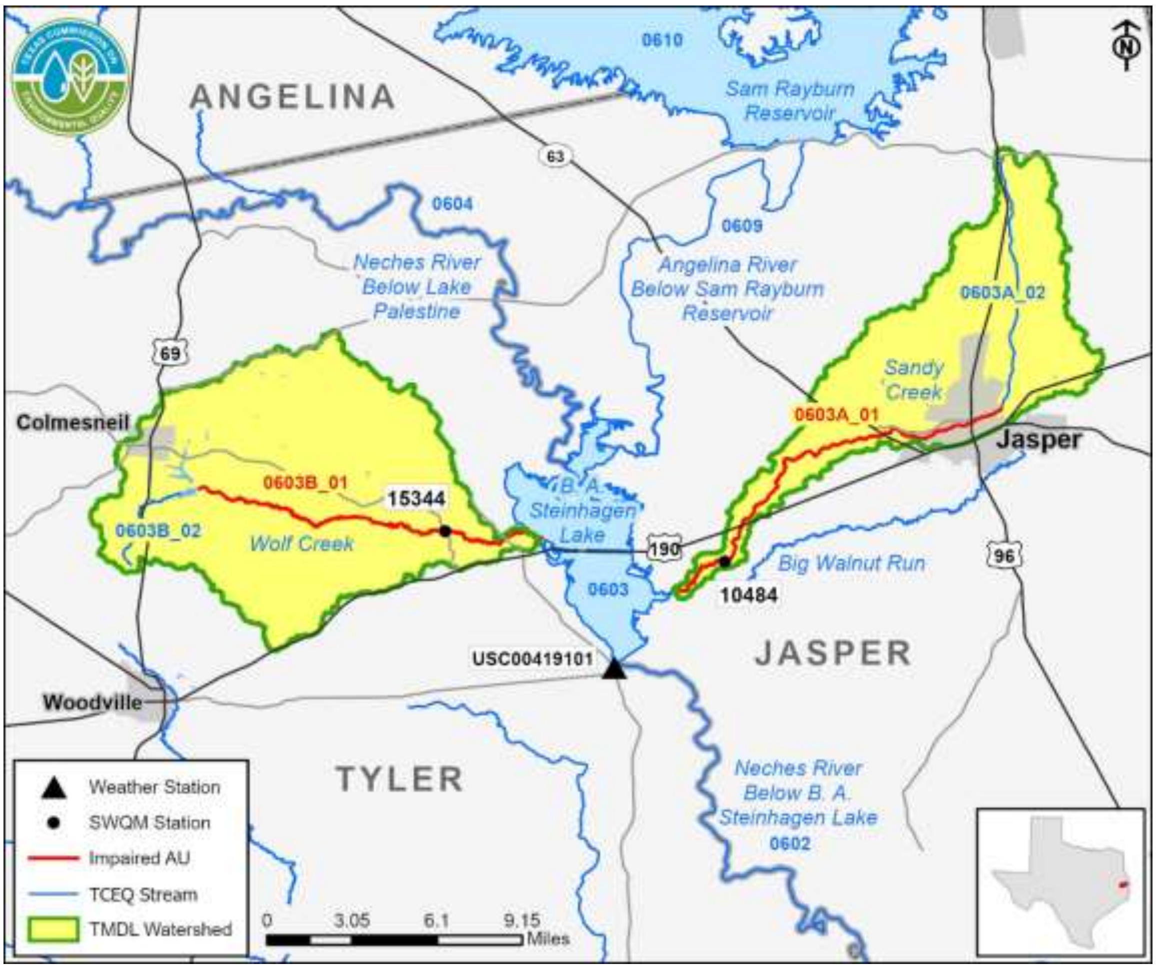

Figure 1. Overview map of the Sandy Creek and Wolf Creek TMDL watersheds

The impaired AUs are:

- Sandy Creek (AU 0603A_01)
- Wolf Creek (AU 0603B_01)

The terms Sandy Creek watershed and Wolf Creek watershed, or simply TMDL watersheds, will be used to the describe the TMDL watersheds depicted in Figure 1.

Ambient Indicator Bacteria Concentration

Recent surface water *E. coli* monitoring within the Sandy Creek watershed occurred at TCEQ surface water quality monitoring (SWQM) Station 10484 (Table 1 and Figure 1). Bacteria monitoring within the Wolf Creek watershed occurred at TCEQ SWQM Station 15344. *E. coli* data collected at these stations from December 1, 2011 through November 30, 2018, were used to determine attainment of the primary contact recreation 1 use as reported in the 2020 Texas Integrated Report (TCEQ, 2020). Data assessed indicate non-support of the primary contact recreation 1 use because geometric mean concentrations of available samples exceed the geometric mean criterion of 126 cfu/100 mL for *E. coli.*

Table 1. 2020 Texas Integrated Report summary for the impaired AUs

Water Body	AU	Parameter	Station	Data Range	No. of Samples	Geometric Mean (cfu/100 mL)
Sandy Creek	0603A_01	*E. coli*	10484	12/01/2011-11/30/2018	20	193.66
Wolf Creek	0603B_01	*E. coli*	15344	12/01/2011-11/30/2018	20	161.49

Watershed Overview

Sandy Creek (0603A) and Wolf Creek (0603B) are in southeast Texas (Figure 1). Sandy Creek is located entirely in Jasper County and consists of two AUs (0603A_01 and 0603A_02). Sandy Creek flows approximately 27 miles from its headwaters near Recreational Road 255 and south through the city of Jasper to its confluence with B. A. Steinhagen Lake. The total watershed area for Sandy Creek is 56.54 square miles (36,184.36 acres).

Wolf Creek is located entirely in Tyler County. Wolf Creek consists of two AUs (0603B_01 and 0603B_02). Wolf Creek flows approximately 23 miles from its headwaters upstream of Lake Amanda to the confluence with B. A. Steinhagen Lake. The total watershed area for Wolf Creek is 83.14 square miles (53,207.52 acres).

The 2020 Texas Integrated Report (TCEQ, 2020) provides the following AU descriptions for the water bodies considered in this document.

- 0603A (Sandy Creek) – From the confluence with B. A. Steinhagen Lake southwest of the City of Jasper in Jasper County upstream to the headwaters at Recreational Road 255 north of Jasper in Jasper County.
  - 0603A_01 From the confluence with B. A. Steinhagen Lake upstream to 0.5 kilometers below FM 776 east of the city of Jasper, per Water Quality Standards Appendix D.

  - 0603A_02 From 0.5 kilometers below FM 776 east of the City of Jasper upstream to headwaters at Recreational Road 255 north of the city of Jasper.

- 0603B (Wolf Creek) – From the confluence of B. A. Steinhagen Lake southeast of Colmesneil in Tyler County to the upstream perennial portion of the stream south of Colmesneil in Tyler County.
  - 0603B_01 From the confluence of B. A. Steinhagen Lake upstream to Lake Amanda Dam.
  - 0603B_02 From the confluence with Lake Amanda upstream to the headwaters.

The Sandy Creek watershed is primarily rural, with large swaths of pine forests contributing to the local forest and paper industries. The city of Jasper is the only municipality in the Sandy Creek watershed. The Wolf Creek watershed is also primarily rural, with a large amount of pine forests. The town of Colmesneil is the only municipality in the watershed. Both watersheds have relatively limited cattle grazing and agricultural production.

Watershed Climate and Hydrology

Regional precipitation and temperature data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center database. The nearest active weather station, Town Bluff Dam Station USC00419101 located at B. A. Steinhagen Lake (Figure 1), was used to summarize temperature and precipitation data from 2000 through 2018 (NOAA, 2019). Precipitation is relatively steady throughout the year, with the highest average monthly precipitation occurring in November at 5.83 inches and the lowest average monthly precipitation occurring in January at 4.01 inches (Figure 2). The highest average monthly maximum temperatures occur in August (93.20° F) and the lowest average monthly minimum temperatures occur in January (38.50° F). From 2000 through 2018, the mean annual precipitation was 58.57 inches with a low of 31.69 inches recorded in 2005 and high of 92.82 inches occurring in 2018 (Figure 3).

Watershed Population and Population Projections

Watershed population estimates were developed using 2010 U.S. Census Bureau (USCB) census block geographic units and population data (USCB, 2010). Census blocks are the smallest geographic units used by USCB to tabulate population data. Using the methodology outlined in Appendix A, the 2010 population of the Sandy Creek watershed is estimated at 7,462 people. The 2010 population of the Wolf Creek watershed is estimated at 1,683 people (Figure 4).

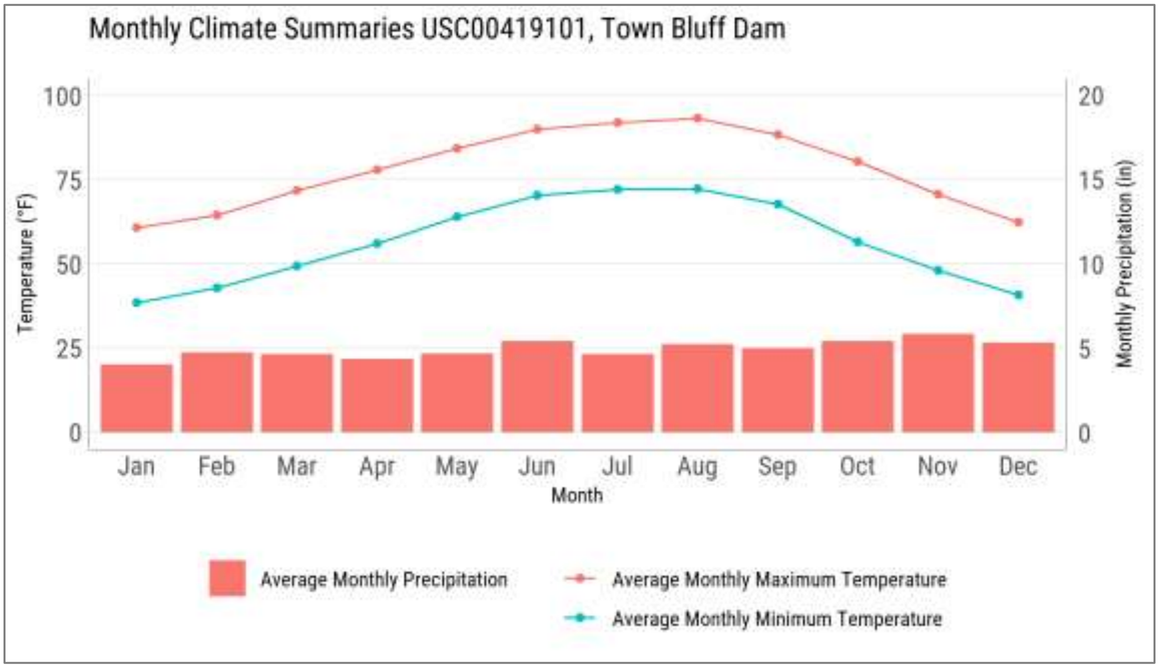

Figure 2. Average monthly temperature and precipitation (2000-2018) at Town Bluff Dam, Texas Station USC00419101

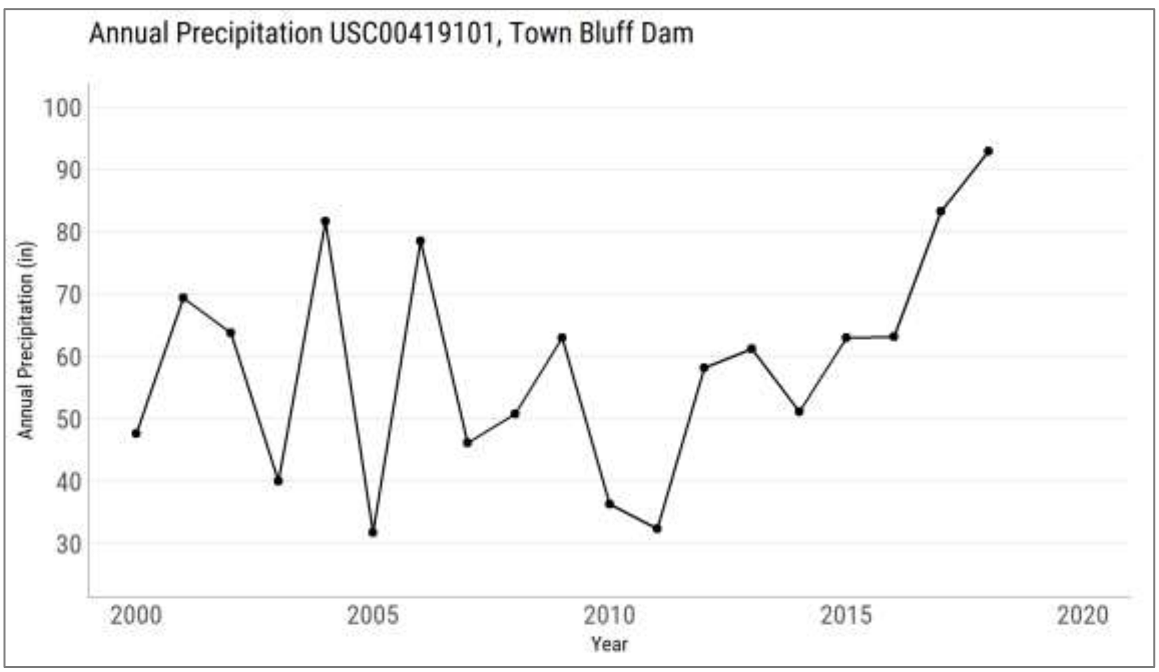

Figure 3. Annual precipitation (2000-2018) at Town Bluff Dam, Texas Station USC00419101

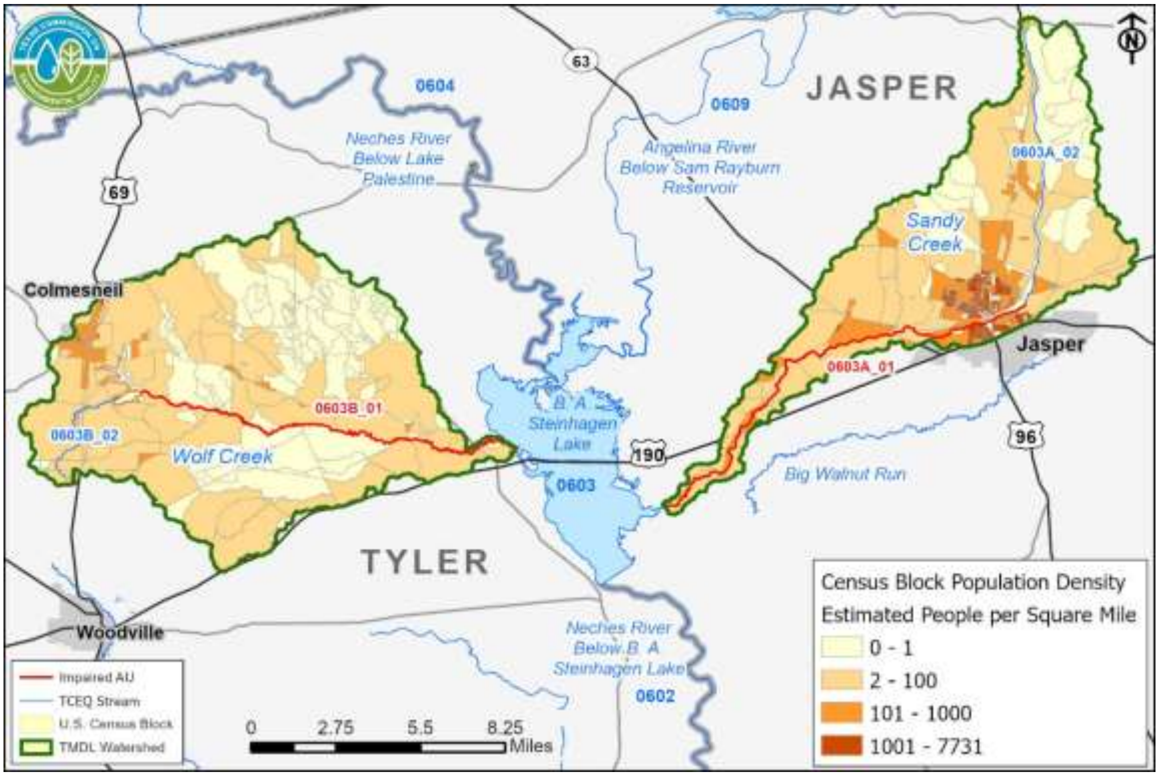

Figure 4. 2010 population density estimates using USCB census block data in Sandy and Wolf Creek TMDL watersheds

Texas Water Development Board (TWDB) 2021 Regional Water Plan Population and Water Demand Projection data (TWDB, 2019) provide population projections for counties within the watersheds. The population projections developed by TWDB indicate a 2.6% increase in population for Jasper County (Sandy Creek watershed) and a 0.5% population increase in Tyler County (Wolf Creek watershed) from 2020 through 2070. Future watershed populations (Table 2) were estimated using the methodology outlined in Appendix A.

Table 2. Sandy Creek and Wolf Creek watersheds population estimates and population projections

Watershed	2020 Population	2070 Population	Projected Increase (2020-2070)	Percentage Increase (2020-2070)
Sandy Creek	7,708	7,908	200	2.6%
Wolf Creek	1,723	1,732	9	0.5%

Land Cover

The land cover data for the watersheds was obtained from the U.S. Geological Survey (USGS) 2016 National Land Cover Database (NLCD) (USGS, 2019a), and is displayed in Figure 5.

The land cover found in the Sandy Creek and Wolf Creek watersheds includes the following categories and definitions (USGS, 2014).

- **Open Water** – Areas of open water, generally with less than 25% cover of vegetation or soil.
- **Developed, Open Space** – Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- **Developed, Low Intensity** – Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% of total cover. These areas most commonly include single-family housing units.
- **Developed, Medium Intensity** – Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of total cover. These areas most commonly include single-family housing units.
- **Developed, High Intensity** – Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of total cover.
- **Barren Land (Rock/Sand/Clay)** – Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
- **Deciduous Forest** – Areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
- **Evergreen Forest** – Areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. More than 75% of the species maintain their leaves all year. Canopy is never without green foliage.

- **Mixed Forest** – Areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
- **Shrub/Scrub** – Areas dominated by shrubs; less than five meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
- **Grasslands/Herbaceous** – Areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing.
- **Pasture/Hay** – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
- **Cultivated Crops** – Areas used to produce annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class includes all land being actively tilled.
- **Woody Wetlands** – Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
- **Emergent Herbaceous Wetlands** – Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil substrate is periodically saturated with or covered with water.

The predominant land cover categories in the Sandy Creek watershed are Evergreen Forest (44.9%) and Shrub/Scrub (12.8%) (Table 3). Total developed land cover accounts for 14.5% of the Sandy Creek watershed.

The predominant land cover categories in the Wolf Creek watershed are Evergreen Forest (49.9%) and Grassland/Herbaceous (13.9%). Total developed land cover accounts for 5% of the Wolf Creek watershed.

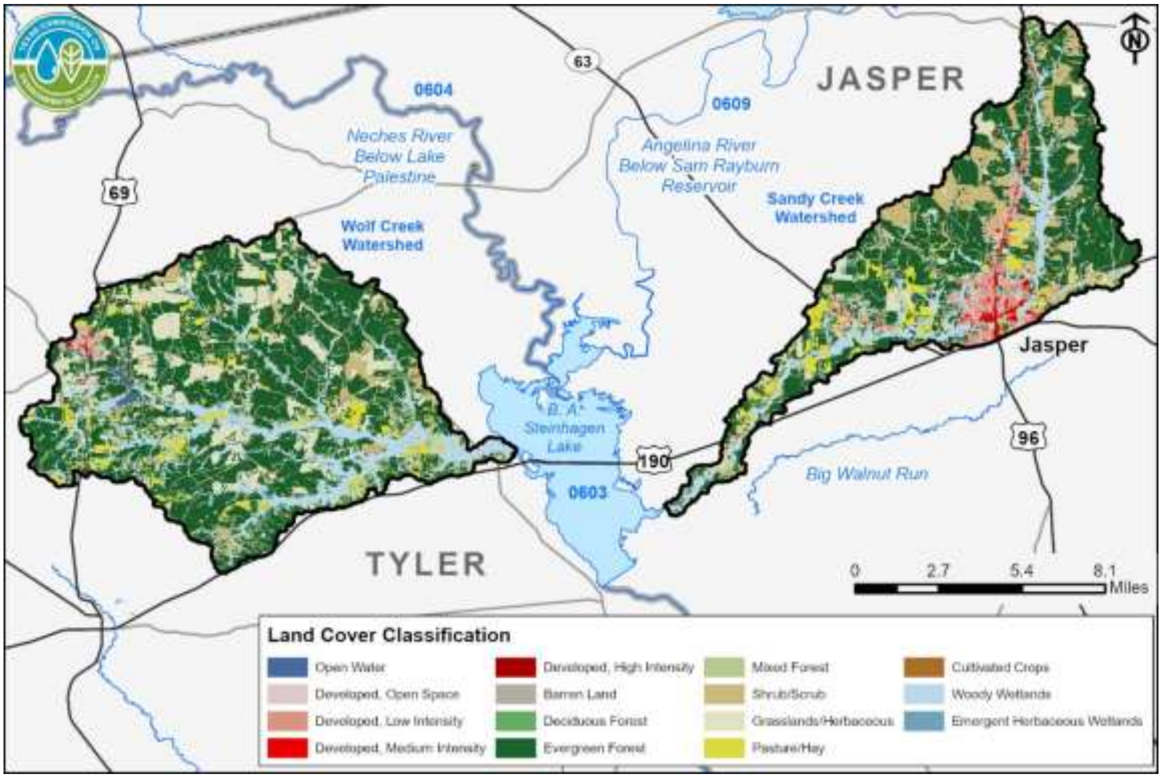

Figure 4. 2016 land cover within the Sandy Creek and Wolf Creek TMDL watersheds

Table 3. Land cover summary in Sandy Creek and Wolf Creek TMDL watersheds

2016 NLCD Classification	Sandy Creek Watershed Percentage of Total	Wolf Creek Watershed Percentage of Total
Open Water	0.2%	0.5%
Developed, Open Space	6.6%	3.5%
Developed, Low Intensity	5.9%	1.4%
Developed, Medium Intensity	1.4%	0.1%
Developed, High Intensity	0.6%	0.0%
Barren Land	0.3%	0.0%
Deciduous Forest	0.3%	0.1%
Evergreen Forest	44.9%	49.9%
Mixed Forest	4.1%	7.6%
Shrub/Scrub	12.8%	4.7%
Grassland/Herbaceous	6.4%	13.9%
Pasture/Hay	5.7%	4.4%
Cultivated Crops	0%	0%
Woody Wetlands	10.5%	13.4%
Emergent Herbaceous Wetlands	0.3%	0.4%
Total	**100%**	**100%**[a]

[a] Totals differ slightly from 100% due to rounding.

Soils

Soils within the Sandy Creek and Wolf Creek watersheds are categorized by hydrologic groups that describe infiltration and runoff potential. These data are provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (NRCS, 2018).

The SSURGO data assign different soils to one of seven possible runoff potential classifications or hydrologic groups. These classifications are based on the estimated rate of water infiltration when soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The four main groups are A, B, C, and D, with three dual classes (A/D, B/D, C/D). The SSURGO database defines the following classifications.

- **Group A** – Soils having high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well-drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- **Group B** – Soils having a moderate infiltration rate when thoroughly wet. These consist of moderately deep or deep, moderately well-drained or well-drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- **Group C** – Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- **Group D** – Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.
    - Soils with dual hydrologic groupings indicate that drained areas are assigned the first letter, and the second letter is assigned to undrained areas. Only soils that are in group D in their natural condition are assigned to dual classes.

The Sandy Creek watershed is composed mostly of soils in hydrologic Group A (69.54%) (Table 4). Spatial distribution of soil hydrologic groups within the project watershed is depicted in Figure 5. The figure shows that most of the Group A soils are found in the upper portion of the watershed. In the downstream portions of the watershed, less well draining soils become more prevalent.

The Wolf Creek watershed is mostly composed of Group A (38.83%) and Group B (26.92%) soils. The Group A and B soils are mainly found north of Wolf Creek. South of Wolf Creek, Group C and D soils become more prevalent.

Table 4. Hydrologic soil group summary for Sandy Creek and Wolf Creek watersheds

Hydrologic Group	Sandy Creek Watershed (Percentage of total)	Wolf Creek Watershed (Percentage of total)
A	69.54%	38.83%
A/D	2.01%	0%
B	11.94%	26.92%
B/D	3.22%	0.39%
C	11.17%	10.65%
C/D	0%	0.12%
D	2.12%	23.10%
Total	**100%**	**100%***

* Totals differ slightly from 100% due to rounding.

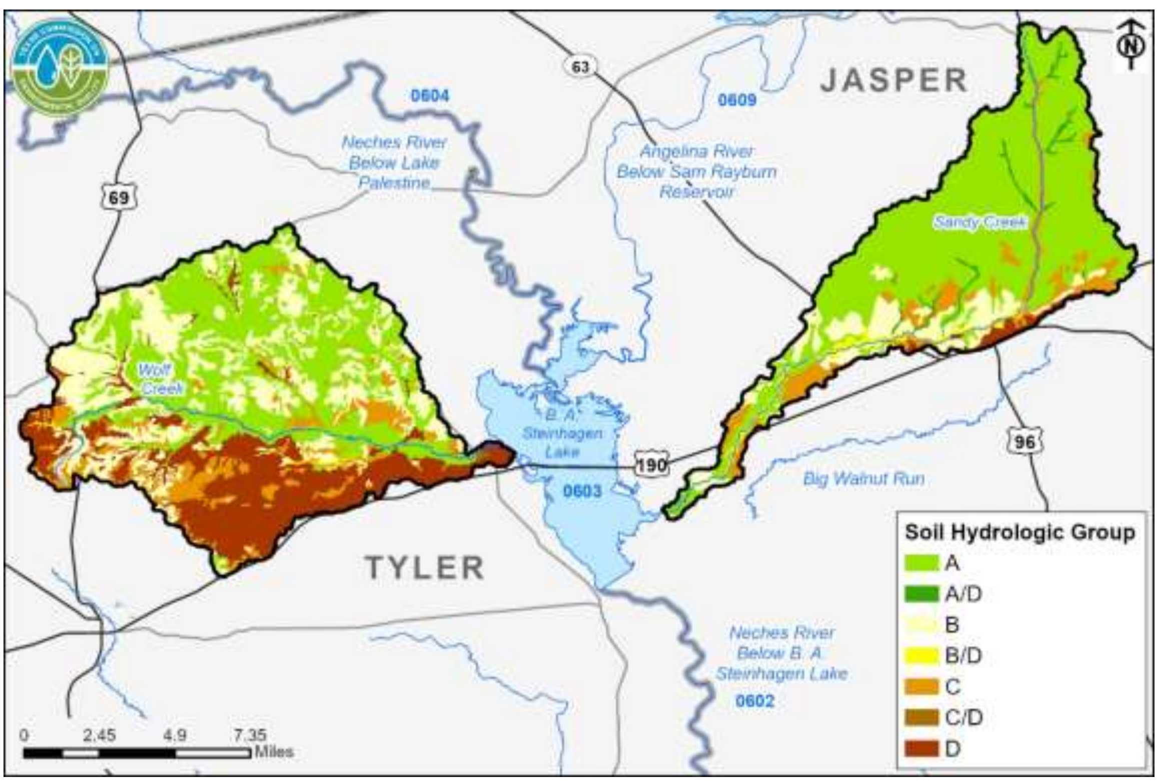

Figure 5. Hydrologic soil groups for Sandy Creek and Wolf Creek watersheds

Endpoint Identification

All TMDLs must identify a quantifiable water quality target that indicates the desired water quality condition and provides a measurable goal for the TMDL. The TMDL endpoint also serves to focus the technical work to be accomplished and as a criterion against which to evaluate future conditions.

The endpoint for these TMDLs is to maintain concentrations of *E. coli* below the geometric mean criterion of 126 cfu/100 mL, which is protective of the primary contact recreation 1 use in freshwater (TCEQ, 2018).

Source Analysis

Pollutants may come from several sources, both regulated and unregulated. Regulated pollutants, referred to as "point sources," come from a single definable point, such as a pipe, and are regulated by permit under the Texas Pollutant Discharge Elimination System (TPDES) program. WWTFs and stormwater discharges from industries, construction, and municipal separate storm sewer systems are considered point sources of pollution.

Unregulated sources are typically nonpoint source in origin, meaning the pollutants originate from multiple locations and rainfall runoff washes them into surface waters. Nonpoint sources are not regulated by permit.

Except for WWTFs, which receive individual WLAs (see the "Wasteload Allocation" section), the regulated and unregulated sources in this section are presented to give a general account of the different sources of bacteria expected in the watersheds. These are not meant to be used for allocating bacteria loads or interpreted as precise inventories and loadings.

Regulated Sources

Regulated sources are controlled by permit under the TPDES program. The regulated sources in the TMDL watersheds include a single domestic WWTF and stormwater from construction sites and concrete production.

Domestic and Industrial WWTFs

As of April 2019, there is one domestic WWTF that operates within the Sandy Creek watershed (Table 5, Figure 7, TCEQ, 2019a). No TPDES-permitted WWTFs discharge within the Wolf Creek watershed. Although the City of Colmesneil WWTF is located in the Wolf Creek watershed, it discharges outside of the watershed to an unclassified stream without a TCEQ Segment ID. Therefore, this facility's discharge is not considered in the loading allocations for Wolf Creek (0603B_01). There are no industrial WWTFs in the TMDL watersheds.

TCEQ/TPDES Water Quality General Permits

Certain types of activities must be covered by one of several TCEQ/TPDES general permits.

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

Table 5. Summary of permitted WWTFs in the Sandy Creek TMDL watershed

AU	TPDES Number	NPDES Number[a]	Facility/ Permittee	Outfall Number	Bacteria Limits (cfu/100 mL)	Primary Discharge Type	Daily Average Flow – Permitted Discharge (MGD[b])
0603A_01	WQ0010197001	TX0024368	City of Jasper WWTF/ City of Jasper	001	126	treated domestic wastewater	3.25

[a] NPDES = National Pollutant Discharge Elimination System

[b] MGD = million gallons per day

A review of active general permit coverage (TCEQ, 2019b) in the Sandy Creek watershed as of May 20, 2020, indicated there is one concrete production facility (Figure 7) covered by a general permit (TXG110000). The permit authorizes the discharge of facility wastewater and stormwater associated with industrial activities from ready-mixed concrete plants, concrete products plants, and their associated facilities and is included in the regulated stormwater allocations. This facility covers approximately 0.028 square miles (Figure 7**Error! Reference source not found.**). TCEQ found no other activities covered under a general permit in the Sandy Creek watershed or the Wolf Creek watershed.

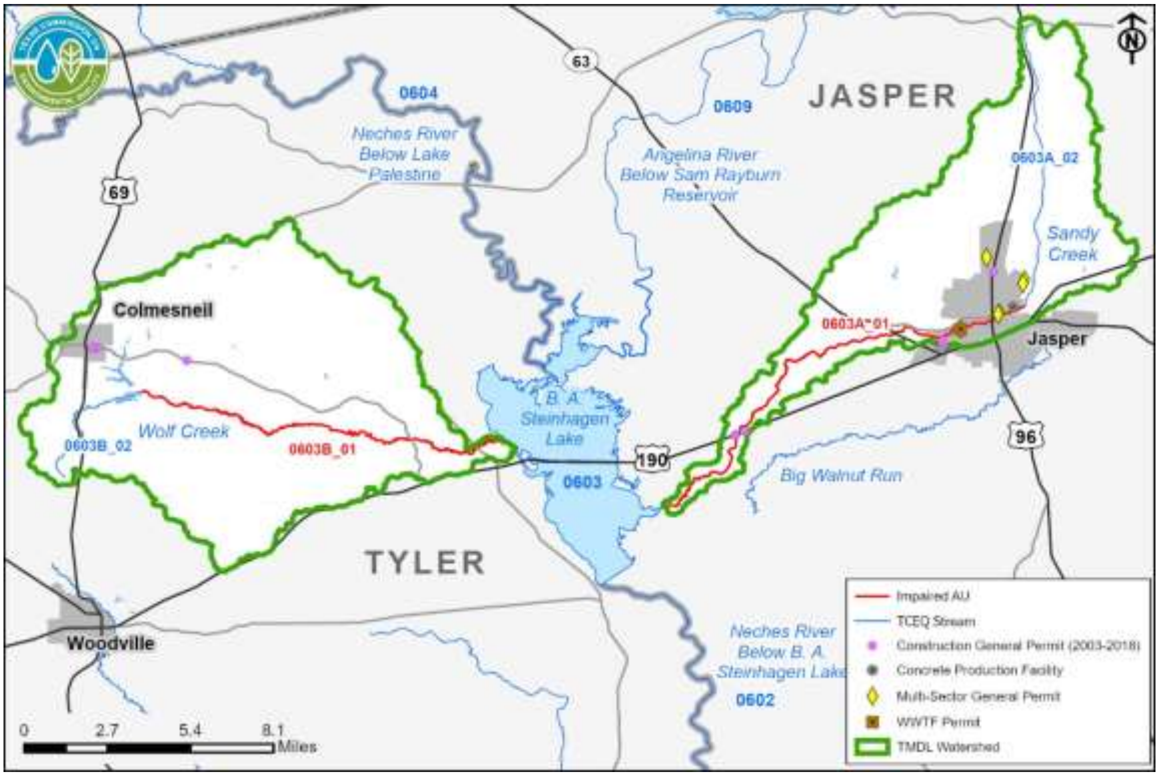

Figure 7. Regulated sources in the Sandy Creek and Wolf Creek TMDL watersheds

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party, either the TPDES permittee or the owner of the collection system that is connected to a permitted system. These overflows in dry weather most often result from blockages in the sewer collection pipes caused by tree roots, grease, and other debris. Inflow and infiltration (I/I) are typical causes of SSOs under conditions of high flow in the WWTF system. Blockages in the line may exacerbate the I/I problem. Other causes, such as a collapsed sewer line, may occur under any condition.

Table 6. Summary of reported SSO events (2005-2018) within the TMDL watersheds

Water Body	Estimated incidents	Total Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
0603A	196	947,860	10	240,000
0603B[b]	4	8,500	1,500	3,000

[b] Although the Wolf Creek watershed does not have any permitted discharges, the service area for the Colmesneil WWTF collection system is within the watershed and reported SSOs are noted in the table.

TCEQ Central Office in Austin provided statewide data on SSO incidents from January 2016 through December 2018 (TCEQ, 2019c) and basin-wide data on

SSO incidents from 2005 through 2015 (TCEQ, 2019d). These data typically contain estimates of the total gallons spilled, the responsible entity, and a general location of the spill. The number and volume of overflow incidents in the watershed are included in Table 6.

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 systems (MS4s), stormwater discharges associated with industrial facilities, and regulated construction activities.
2) Stormwater runoff not subject to regulation.

TPDES MS4 Phase I and II rules require municipalities and certain other entities in urbanized 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 MS4s with populations of 100,000 or more based on the 1990 U.S. Census, whereas the Phase II general permit regulates small MS4s within an urbanized area as defined by USCB.

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

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

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

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

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

The geographic region of the Sandy Creek and Wolf Creek watersheds is not within a USCB defined urbanized area and does not include any Phase I or Phase II MS4 permits. A review of active stormwater general permits coverage (TCEQ, 2019b) in the Sandy Creek watershed, as of December 31, 2018, revealed seven MSGP authorized facilities and one concrete production facility with a stormwater discharge (Table 7). No active stormwater general permit authorizations were found in the Wolf Creek watershed.

Table 7. Summary of active TPDES general permit authorizations (as of 12/31/2018)

AU	Authorization Holder	TPDES General Permit Type	Authorization Number	Estimated Site Area (square miles)
0603A_01	City of Jasper	MSGP	TXR05V360	0.009
0603A_01	APAC-Texas, Inc.	MSGP	TXR05AK68	0.044
0603A_01	APAC-Texas, Inc.	MSGP	TXR05AK73	0.005
0603A_01	Terra Biochem, L.L.C.	MSGP	TXR05AX84	0.019
0603A_01	North Star RMS, LLC	MSGP	TXR05BW41	0.042
0603A_01	Beaumont Iron & Metal Corporation DBA Jasper Iron & Metal	MSGP	TXR05P538*	0.003
0603A_01	Rogers Auto Salvage Yard	MSGP	TXR05EB42	0.032
0603A_01	Few Ready Mix Concrete Co.	Concrete Production	TXG110385	0.028
			0603A_01 Total	0.182
			0603B_01 Total	0

* TXR05P538 was terminated 2/27/2020, but not removed from total area since the estimation is reasonable.

On average, 0.06 square miles (35.51 acres) per year were regulated under CGP authorizations in the Sandy Creek watershed from January 2015 through December 2018, with four authorizations during that time span. On average, 0.01 square miles (7.04 acres) per year were under CGP authorizations from January 2015 through December 2018, with three authorizations during that time span in the Wolf Creek watershed.

Total area of regulated stormwater for the TMDLs was calculated based on the review above to provide a reasonable estimate of the portion of each watershed that may be subject to stormwater regulation at any given time. Regulated stormwater comprises only 0.24 square miles in the Sandy Creek watershed and 0.01 square miles in the Wolf Creek watershed.

Illicit Discharges

Pollutant loads can enter water bodies from MS4 outfalls that carry authorized sources as well as illicit discharges under both dry- and wet-weather conditions. The term "illicit discharge" is defined in TPDES General Permit TXR040000 for Phase II MS4s as "Any discharge to a municipal separate storm sewer that is not entirely composed of stormwater, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency firefighting activities." Illicit discharges can be categorized as either direct or indirect contributions. Examples of illicit discharges identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003) include:

Direct Illicit Discharges

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

Indirect Illicit Discharges

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

Unregulated Sources

Unregulated sources of fecal bacteria are generally nonpoint. Nonpoint source loading enters the impaired water body through distributed, nonspecific locations, which may include urban runoff not covered by a permit. Potential sources detailed below include wildlife, various agricultural activities, domestic animals, failing on-site sewage facilities (OSSFs), and unmanaged and feral animals.

Unregulated Agricultural Activities and Domesticated Animals

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

Table 8 provides estimated numbers of selected livestock in the project watershed based on the 2017 Census of Agriculture conducted by USDA (USDA, 2019). The county-level data were refined to reflect acres of grazeable land within each TMDL watershed as identified in the 2016 NLCD and were reviewed by Texas State Soil and Water Conservation Board staff. The refinement was determined by the area classified in the 2016 NLCD as Pasture/Hay and Grassland/Herbaceous in the watershed divided by the total area of the county classified as Pasture/Hay and Grassland/Herbaceous.

The ratio was the grazeable area of each watershed that resides within a county divided by the total grazeable area of the county. Watershed-level livestock numbers were calculated as this ratio multiplied by county-level livestock population data and were distributed based on Geographic Information System (GIS) calculations of grazeable land in the watershed from the 2016 NLCD (USGS, 2019a). These livestock numbers, however, were not used to develop an allocation of allowable bacteria loading to livestock.

Table 8. Livestock estimates for the Sandy Creek and Wolf Creek watersheds

Watershed	Cattle and Calves	Hogs and Pigs	Goats and Sheep	Horses
Sandy Creek	856	16	72	68
Wolf Creek	1,827	46	201	111

Fecal matter from dogs and cats is transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 9 summarizes the estimated number of dogs and cats in the TMDL watersheds. The American Veterinary Medical Association (AVMA) estimates there are 0.614 dogs and 0.457 cats per American household (AVMA, 2018). The number of domestic cats and dogs in the watersheds was estimated by applying the AVMA estimates to the number of households in the watersheds. The number of watershed households was estimated with 2010 census block household counts, multiplied by the proportion of the census block within the watershed. The actual contribution and significance of bacteria loads from pets reaching the water bodies of the watershed is unknown.

Table 9. Estimated households and pet populations in the Sandy Creek AU 0603A_01 and Wolf Creek AU 0603B_01 watersheds

Watershed	Estimated Households	Estimated Dog Population	Estimated Cat Population
Sandy Creek	3,447	2,116	1,575
Wolf Creek	1,077	661	492

Wildlife and Unmanaged Animals

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

The Texas Parks and Wildlife Department provided deer population-density estimates by Resource Management Unit (RMU) and Ecoregion in the state (TPWD, 2018). Both watersheds are within RMU 14 (Pineywoods Ecoregion), with an average deer density of one deer per 48.9 acres over the period 2005-2016. This density was applied to land cover acreage considered suitable for deer habitat (land classified in the 2016 NLCD as Pasture/Hay, Shrub/Scrub, Grasslands/Herbaceous, Deciduous Forest, Evergreen Forest, Mixed Forest, Woody Wetlands, and Emergent Herbaceous Wetlands). Based on an estimated 30,755 acres of suitable habitat, there are an estimated 634 deer in the Sandy Creek watershed. Based on an estimated 50,219 acres of suitable habitat, there are an estimated 1,036 deer in the Wolf Creek watershed.

Texas A&M AgriLife Extension (2012) estimates one hog per 39 acres as a statewide average density for feral hogs. This density was applied to land classified in the 2016 NLCD as Pasture/Hay, Shrub/Scrub, Grasslands/Herbaceous, Deciduous Forest, Evergreen Forest, Mixed Forest, Woody Wetlands, and Emergent Herbaceous Wetlands. Based on these assumptions, there are an estimated 789 and 1,288 feral hogs in the Sandy Creek and Wolf Creek watersheds, respectively.

On-site Sewage Facilities

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

Several pathways of the liquid waste in OSSFs afford opportunities for bacteria to enter ground and surface waters if the systems are not properly operating. Properly designed and operated, however, OSSFs would be expected to contribute virtually no fecal bacteria to surface waters. For example, it has been reported that less than 0.01% of fecal coliforms originating in household wastes move further than 6.5 feet down gradient of the drainfield of a septic system (Weiskel et al., 1996). Reed, Stowe, and Yanke LLC (2001) provide information on estimated failure rates of OSSFs for different regions of Texas. Sandy Creek and Wolf Creek are located in the TCEQ Region 10 area, which has a reported failure rate of about 19%, providing insights into expected failure rates for the area.

Estimates of the number of OSSFs in the project watersheds were determined by using 911 addresses to estimate residence locations, and these were verified with aerial imagery data (Arctur and Maidment, 2018). OSSFs were estimated to be residential and business addresses that were outside of city boundaries and Certificate of Convenience and Necessity areas (PUC, 2017). The total estimates are shown in Table 10, and the OSSF density is shown in Figure 8.

Table 10. OSSF estimates for the Sandy Creek and Wolf Creek watersheds

Watershed and AU	Estimated OSSFs
Sandy Creek AU 0603A_01	1,433
Wolf Creek AU 0603B_01	936
Total	**2,369**

Bacteria Survival and Die-Off

Bacteria are living organisms that survive and die. Certain enteric bacteria can survive and replicate in organic materials if appropriate conditions prevail (e.g., warm temperature). Fecal organisms can survive and replicate from improperly treated effluent during their transport in pipe networks, and they can survive and replicate in organic-rich materials such as improperly treated compost and sewage sludge (or biosolids). While die-off of bacteria has been demonstrated in natural water systems due to the presence of sunlight and predators, the potential for their re-growth is less understood. Both replication and die-off are instream processes and are not considered in the bacteria source loading estimates for the TMDL watersheds.

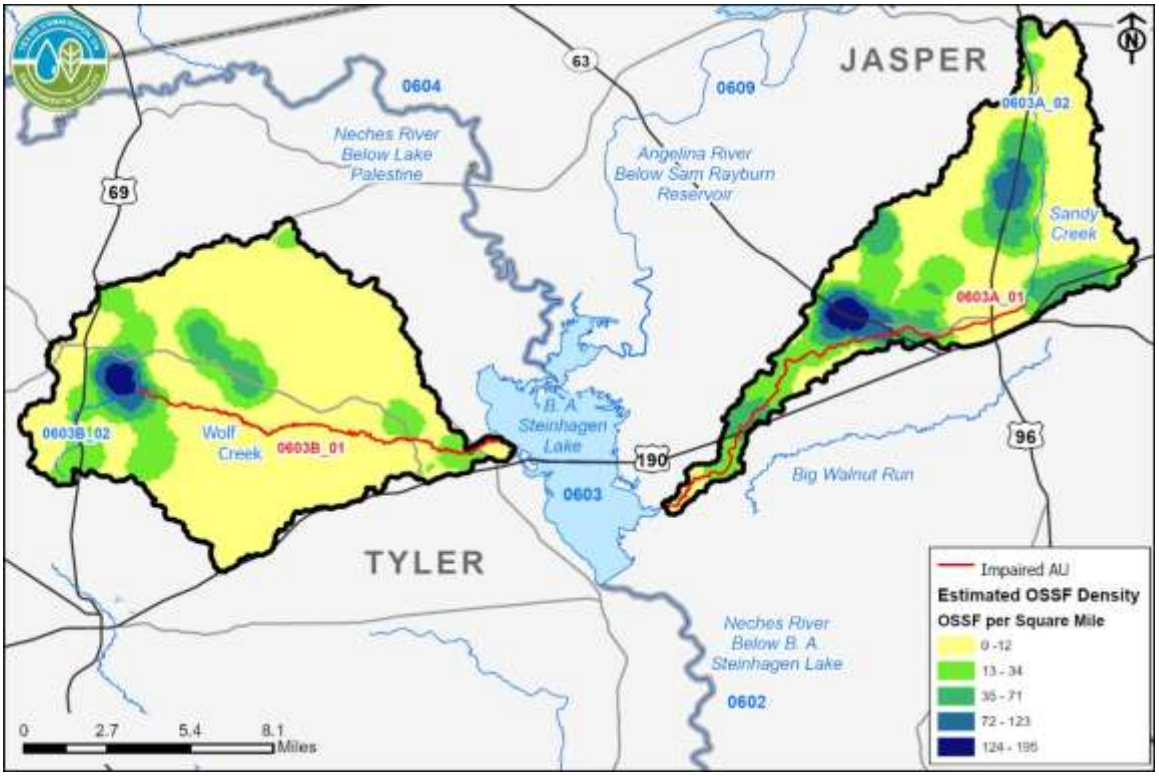

Figure 8. Estimated OSSF density in the Sandy Creek and Wolf Creek watersheds

Linkage Analysis

Establishing the relationship between instream water quality and the source of loadings is an important component in developing a TMDL. It allows for the evaluation of management options that will achieve the desired endpoint. This relationship may be established through a variety of techniques.

Generally, if high bacteria concentrations are measured in a water body at low to median flows in the absence of runoff events, the main contributing sources are likely to be point sources such as direct fecal deposition into the water body. During ambient flows, these inputs to the system will increase pollutant concentrations depending on the magnitude and concentration of the sources. As flows increase in magnitude, the impact of point sources is typically diluted, and would, therefore be a smaller part of the overall concentrations.

Bacteria load contributions from regulated and unregulated stormwater sources are greatest during runoff events. Rainfall runoff, depending upon the severity of the storm, has the capacity to carry bacteria from the land surface into the receiving stream. Generally, this loading follows a pattern of higher concentrations in the water body as the first flush of storm runoff enters the receiving stream. Over time, the concentrations decline because the sources of indicator bacteria are attenuated as runoff washes them from the land surface and the volume of runoff decreases following the rain event.

Load Duration Curve Analysis

LDCs are graphs of the frequency distribution of loads of pollutants in a water body. LDC analyses were used to examine the relationship between instream water quality and the broad sources of bacteria loads which are the basis of the TMDL allocations. In the case of these TMDLs, the loads shown are of *E. coli* bacteria in cfu/day. LDCs are derived from flow duration curves (FDCs). LDCs shown in the following figures represent the maximum acceptable load in the stream that will result in achievement of the TMDL water quality target. The basic steps to generate LDCs include all of the following.

- Generating a daily flow record – the mean daily streamflow record incorporating full permitted discharges and FG was developed using a drainage area ratio (DAR) at the TCEQ SWQM stations within AU 0603A_01 and AU 0603B_01.
- Developing the FDC – the mean daily streamflow is plotted against the exceedance probability of the mean daily streamflow for each day.
- Converting the FDC to an LDC – the mean daily streamflow for each day is multiplied by the primary contact recreation 1 use geometric mean criterion and a conversion factor to produce a graph of the frequency distribution of allowable loads.
- Overlaying the LDC with available indicator bacteria loading measurements to understand under what flow conditions indicator bacteria loading exceeds the primary contact recreation 1 use geometric mean criterion.

Hydrologic data in the form of daily streamflow records were unavailable in the TMDL watersheds. However, streamflow records are available in the nearby Menard Creek and Big Cow Creek watersheds. Streamflow records in both watersheds are collected and made available by USGS, which operates streamflow gauges 08066300 (Menard Creek) and 08029500 (Big Cow Creek) that were used to develop mean daily streamflow for the TMDL watersheds (USGS, 2019b). The gauges used to develop naturalized streamflow records were chosen due to their proximity and similarity in land cover. Asquith et al. (2006) suggest choosing watersheds less than 100 miles in proximity and with minimal streamflow alterations due to permitted discharges and withdrawals and describe the use of two gauges to develop flows at an ungauged site.

A DAR approach was used to develop the necessary streamflow record for the FDC/LDC location (TCEQ SWQM station location). The DAR approach involves multiplying a USGS gauging station daily naturalized streamflow value by a factor to estimate the flow at a desired TCEQ SWQM station location. The factor is determined by dividing the drainage area above the desired monitoring station location by the drainage area above the USGS gauge and raising the quotient to a conditional exponent which is a function of the streamflow percentile. Since two USGS gauging stations were selected to derive the flow for both sampling stations, a DAR was applied to the flow record for each gauge.

The daily streamflow value with the appropriate factor applied for each gauge was then added together and the mean of the combined daily streamflow was used to represent the daily naturalized streamflow at the TCEQ SWQM monitoring station. The final refinement to the streamflow record was the addition of full permitted discharges and daily streamflow allocated to FG.

The FDC was converted to an LDC by multiplying each streamflow value by the primary contact recreation 1 geometric mean criterion for *E.coli* (126 cfu/100 mL) and a conversion factor [28,316.8 mL per cubic foot (ft^3) × 86,400 seconds per day (s/d)], resulting in units of cfu per day. The resulting LDC plots each bacteria load value (y-axis) against its exceedance value (x-axis). Exceedance values along the x-axis represent the percentage of days that the bacteria load was at or above the allowable load on the y-axis.

Measured bacteria loads were overlaid on the LDC plots. Historical bacteria data obtained from TCEQ SWQM stations 10484 and 15344 were converted to a daily load by multiplying the measured concentration by the streamflow value on the day the measurement was collected, and the conversion factor described in the previous paragraph. The resulting measured daily loads points were plotted against the load exceedance for the day the sample was collected.

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

A useful refinement of the LDC approach is to divide the curve into flow-regime regions to analyze exceedance patterns in smaller portions of the duration curves. This approach can assist in determining streamflow conditions under which exceedances are occurring. A commonly used set of regimes that is provided in Cleland (2003) is based on the following five intervals along the x-axis of the FDCs and LDCs: (1) 0-10% (high flows); (2) 10-40% (moist conditions); (3) 40-60% (mid-range flows); (4) 60-90% (dry conditions); and (5) 90-100% (low flows). The selection of the flow regime intervals was based on general observation of the developed LDCs.

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

The *Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek*[2] (Schramm and Jha, 2020) provides further details on the methods used to develop the LDCs.

Load Duration Curve Results

For the Sandy Creek (AU 0603A_01) watershed, historical *E. coli* data indicate that elevated bacteria loading primarily occurs under high flow, moist, and mid-range flow conditions (Figure 6). However, bacteria loads are most elevated under the high flow conditions. Under dry conditions, loadings fall below the geometric mean criterion. Under low flow conditions, bacteria loads are typically under the single sample criterion and approach the geometric mean criterion (Figure 9).

For the Wolf Creek (AU 0603B_01) watershed, historical *E. coli* data indicate that elevated bacteria loading primarily occurs under high flow, moist, and mid-range flow conditions (Figure 7). However, bacteria loads are most elevated under the high flow conditions. Under dry conditions and low flows, loadings fall below the allowable load for the geometric mean criterion (Figure 10).

Regulated stormwater comprises a minor portion of both watersheds; therefore, unregulated stormwater likely contributes to the majority of high-flow-related loadings. Within the Wolf Creek (AU 0603B_01) watershed, there are no WWTFs to contribute point source loadings under dry and low flow conditions. Low flow exceedances in the Sandy Creek watershed likely cannot be attributed to regulated point sources alone, because there is only one permitted discharger in the watershed with a limited number of non-compliance events related to bacteria discharges. Other sources of bacteria loadings under dry and low flow conditions and in the absence of overland flow contributions (i.e., without stormwater contribution) are most likely to contribute bacteria directly to the water. These sources may include wildlife, feral hogs, and livestock. However, the actual contributions of bacteria loadings directly attributable to these sources cannot be determined using LDCs.

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

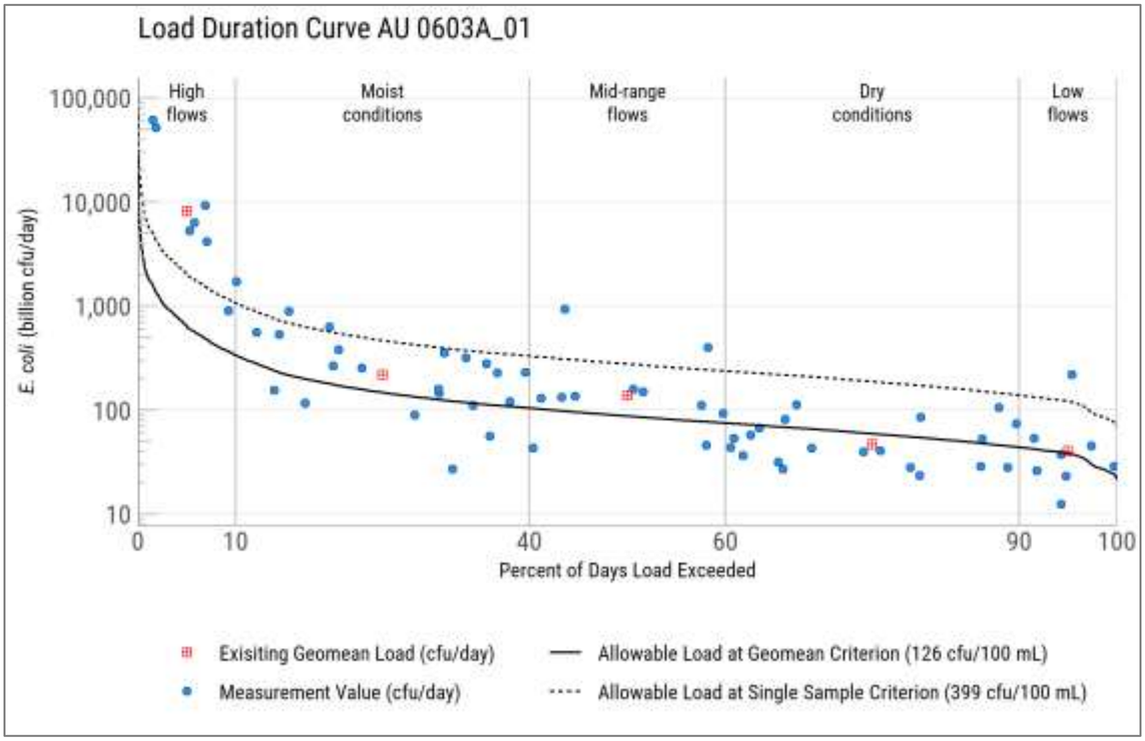

Figure 6. LDC for Sandy Creek TMDL watershed at TCEQ SWQM Station 10484

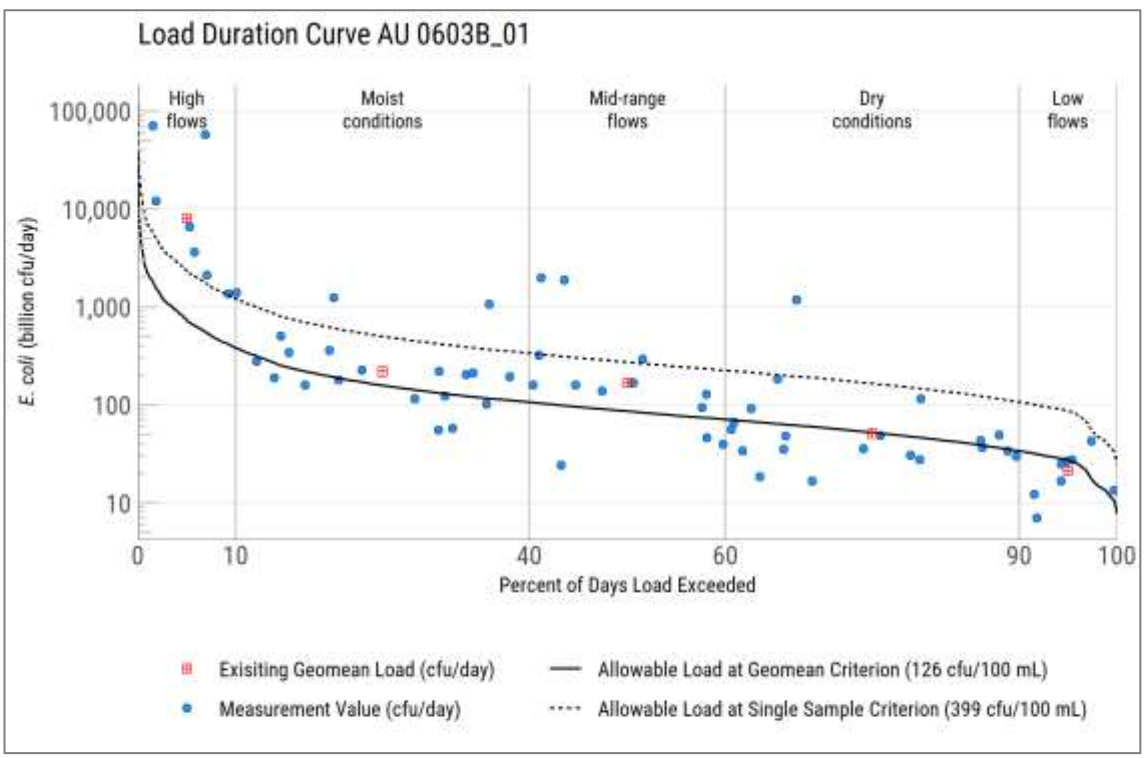

Figure 7. LDC for Wolf Creek TMDL watershed at TCEQ SWQM Station 15344

Margin of Safety

The margin of safety (MOS) is used to account for uncertainty in the analysis used to develop the TMDL and thus provide a higher level of assurance that the goal of the TMDL will be met. According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using two methods:

1) Implicitly incorporating the MOS using conservative model assumptions to develop allocation.
2) Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning an MOS. These TMDLs incorporate an explicit MOS of 5% of the total TMDL allocation.

Pollutant Load Allocation

The TMDLs represent the maximum amount of a pollutant that the stream can receive in a single day without exceeding water quality standards. The pollutant load allocations for the selected scenarios were calculated using the following equation:

TMDL = WLA + LA + FG + MOS

Where:

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

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

FG = loading associated with future growth from potential regulated facilities

MOS = margin of safety load

TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures [40 CFR 130.2(i)]. For *E. coli*, TMDLs are expressed as cfu/day, and represent the maximum one-day load the stream can assimilate while still attaining the standards for surface water quality.

The TMDL components for the impaired AUs covered in this report are derived using the median flow within the high-flow regime (or 5% flow) of the LDCs developed for Sandy Creek and Wolf Creek. For the remainder of this report, each section will present an explanation of the TMDL component first, followed by the results of the calculation for that component.

AU-Level TMDL Calculations

The TMDLs for the impaired AUs were developed as pollutant load allocations based on information from the LDC developed for TCEQ SWQM Station 10484 on Sandy Creek and TCEQ SWQM Station 15344 on Wolf Creek (Figure 6, Figure 7). Each bacteria LDC was developed by multiplying the streamflow value along the FDC by the primary contact recreation 1 geometric mean criterion (126 cfu/100 mL *E. coli*) and by the conversion factor to convert to loading in cfu per day. This effectively displays the LDC as the TMDL curve of maximum allowable loading.

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

Where:

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

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

Conversion Factor (to billion cfu/day) = 28,316.8 mL/ft^3 * 86,400 s/d ÷ 1,000,000,000

At the 5% load duration exceedance, the TMDL values are provided in Table 11.

Table 11. Summary of allowable loadings for Sandy Creek (0603A_01) and Wolf Creek (0603B_01) watersheds

AU	5% Exceedance Flow (cfs)	5% Exceedance Load (cfu/day)	TMDL (Billion cfu/day)
0603A_01	205.853	6.34×10^{11}	634.579
0603B_01	236.782	7.29×10^{11}	729.923

Margin of Safety Formula

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

MOS = 0.05 * TMDL

Where:

TMDL = total maximum daily load

The MOS for each AU is presented in Table 12.

Table 12. MOS allocation for Sandy Creek (0603A_01) and Wolf Creek (0603B_01) watersheds

AU	TMDL (Billion cfu/day)	MOS (Billion cfu/day)
0603A_01	634.579	31.729
0603B_01	729.923	36.496

Wasteload Allocation

The WLA is the sum of loads from regulated sources. The WLA consists of two parts – the wasteload that is allocated to TPDES-regulated WWTFs (WLA_{WWTF}) and the wasteload that is allocated to regulated stormwater dischargers (WLA_{SW}).

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

Wastewater Treatment Facilities

Determination of the WLA_{WWTF} requires development of a daily wasteload allocation for each TPDES-permitted facility. The full permitted daily average flow of each WWTF is multiplied by the instream geometric criterion for the water body and the conversion factor. This calculation is expressed by:

$$WLA_{WWTF} = Criterion * Flow * Conversion\ Factor$$

Where:

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

Flow = full permitted flow in MGD

Conversion Factor (to billion cfu/day) = 3,785,411,800 mL/million gallons ÷ 1,000,000,000

Using this equation, each WWTF's allowable loading was calculated using the permittee's full permitted flow for Sandy Creek. The criterion was applied based on the indicator bacteria designated for the water body. The daily allowable loading of *E. coli* assigned to WLA_{WWTF} was determined to be zero in Wolf Creek (AU 0603B_01), because there are no WWTFs in the watershed; therefore, there are no regulated flows from any WWTFs. Table 13 presents the load allocations for the WWTF discharging into Sandy Creek (AU 0603A_01), which is the total WLA_{WWTF} for the AU.

Table 13. WLA_{WWTF} allocation for Sandy Creek (0603A_01) and Wolf Creek (0603B_01)

AU	TPDES Permit Number	Permittee	Bacteria Limit (cfu/100 mL)	Full Permitted Flow (MGD)	WLA_{WWTF} (Billion cfu/day)
0603A_01	WQ0010197001	City of Jasper WWTF	126	3.25	15.501
0603B_01	NA	NA	NA	0	0

Regulated Stormwater

Stormwater discharges from MS4, industrial, concrete production, and construction areas are considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA for the area was used in the development of these TMDLs due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of each watershed that is under the jurisdiction of stormwater permits (i.e., defined as the area designated as urbanized area in the 2000 United States Census) is used to estimate the amount of overall runoff load that should be allocated as the regulated stormwater contribution in the WLA_{SW} component of the TMDL (Table 14). The load allocation (LA) component of the TMDL corresponds to direct nonpoint source runoff and is the difference between the total load from stormwater runoff and the portion allocated to WLA_{SW}.

WLA_{SW} is the sum of loads from regulated stormwater sources and is calculated as:

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

Where:

TMDL = total maximum daily load

WLA_{WWTF} = sum of WWTF loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety load

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

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

Table 14. Regulated stormwater area and FDA_{SWP} calculations for Sandy Creek (AU 0603A_01) and Wolf Creek (AU 0603B_01) watersheds

AU	MS4 GP (square miles)	MSGP (square miles)	CGP (square miles)	Concrete Production (square miles)	Total Area of Permits (square miles)	Watershed Area (square miles)	FDA_{SWP}
0603A_01	0	0.154	0.06	0.028	0.24	56.54	0.0042
0603B_01	0	0	0.01	0	0.01	83.14	0.0001

In order to calculate the WLA_{SW}, the FG term must be known. The calculation for the FG term is presented in the later section "Allowance for Future Growth," but the results will be included here for continuity. The WLA_{SW} calculations are presented in Table 15.

Table 15. Regulated stormwater WLA allocations for Sandy Creek (AU 0603A_01) and Wolf Creek (AU 0603B_01)

AU	TMDL	WLA_{WWTF}	FG	MOS	FDA_{SWP}	WLA_{SW}
0603A_01	634.579	15.501	0.403	31.729	0.0042	2.465
0603B_01	729.923	0	0.715	36.496	0.0001	0.069

All loads are expressed in billion cfu/day.

With the WLA_{SW} and WLA_{WWTF} terms, the total WLA term can be determined as shown in Table 16.

Table 16. Wasteload allocation summary for Sandy Creek (AU 0603A_01) and Wolf Creek (AU 0603B_01)

AU	WLA_{WWTF}	WLA_{SW}	WLA
0603A_01	15.501	2.465	17.966
0603B_01	0	0.069	0.069

All loads are expressed in billion cfu/day.

Implementation of Wasteload Allocations

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

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

Permit requirements are implemented during the routine permit renewal process. However, there may be a more economical or technically feasible means of achieving the goal of improved water quality, and circumstances may warrant changes in individual WLAs after this TMDL is adopted. Therefore, the individual WLAs, as well as the WLAs for stormwater, are non-binding until implemented via separate TPDES permitting actions, which may involve preparation of an update to the state's WQMP. Regardless, all permitting actions will demonstrate compliance with the TMDL.

The executive director or commission may establish interim effluent limits and/or monitoring-only requirements during a permit amendment or permit renewal. These interim limits will allow a permittee time to modify effluent quality in order to attain the final effluent limits necessary to meet TCEQ- and EPA approved TMDL allocations. The duration of any interim effluent limits may not be any longer than three years from the date of permit re-issuance. New permits will not contain interim effluent limits, because compliance schedules are not allowed for a new permit.

Where a TMDL has been approved, domestic WWTF TPDES permits will require conditions consistent with the requirements and assumptions of the WLAs. For TPDES-regulated MS4s, construction stormwater discharges, and industrial stormwater discharges, water quality-based effluent limits (WQBELs) that implement the WLA for stormwater may be expressed as BMPs or other similar requirements, rather than as numeric effluent limits.

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

> "Incorporating greater specificity and clarity echoes the approach first advanced by EPA in the 1996 Interim Permitting Policy, which anticipated that where necessary to address water quality concerns, permits would be modified in subsequent terms to include "more specific conditions or limitations [which] may include an integrated

suite of BMPs, performance objectives, narrative standards, monitoring triggers, numeric WQBELs, action levels, etc."

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

Updates to Wasteload Allocations

These TMDLs are, by definition, the total of the sum of the WLAs, the sum of the LA, and the MOS. Changes to individual WLAs may be necessary in the future in order to accommodate growth or other changing conditions. These changes to individual WLAs do not ordinarily require a revision of the TMDL document; instead, changes will be made through updates to the state's WQMP. Any future changes to effluent limitations will be addressed through the permitting process and by updating the WQMP.

Load Allocation

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

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

Where:

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

WLA_{SW} = sum of all regulated stormwater loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety load

Table 17 summarizes the LA calculations.

Table 17. Load allocation summary for Sandy Creek (AU 0603A_01) and Wolf Creek (AU 0603B_01) watersheds

AU	TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
0603A_01	634.579	15.501	2.465	0.403	31.729	584.481
0603B_01	729.923	0	0.069	0.715	36.496	692.643

All loads are expressed in billion cfu/day.

Allowance for Future Growth

The FG component of the TMDL equation addresses the requirement to account for future loadings that may occur due to population growth, changes in community infrastructure, and development. Specifically, this TMDL component takes into account the probability that new flows from WWTF discharges may occur in the future. The assimilative capacity of water bodies increases as the amount of flow increases.

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

To account for the FG component of the impaired AUs, the loadings from WWTFs are included in the FG computation, which is based on the WLA_{WWTF} formula. The FG equation contains an additional term to account for projected population growth within WWTF service areas between 2020 and 2070, based on TWDB 2021 Region I Regional Water Plan data (Region I (East Texas) Water Planning Group, 2019) (Table 3). The FG calculation for Sandy Creek is shown in Table 18.

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

Where:

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

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

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

Conversion Factor (to billion cfu/day) = 3,785,411,800 mL/million gallons ÷ 1,000,000,000

Table 18. Future growth allocation for Sandy Creek AU 0603A_01 watershed

AU	Percentage Population Increase (2020-2070)	Full Permitted Discharge (MGD	FG Flow (MGD)	FG
0603A_01	2.6	3.25	0.0845	0.403

Load units expressed as billion cfu/day

For Wolf Creek, the conventional FG calculations are hampered by the $WWTF_{FP}$ being zero. While there are no plans for a WWTF to be built in the watershed, the TMDL must still account for the possibility of FG for the impaired AU. In order to address this shortcoming, an FG term was calculated for the Wolf Creek (AU 0603B_01) watershed to accommodate the potential of a WWTF to serve residents within the watershed.

The City of Colmesneil currently has a permitted WWTF that discharges outside of the TMDL watershed. Because of the low population density and minimal projected population growth, FG was set as the current permit discharge flow limit for the Colmesneil WWTF (0.15 MGD). This is based on the assumption that if another WWTF plant is required in the future, it would be similar in size to the existing Colmesneil WWTF. Under this scenario, FG is calculated as shown in Table 19.

Table19. Future growth allocation for Wolf Creek AU 0603B_01 watershed

AU	FG Flow (MGD)	FG
0603B_01	0.15	0.715

Load units expressed as billion cfu/day

Compliance with these TMDLs is based on keeping the bacteria concentrations in the selected waters below the limits that were set as criteria for the individual sites. FG of existing or new point sources is not limited by these TMDLs as long as the sources do not cause bacteria to exceed the limits. The assimilative capacity of water bodies increases as the amount of flow increases. Consequently, increases in flow allow for increased loadings. The LDCs and tables in these TMDLs will guide determination of the assimilative capacity of the water bodies under changing conditions, including FG.

Summary of TMDL Calculations

The TMDL was calculated based on median flow in the 0-10 percentile range (5% exceedance, high-flow regime) for flow exceedance from the LDCs developed for the identified TCEQ SWQM station within each AU. Allocations are based on the current geometric mean criterion for *E. coli* of 126 cfu/100 mL for each component of the TMDL. The TMDL allocations for the Sandy Creek and Wolf Creek TMDL watersheds are summarized in Table 20.

Table20. TMDL allocation summary for Sandy Creek AU 0603A_01 and Wolf Creek AU 0603B_01

AU	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA	FG
0603A_01	634.579	31.729	15.501	2.465	584.481	0.403
0603B_01	729.923	36.496	0	0.069	692.643	0.715

All loads are expressed in billion cfu/day.

The final TMDL allocations (Table 21) needed to comply with the requirements of 40 CFR 103.7 include the FG component within the WLA_{WWTF}.

Table21. Final TMDL allocations for Sandy Creek AU 0603A_01 and Wolf Creek AU 0603B_01

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
0603A_01	634.579	15.904	2.465	584.481	31.729
0603B_01	729.923	0.715	0.069	692.643	36.496

All loads are expressed in billion cfu/day.

Seasonal Variation

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

Seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* data obtained from routine monitoring samples collected in the warmer months (May-September) against data collected during cooler months (November-March). The months of April and October were considered transitional between warm and cool seasons and were excluded from the seasonal analysis. Differences in seasonal concentrations were then evaluated with a Wilcoxon Rank Sum test (also known as the “Mann-Whitney” test). The Wilcoxon Rank Sum test was chosen for its ability to handle non-normal data without requiring data transformation. The test was considered significant at the $\alpha = 0.05$ level.

The Wilcoxon Rank Sum test suggests there is a slight seasonal difference in *E. coli* concentrations in Sandy Creek (AU 0603A_01) ($W = 245$, $p < 0.01$), with cool season samples higher than warm season samples on average. The Wilcoxon Rank Sum test did not detect a difference in seasonal concentrations in Wolf Creek (AU 0603B_01) ($W = 358$, $p = 0.285$). It should be noted that the criteria used by TCEQ to assess recreational uses apply to water bodies during all seasons of the year. Therefore, seasonal variation is accounted for in the bacteria TMDL presented in this document by virtue of the fact that these variations affect neither the calculation nor the implementation of bacteria TMDLs in Texas.

Public Participation

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

TCEQ and the Texas Water Resources Institute (TWRI) are jointly providing coordination of public participation for development of both the TMDL and implementation plan (I-Plan). The first of a series of public meetings to engage public participation were held on November 21, 2019, in Woodville and Jasper, to discuss the project and keep the public aware about the TMDL. Project staff held a webinar on September 1, 2020 to present preliminary TMDL allocation information and initiate I-Plan development.

Notices of meetings were posted on the project webpages for both TCEQ and TWRI. At least two weeks prior to scheduled meetings, TWRI issued media releases through Texas A&M AgriLife and local AgriLife Extension Offices, and formally invited stakeholders to attend. To ensure that absent or new stakeholders could get information about past meetings and pertinent material, the TCEQ project webpage[3] provided meeting summaries, presentations, and documents produced for review.

Implementation and Reasonable Assurance

The issuance of TPDES permits consistent with TMDLs provides reasonable assurance that WLAs in this TMDL report will be achieved. Per federal requirements, each TMDL is included in an update to the Texas WQMP as a plan element.

The WQMP coordinates and directs the state's efforts to manage water quality and maintain or restore designated uses throughout Texas. The WQMP is continually updated with new, more specifically focused plan elements, as identified in federal regulations [40 CFR 130.6(c)]. Commission adoption of a TMDL is the state's certification of the associated WQMP update.

Because the TMDL does not reflect or direct specific implementation by any single pollutant discharger, TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the commission. Based on the TMDL and I-Plan, TCEQ will propose and certify WQMP updates if needed to establish required WQBELs for specific TPDES wastewater discharge permits.

Currently, there are no Phase II MS4 permit authorizations or Phase I MS4 individual permits held in the TMDL watersheds. However, future population growth within the urbanized areas located near or in the watersheds may require some entities to obtain authorizations under the Phase II MS4 general permit. Where numeric effluent limitations are infeasible for MS4 entities, TCEQ normally establishes BMPs, which are a substitute for effluent limitations, as allowed by federal rules. When such practices are established in Phase II MS4 permit authorizations or Phase I MS4 individual permits, TCEQ will not identify specific implementation requirements applicable to a specific TPDES stormwater permit or permit authorization through an effluent limitation update. Rather, TCEQ will revise its Phase II MS4 general permit during the renewal process or amend or revise a permittee's Phase I MS4 individual permit as needed, to require a revised SWMP or to require the implementation of other specific revisions in accordance with an approved I-Plan.

[3] www.tceq.texas.gov/waterquality/tmdl/nav/118-sandy-wolf-creeks-bacteria

Strategies for achieving pollutant loads in TMDLs from both point and nonpoint sources are reasonably assured by the state's use of an I-Plan. TCEQ is committed to supporting implementation of all TMDLs adopted by the commission.

I-Plans for Texas TMDLs use an adaptive management approach that allows for refinement or addition of methods to achieve environmental goals. This adaptive approach reasonably assures that the necessary regulatory and voluntary activities to achieve pollutant reductions will be implemented. Periodic, repeated evaluations of the effectiveness of implementation methods ascertain whether progress is occurring and may show that the original distribution of loading among sources should be modified to increase efficiency. I-Plans will be adapted as necessary to reflect needs identified in evaluations of progress.

Key Elements of an I-Plan

An I-Plan includes a detailed description and schedule of the regulatory and voluntary management measures to implement the WLAs and LAs of particular TMDLs within a reasonable time. I-Plans also identify the organizations responsible for carrying out management measures, and a plan for periodic evaluation of progress.

Strategies to optimize compliance and oversight are identified in an I-Plan when necessary. Such strategies may include additional monitoring and reporting of effluent discharge quality to evaluate and verify loading trends, adjustment of an inspection frequency or a response protocol to public complaints, and escalation of an enforcement remedy to require corrective action of a regulated entity contributing to an impairment.

TCEQ works with stakeholders and interested governmental agencies to develop and support I-Plans and track their progress. Work on the I-Plan begins during development of TMDLs. The cooperation required to develop an I-Plan will become a cornerstone for the shared responsibility necessary to carry it out.

Ultimately, the I-Plan will identify the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the I-Plan that is approved may not approximate the predicted loadings identified category by category in the TMDL and its underlying assessment. The I-Plan is adaptive for this very reason; it allows for continuous update and improvement.

In most cases, it is not practical or feasible to approach all TMDL implementation as a one-time, short-term restoration effort. This is particularly true when a challenging wasteload reduction or load reduction is required by the TMDL, there is high uncertainty with the TMDL analysis, there is a need to reconsider or revise the established water quality standard, or the pollutant load reduction would require costly infrastructure and capital improvements.

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Appendix A. Population and Population Projections

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

Estimate 2010 watershed population

1) Obtained census block level population and spatial data for Jasper and Tyler counties for the year 2010 from U.S. Census Bureau.
2) The Sandy Creek watershed includes 455 census blocks and the Wolf Creek watershed includes 346 census blocks, located entirely or partially in each watershed. Estimated population for those census blocks partially located in the watershed by multiplying the census block population and the percentage of each block within the TMDL watershed. It was assumed for this estimation that population was evenly distributed within a census block.
3) Summed the estimated partial census block populations with the populations from the census blocks located entirely within each TMDL watershed. This was the resulting 2010 population estimate for each watershed.

Estimate 2020–2070 watershed population

4) Obtained population projections for Jasper and Tyler counties for 2020 through 2070 from the 2021 Regional Water Plan Population and Water Demand Projection data (TWDB, 2019).
5) Calculated the proportional increase from the published 2010 county population and the published 2020 county population to estimate the 2020 watershed population.
6) Calculated the projected population percentage increase in each decade from 2020 to 2070 from the 2021 Regional Water Plan Population and Water Demand Projection data (TWDB, 2019) for Jasper and Tyler counties.
7) Applied the percentage increase, 2.6% for Jasper County and 0.5% in Tyler County, for each decade to the estimated 2020 watershed population