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FINAL

October 2018 Update to the Texas Water Quality Management Plan

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Prepared by the
Office of Water
Water Quality Division

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P.O. Box 13087, MC-150
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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.

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 2018 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

[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, and 07/2018.

The public comment period for the October WQMP update was from November 9, 2018, through December 11, 2018.

The Projected Effluent Limit Update section provides information compiled from August 1, 2018 through October 31, 2018, 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
10264-002	1244	TX0101940	City of Round Rock, City of Cedar Park & City of Austin Williamson	40.0	7	2335.20	2	667.20			6	
10396-001	2422	TX0033944	City of Anahuac & Trinity Bay Conservation District Chambers	0.95	5	39.62	1.7	13.47			4	
10883-002	0814	TX0138703	City of Venus Ellis	0.18	10	15.01	3	4.50			4	
11300-001	0803	TX0027677	Westwood Shores MUD Trinity	0.257	10	21.43	3	6.43			4	Outfall 001
				0.257	5	10.72	1.7	3.64			6	Outfall 002
11546-001	2439	TX0071978	San Leon MUD Galveston	1.9					20	316.92	2	
11771-001	0506	TX0138631	Mercy Ships Foundation Smith	0.05					20	8.34	2	
12074-001	1805	TX0031232	U.S. Dept Of The Air Force Comal	0.021					10	1.75	4	
12098-001	0701	TX0079138	Hamshire-Fannett ISD Jefferson	0.024	20	4.00	35	7.01			2	
12296-001	1209	TX0085456	ILC College Station L.L.C. Brazos	0.025					20	4.17	3	
13449-001	1806	TX0138452	The Camp Recovery Centers, L.L.C. Kerr	0.012	5	0.50	2	0.20			4	

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
14377-001	1810	TX0125288	Sunfield MUD No. 4 Hays	0.80	5	33.36	1.7	11.34			5	Outfall 001
				0.70	5	29.19	1.7	9.92			5	Outfall 002
				2.70	5	112.59	1.7	38.28			5	Outfall 003
				4.00	5	166.80	1.7	56.71			5	Aggregate Max Flow Outfalls 001thru 003
15092-001	1908	TX0138304	DTB Investments, L.P. Comal	0.30	5	12.51	2	5.00			4	
15241-001	1202	TX0135305	Fort Bend County MUD No. 143 Fort Bend	0.50	10	41.70	3	12.51			6	
15266-001	1808	TX0135488	Crystal Clear SUD Comal	0.10	10	8.34	3	2.50			4	
15308-001	1245	TX0135879	Fort Bend County MUD No. 142 Fort Bend	1.20	10	100.08	2	20.02			6	Refer to Appendix V. TMDL Update
15620-002	1242	TX0138797	City Of Bruceville-Eddy McLennan	0.23					30	57.55	4	
15633-001	0819	TX0138100	JLM 717 Kaufman L.P. & Kaufman County FWSD 4A Kaufman	1.68	5	70.06	1.2	16.81			6	
15697-001	0829	TX0138622	Markum Land Properties, L.L.C. Tarrant	0.04					20	6.67	2	

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
15709-001	0829	TX0138649	Pampa Investment Group, L.P. Bell	0.30	10	25.02	3	7.51			4	
15714-001	1108	TX0138665	Mc Alister Opportunity Fund III, L.P. Brazoria	0.90	10	75.06	3	22.52			5	
15715-001	0605	TX0138681	LKW Saline Creek Senior Village Ltd. Smith	0.02					20	3.34	2	
15722-001	0826	TX0138754	Sigma Pro Properties, L.L.C. Tarrant	0.0095	10	0.79	3	0.24			4	
15725-001	2312	TX0138762	Quail Run Services, L.L.C. Reeves	0.30	10	25.02	3	7.51			4	
15726-001	1202	TX0138771	Smith, Ronan Bailey Washington	0.025	10	2.09	3	0.63			4	

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
City of Chandler	City Limits	T	2018	Neches River Basin	0606	Henderson	9/13/2018	WWTF improvements	2018	4,197
									2020	4,594
									2030	5,385
									2040	6,046
City of China	City Limits	T/C	2018	Neches River Basin	N/A	Jefferson	8/30/2018	Collection system and WWTF improvements. **Population projections were not provided with the application.**	2018	
									2020	
									2030	
									2040	
City of Bevil Oaks	City Limits	C	2018	Neches-Trinity Coastal Basin	0607	Jefferson	9/6/2018	Lift station rehabilitation	2018	1,244
									2020	1,247
									2030	1,260
									2040	1,272
City of Bridge City	City Limits	C	2018	Sabine River Basin	0511	Orange	8/29/2018	Collection system improvements	2018	7,840
									2020	7,850
									2030	7,863
									2040	7,879
City of Granbury	City Limits	T	2018	Brazos River Basin/ NCTCOG	1205	Hood	9/14/2018	Construction of new WWTP	2018	10,137
									2020	10,671
									2030	13,264
									2040	15,060
City of Houston	City Limits	F	2018	San Jacinto River Basin/ H-GAC	Various	Harris	9/6/2018	Flood mitigation, does not require a DMA Resolution	2018	2,201,986
									2020	2,248,414
									2030	2,377,662
									2040	2,550,707
Jasper County WCID #1	District Boundaries	C	2018	Sabine River Basin	0511	Jasper	8/21/2018	Collection system improvements	2018	2,975
									2020	2,995
									2030	3,062
									2040	3,074

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 be awarded a state revolving fund loan, it must be recommended for designation as the management agency in the approved WQMP. The facilities listed in Table 3 have submitted Designated Management Agencies (DMA) agreements 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
City of Chandler	City Limits	T	4/10/2018
City of China	City Limits	T/C	8/17/2018
City of Bevil Oaks	City Limits	C	5/31/2018
City of Bridge City	City Limits	C	7/17/2018
Jasper County WCID #1	District Boundaries	C	7/9/2018

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. Three Total Maximum Daily Loads for Indicator Bacteria in the Carters Creek Watershed For Segment Numbers 1209C, 1209D, and 1209L

TMDL Updates to the WQMP: Carters Creek Watershed (Segments 1209C, 1209D, and 1209L)

The document Three Total Maximum Daily Loads for Indicator Bacteria in the Carters Creek Watershed For Segment Numbers 1209C, 1209D, and 1209L was adopted by the TCEQ on 08/22/12 and approved by EPA on 09/27/12, and became an update to the state's Water Quality Management Plan (WQMP). It has had one WQMP update prior to this one.

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

- update the WLA and permittee name 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 one assessment unit (AU). This was originally presented in Table 20 in the original TMDL document, and the affected AU is included here as Table 2.

In Table 21 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 21 of the TMDL remains the same.

Table 1 – Wasteload allocations for TPDES-permitted facilities (Updates Table 15, p. 34 in the TMDL document)

AU	TPDES Number	Outfall	NPDES Number	Permittee/Facility Name	Final Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (Billion MPN/day)	TMDL Comments
1209C_01	WQ0012296-001	001	TX0085456	ILP COLLEGE STATION LLC/ GLEN OAKS MHP WWTF	0.025	0.1133	Increased discharge; updated permittee name

Table 2 - *E. coli* TMDL Summary Calculations (Updates Table 20, p. 37 in the TMDL document.)
All loads expressed in billion MPN/day

Segment	Stream Name	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA_{SEG}	LA_{TL}	Future Growth
1209C	Carters Creek	814.6	30.74	47.41	300.5	228.5	199.9	7.55

Appendix II. One Total Maximum Daily Load for Bacteria in the Lower San Antonio River: For Segment Number 1901

TMDL Updates to the WQMP: One Total Maximum Daily Load for Bacteria in the Lower San Antonio River (Segment 1901)

The document *One Total Maximum Daily Load for Bacteria in the Lower San Antonio River: For Segment 1901* was adopted by the TCEQ on 8/20/2008 and approved by EPA on 10/10/08, and became an update to the state's Water Quality Management Plan (WQMP). It has had three subsequent WQMP updates prior to this one.

The purpose of this WQMP update is to make the following change to the TMDL:

- update the name of one facility;
- remove two expired permits and include the permit that replaced them;
- correct the TMDL equations for two stations to correctly reflect the facilities discharging upstream of them.

Table 1 – Permitted Bacteria Allocations (p. 28 in original TMDL document)

State Permit Number	Outfall	EPA Permit Number	Segment Number	Permittee Name	Flow (MGD)	Waste Load Allocation (WLA) – *E. coli* 10^9 cfu/day	Comments
15079-001	001	TX0134350	1901	ENCANA OIL AND GAS USA, INC	NA	NA	Updated name.
10352-001	001	TX0086134	1901	CITY OF KARNES CITY	NA	NA	Permit expired.
10352-002	001	TX0069868	1901	CITY OF KARNES CITY	NA	NA	Permit expired.
10352-003	001	TX0129984	1901	CITY OF KARNES CITY	0.8	3.8	New permit. Replaces two expired City of Karnes City permits and moves loading to TMDL for 12794 from 12793.
10746-001	001	TX0027774	1901	CITY OF KENEDY	2.0	9.5	Moves loading to TMDL for 12794 from 12793.

For this project, TMDLs were developed for four sampling stations in the segment. The changes reflected in this update resulted in the shifting of allocations for two of the TMDL equations. Because the original TMDL equations did not include an allowance for future growth, loading is borrowed from the Load Allocation category in each case so that the original TMDL allocations are maintained. The affected equations were originally presented in Tables 16 and 17 in the original TMDL document, and are included here as Tables 2 and 3.

Table 2 - TMDL Allocation Summary for Station 12794 (*E. coli* 10^9 cfu/day) – Updates Table 16 in original TMDL

	Flow Regime (percentile)				
	0-10	**10-40**	**40-60**	**60-90**	**90-100**
Wasteload Allocation (WLA)	13.7	13.7	13.7	13.7	13.7
Load Allocation (LA)	9,321.0	2,426.9	1,351.5	865.0	482.2
Margin of Safety (MOS)	491.3	128.4	71.8	46.3	26.1
TMDL (WLA+LA+MOS)	9,826.0	2,569.0	1,437.0	925.0	522.0

Table 3 - TMDL Allocation Summary for Station 12793 (*E. coli* 10^9 cfu/day) – Updates Table 17 in original TMDL

	Flow Regime (percentile)				
	0-10	**10-40**	**40-60**	**60-90**	**90-100**
Wasteload Allocation (WLA)	0.0	0.0	0.0	0.0	0.0
Load Allocation (LA)	9,547.5	2,462.4	1,387.0	887.3	499.7
Margin of Safety (MOS)	502.5	129.6	73.0	46.7	26.3
TMDL (WLA+LA+MOS)	10,050.0	2,592.0	1,460.0	934.0	526.0

Appendix III. Six Total Maximum Daily Loads for Bacteria in Waters of the Upper Gulf Coast: Segments 2421, 2422, 2423, 2424, 2432, and 2439

TMDL Updates to the Water Quality Management Plan (WQMP): Six Total Maximum Daily Loads for Bacteria in Waters of the Upper Gulf Coast (Segments 2421, 2422, 2423, 2424, 2432, and 2439)

The *document Six Total Maximum Daily Loads for Bacteria in Waters of the Upper Gulf Coast: Segments 2421, 2422, 2423, 2424, 2432, and 2439* was adopted by the TCEQ on 08/20/08 and approved by EPA on 02/04/09, and became an update to the state's Water Quality Management Plan (WQMP). Ten subsequent WQMP updates prior to this one have updated the list of individual wasteload allocations (WLAs) found in the original TMDL document. Additionally, two addenda to the original TMDL were submitted through the January 2012 and April 2012 WQMP updates. These addenda added four new assessment units (AUs) to the original TMDL project.

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

- include and update the WLA for one facility that has increased its permitted discharge.

Note that this is a concentration-based TMDL, and therefore there are no final TMDL equations to be affected by this change. The facility presented in Table 1 was incorrectly removed in a previous WQMP update (April 2009). It is being restored in this update, with its new discharge amount.

Table 1 –Daily Loads for WWTFs based on Concentration Allocations (Updates p. A-1 in TMDL)

State Permit Number	Outfall	EPA Permit Number	Segment Number	Permittee Name	Flow (MGD)	Waste Load Allocation (WLA) Fecal Coliform (org/day)*	Waste Load Allocation (WLA) *E. coli* (org/day) *	Waste Load Allocation (WLA) Enterococcus (org/day) *	Comments
11546-001	001	TX0071978	2439	SAN LEON MUNICIPAL UTILITY DISTRICT	1.9	14,384,564,764	9,062,275,801	2,517,298,834	Increased discharge

*Concentrations limits will be based on the applicable indicator bacteria criterion geometric means (Fecal coliform
or *E. coli* or Enterococcus).

Appendix IV. One Total Maximum Daily Load for Bacteria in Upper Oyster Creek for Segment Number 1245

TMDL Updates to the Water Quality Management Plan (WQMP): Bacteria in Upper Oyster Creek (Segment 1245)

The document *One Total Maximum Daily Load for Bacteria in Upper Oyster Creek for Segment Number 1245* was adopted by the TCEQ on 08/08/07 and approved by EPA on 09/28/07, and became an update to the state's Water Quality Management Plan (WQMP). Eleven subsequent WQMP updates prior to this one have provided individual wasteload allocations (WLAs) for permitted facilities.

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

- update the WLA for one facility that has increased its permitted discharge, and
- remove a permit that was cancelled.

Table 1 –Permitted Bacteria Allocation for Amended Discharges (pp. 35-37 in original TMDL document)

State Permit Number	Outfall	EPA Permit Number	Segment Number	Permittee Name	Flow (MGD)	Waste Load Allocation (WLA)	TMDL/ Comments
15308-001	001	TX0135879	1245	FORT BEND CO. MUD # 142	1.2	1.79×10^{10} cfu *E. coli* per day	Increased discharge
15428-001	001	TX0136786	1245	FORT BEND CO. MUD # 132	NA	NA	Permit cancelled

Note that this TMDL was written for *E. coli* and that it used the single sample criterion of 394 cfu/100 mL. All of the permitted facilities covered by the original TMDL and subsequent WQMP updates have also been given a daily average for *E. coli* of 126 cfu/100 mL consistent with standard bacteria permitting practices for the state of Texas. In addition, watershed stakeholders are meeting annually to discuss water quality in Upper Oyster Creek related to this TMDL project (both instream data as well as self-reported data from permitted facilities), and may recommend stricter permit limits for *E. coli* in the future if deemed necessary.

The changes reflected in this update resulted in the shifting of allocations between WLA Non-continuous and LA Other terms in Allocation Reach 2. This was originally presented in Table 11 in the original TMDL document, and the new allocations are updated here in Table 2. This shifting of allocations is done in such a way that the WLA Non-continuous and LA Other terms maintain the proportions presented in the April 2016 WQMP update.

Table 2 – TMDL allocation summary for Allocation Reach 2 (Updates Table 11, p. 37 in the TMDL document)

All units expressed in billion cfu of *E. coli* per day

Allocation Reach	TMDL	WLA Continuous	WLA Non-continuous	LA Other	MOS
2	1,682	202	693	787	Implicit

Appendix V. Two Total Maximum Daily Loads for Dissolved Oxygen in Upper Oyster Creek: Segment Number 1245

TMDL Updates to the Water Quality Management Plan (WQMP): Dissolved Oxygen in Upper Oyster Creek (Segment 1245)

The document Two Total Maximum Daily Loads for Dissolved Oxygen in Upper Oyster Creek: Segment 1245 was adopted by the TCEQ on 07/28/10 and approved by EPA on 09/21/10, and became an update to the state's Water Quality Management Plan (WQMP). It has had six subsequent WQMP updates prior to this one.

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

update the WLA for one facility that has increased its permitted discharge, and remove a permit that was cancelled.

The allocations presented in this update were verified as satisfactory using the QUAL2K model used in establishing the original TMDL.

Table 1 –WLA for Upper Reach 1245_03 by Individual WWTF (Table 9, p. 29 in original TMDL document)

Facility	TCEQ Permit No. EPA Permit No. Outfall No.	Final Permitted Discharge (MGD)	Allowable CBOD5 Loading (kg/d) | (lb/d)	Allowable NH3-N Loading (kg/d) | (lb/d)	Comments
FORT BEND CO. MUD # 142	WQ0015308-001 TX0135879 Outfall 001	1.2	45.42 | 100.15	9.08 | 20.03	Increased discharge
FORT BEND CO. MUD # 132	WQ0015428-001 TX0136786 Outfall 001	NA	NA	NA	Permit cancelled

The relevant permit limits for the facility that increased its discharge are provided in Table 2.

Table 2 – Permitted Loadings for Individual WWTFs (Corresponds to Table 3, p. 13 in original TMDL document)

Facility	TCEQ Permit No. EPA Permit No. Outfall No.	Final Permitted Discharge (MGD)	$CBOD_5$ (mg/L)	NH_3-N (mg/L)	Dissolved Oxygen (mg/L)
FORT BEND CO. MUD # 142	WQ0015308-001 TX0135879 Outfall 001	1.2	10	2	6

The TMDL summary equations must also be updated for carbonaceous biochemical oxygen demand (CBOD5; Table 3) and ammonia nitrogen (NH3-N; Table 4) to reflect these changes.

Table 3 - Summary of TMDLs for Upper Reach $CBOD_5$ (Table 13, p. 36 in original TMDL document)

Source Category	Proposed (Full Permitted) Loading[1] (kg/d)	Allowable Loading[2] (kg/d)
1245_03:		
Waste Load Allocation	305.18	305.18
Load Allocation	96.00	96.00
Total Loading	401.18	401.18

Table 4 - Summary of TMDLs for Upper Reach NH_3-N (Table 14, p. 37 in original TMDL document)

Source Category	Proposed (Full Permitted) Loading[1] (kg/d)	Allowable Loading[2] (kg/d)
1245_03:		
Waste Load Allocation	78.52	78.52
Load Allocation	3.69	3.69
Total Loading	82.21	82.21

1 Those facilities routing wastewater through polishing ponds are included in the total, assuming quality exiting the pond(s) is 1.3 mg/L CBOD5 and 0.05 mg/L NH3-N.

2 Allowable loading is determined using the QUAL2K model developed for the TMDL and existing/proposed discharges at limits necessary to meet the relevant dissolved oxygen criteria.

Note: As stated earlier, the allocations presented in this update were verified as satisfactory using the QUAL2K model used in establishing the original TMDL. The original water quality sampling for the project was completed in 2005, and since then conditions in the watershed have changed and there had been limited sampling to assess water quality. A new sampling project for Segment 1245 began in December 2015 and continued approximately monthly through August 2017. In addition to providing valuable information to concerned stakeholders in the watershed, these data are now being analyzed and a new modeling effort is underway.

Appendix VI. Addendum One to Six Total Maximum Daily Loads for Indicator Bacteria in the Armand Bayou Watershed

One Total Maximum Daily Load for Indicator Bacteria in Armand Bayou Tidal
For Segment 1113
Assessment Unit 1113_03

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *Six Total Maximum Daily Loads for Indicator Bacteria in the Armand Bayou Watershed: Segments 1113, 1113A, 1113B, 1113C, 1113D, and 1113E* (TCEQ, 2015a) on August 5, 2015. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency (USEPA) on October 2, 2015. 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 Armand Bayou. Concentrations of indicator bacteria in this AU exceed the criteria 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 One Total Maximum Daily Load for Indicator Bacteria in Armand Bayou: Segment 1113* (Brady et al., 2018). Refer to the original, approved TMDL document for details related to the overall Armand Bayou watershed as well as the methods and assumptions used in developing the original TMDLs.

The addendum watershed was addressed in the original TMDL. 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 within the Armand Bayou AU included within this addendum in the 2014 edition of the *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303 (d)* (2014 Integrated Report; TCEQ, 2015b). Table 1 provides a summary for the 2014 Integrated Report (the most recent approved version). The impaired AU is Armand Bayou Tidal (1113_03), as shown in Figure 1. The Armand Bayou Tidal segment has three AUs. The downstream AU (1113_01) is not impaired, and the middle AU (1113_02) was addressed in the original TMDL document. The project watershed is located entirely within Harris County. (The term "project watershed" will be used throughout this document to refer to the watershed for only AU 1113_03. "Armand Bayou watershed" will be used to refer to the entire area addressed by the original TMDL document, which included all AUs of Armand Bayou as well as its tributaries.)

The Texas Surface Water Quality Standards (TSWQS; TCEQ, 2010) provide numeric and narrative criteria to evaluate attainment of designated uses. The basis for the water quality target

for the TMDL developed in this report is the numeric criteria for indicator bacteria from the 2010 TSWQS. *Enterococcus* species (Enterococci) are the preferred indicator bacteria for assessing contact recreation use in saltwater.

Table 1. Synopsis of the 2014 Integrated Report for Armand Bayou Tidal (1113_03).

Integrated Report Year	Segment	AU	Parameter	Contact Recreation Use	Year First Impaired	Category
2014	1113	1113_03	Enterococci	Nonsupport	2014	5c

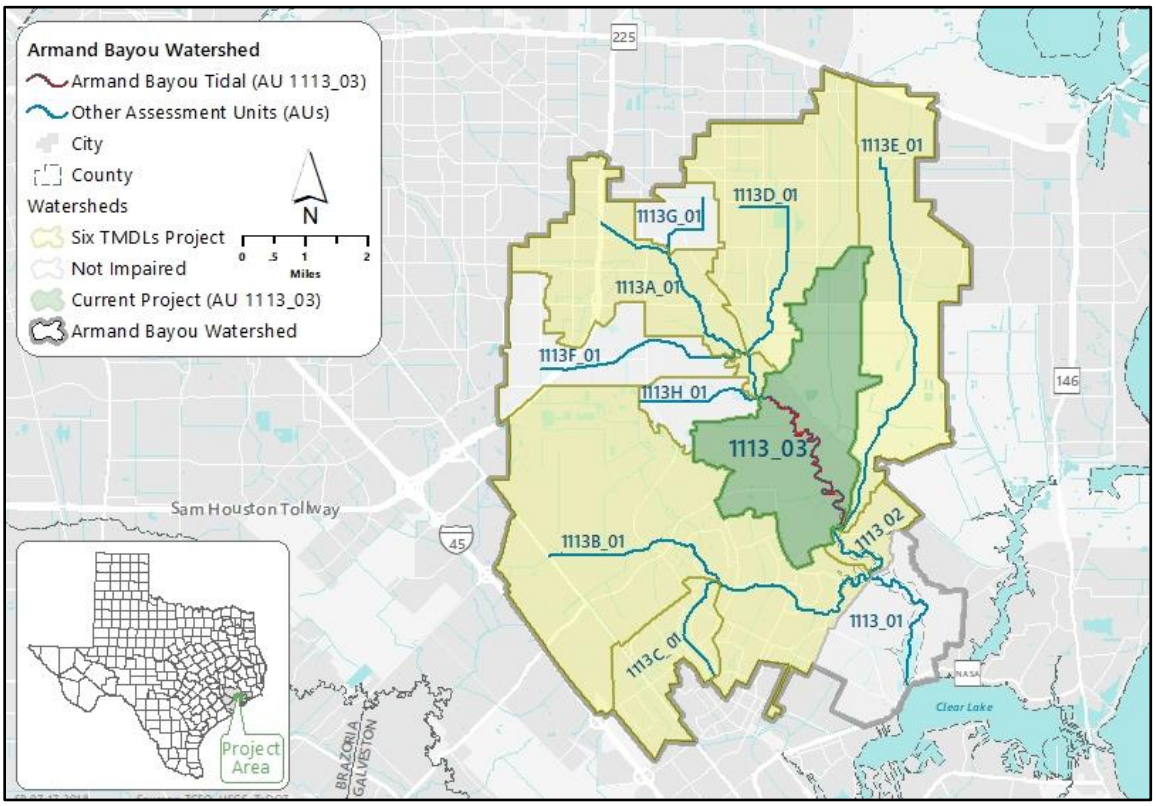

Figure 1. Map showing the full Armand Bayou watershed and the project watershed (for 1113_03) considered in this addendum.

Table 2 summarizes the ambient water quality data for the TCEQ surface water quality monitoring (SWQM) station on the affected AU of Armand Bayou, as reported in the 2014 Integrated Report. The data from the assessment indicate nonsupport of the primary contact recreation use for Armand Bayou, because the geometric mean concentration for Enterococci exceeds the geometric mean criterion of 35 most probable number (MPN)/100 milliliters (mL) in water. Recent environmental monitoring within this AU of Armand Bayou has occurred at TCEQ monitoring station 11505 (Figure 2).

Table 2. 2014 Integrated Report summary for Armand Bayou Tidal (1113_03).
(The geometric mean criterion for Enterococci for primary contact recreation use is 35 MPN/100 mL of water.)

Integrated Report Year	AU	Parameter	Station	Number of Samples	Data Range	Enterococci Geometric Mean (MPN/100 mL)
2014	1113_03	Enterococci	11505	24	2005–2012	47.59

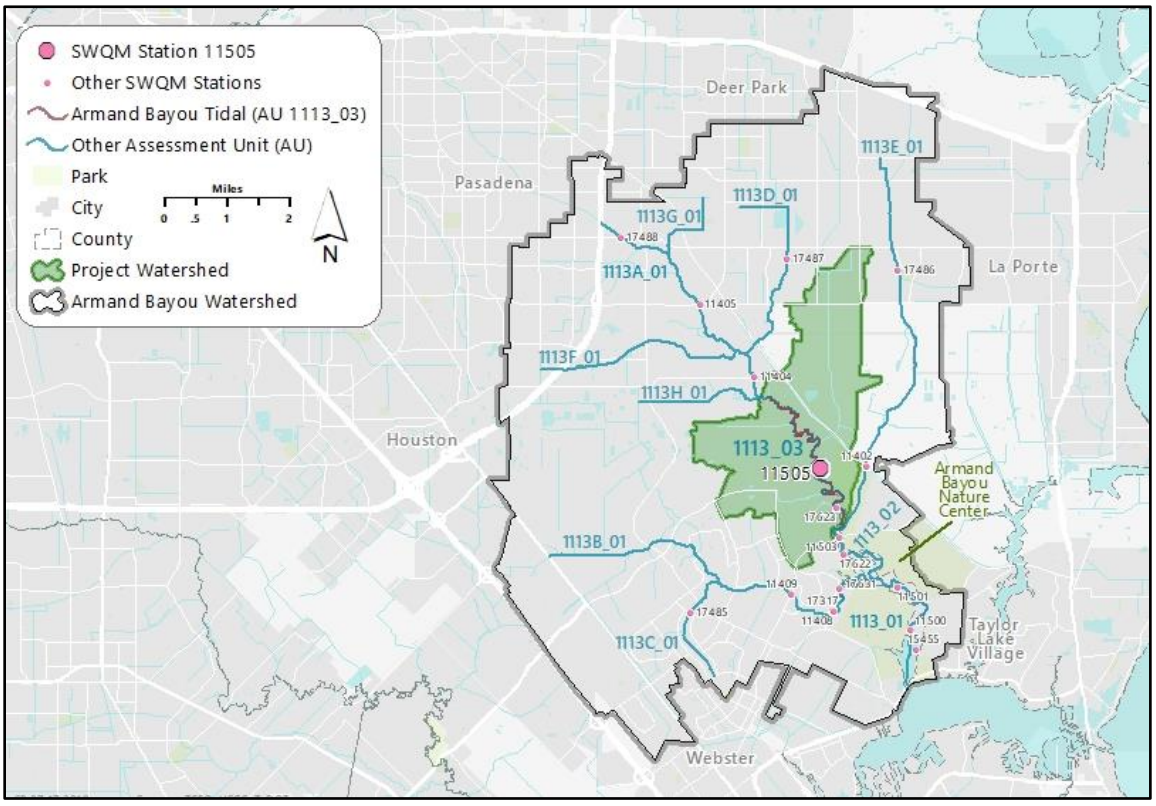

Figure 2. Map showing SWQM stations within the project watershed and the entire Armand Bayou watershed.

Description of the Study Area

Armand Bayou Tidal debouches into Clear Lake (Segment 2425), which connects to the Upper Galveston Bay (Segment 2421) and thence to the Gulf of Mexico. The entire Armand Bayou Tidal segment comprises three assessment units. The subject AU (1113_03) is the farthest upstream AU. Armand Bayou Tidal AU 1113_03 is approximately 4.82 miles in length and drains an area of 4,580.7 acres. The project watershed makes up 12.11% of the entire Armand Bayou watershed, which covers 37,840.4 acres.

The 2014 Integrated Report (TCEQ, 2015) provides the following segment and AU description for the water body considered in this document:

- Segment 1113 (Armand Bayou Tidal) - From the Clear Lake confluence (at NASA Road 1 bridge) in Harris County to a point 0.8 km (0.5 miles) downstream of Genoa-Red Bluff Road in Pasadena in Harris County (includes Mud Lake/Pasadena Lake)
    - 1113_03 – From the Big Island Slough confluence upstream to a point 0.8 km (0.5 mi) downstream of Genoa-Red Bluff Road

Watershed Climate

The Armand Bayou watershed is located in the eastern portion of the state of Texas, where the climate is classified as “Subtropical Humid” (Larkin & Bomar, 1983). 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 & Bomar, 1983). Occasional anomalous climatic events, including floods and droughts, are a feature of the climate.

For the period from 1981 through 2010, average annual precipitation in the project watershed was calculated to be 55.13 inches, which is slightly higher than the average annual total precipitation for the entire Armand Bayou watershed of 55.05 inches (PRISM Climate Group at Oregon State University, 2012). The wettest month is June (7.1 inches), while February and March (both at 3.2 inches) are the driest months, with rainfall occurring throughout the year. Average high temperatures typically peak (93 °F) in August. During winter, the average low temperature (45 °F) generally occurs in January (Figure 3).

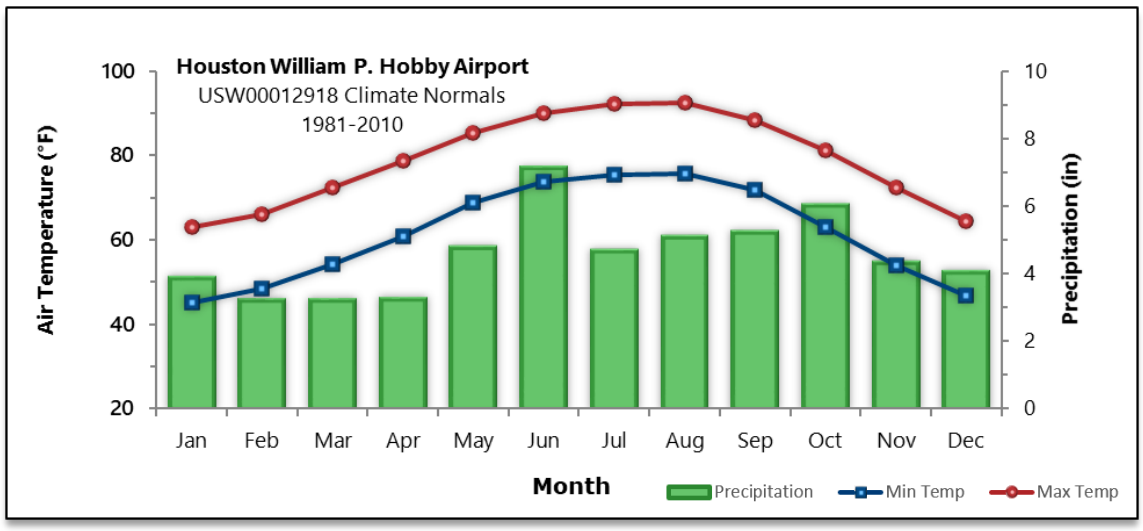

Figure 3. Chart showing the average minimum and maximum air temperature and total precipitation by month from 1981 through 2010 for the Hobby Airport weather station.

Land Use

The land use/land cover data for the project watershed and the entire Armand Bayou watershed were obtained from the Houston-Galveston Area Council (H-GAC) 2015 10 Class Land Cover Data Set (H-GAC, 2017) and are displayed in Figure 4.

As shown in Table 3, the watershed area for the project watershed is 4,580.7 acres. Dominant land uses in the project watershed include Wetlands (22%) and Pasture/Grasslands (17%).

The watershed area encompassing the entire Armand Bayou watershed is about 37,840 acres and the dominant land uses are Developed Medium Intensity (23%) and Developed Low Intensity (22%).

While the project watershed is mostly rural (53%), the entire Armand Bayou watershed is mostly urban, with 72% of the area classified as Developed.

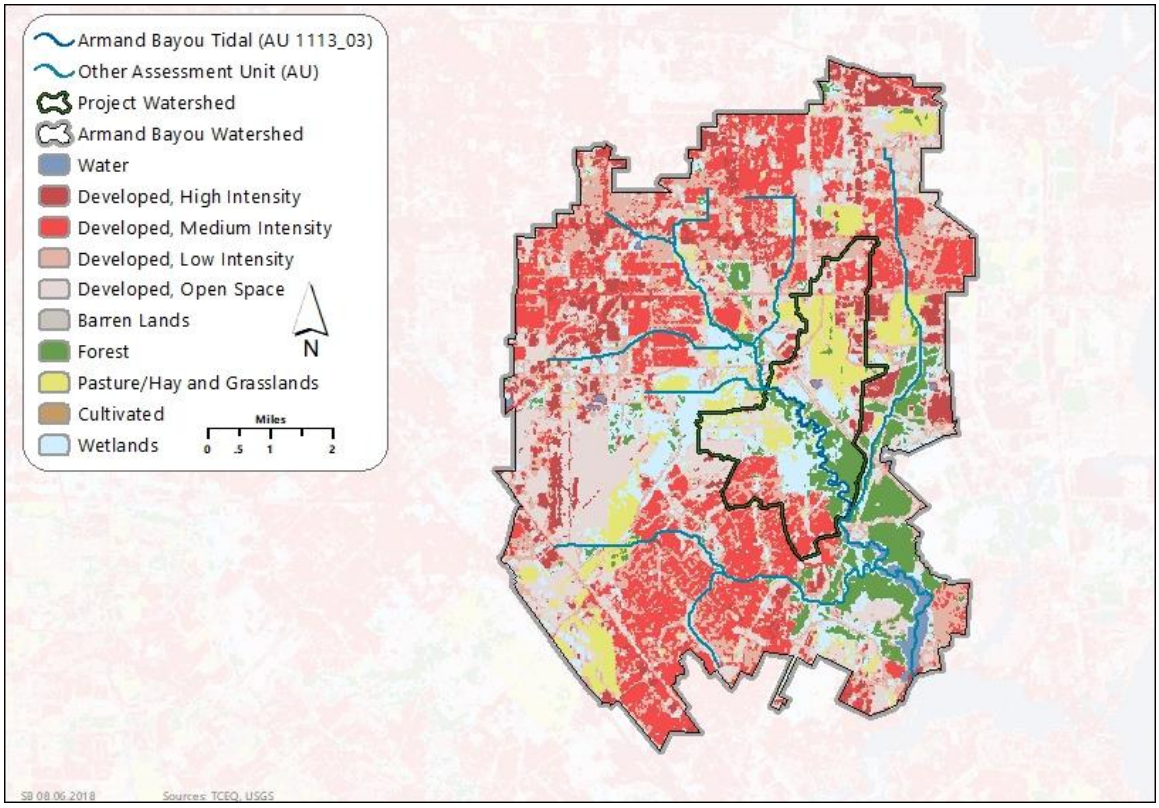

Figure 4. Land use/land cover map showing categories within the project watershed and within the entire Armand Bayou watershed.

Table 3. Land use/land cover within the project watershed.

2011 NLCD Classification	Project Area (Acres)	Percent of Total Project Area	Full Armand Bayou Watershed Area (Acres)	Percent of Full Armand Bayou Watershed
Open Water	16.9	0.4%	450.3	1.2%
Developed High Intensity	143.8	3.1%	2,660.2	7.0%
Developed Medium Intensity	652.3	14.2%	8,544.4	22.6%
Developed Low Intensity	671.1	14.7%	8,290.8	21.9%
Developed Open Space	697.2	15.2%	7,674.0	20.3%
Barren Lands	7.8	0.2%	177.8	0.5%
Forest/Shrubs	609.7	13.3%	2,686.7	7.1%
Pasture/Grasslands	787.0	17.2%	2,838.0	7.5%
Cultivated Crops	0.9	0.0%	7.6	0.0%
Wetlands	994.0	21.7%	4,510.6	11.9%
Total	4,580.7	100.0%	37,840.4	100.0%

Watershed Population and Population Projections

According to the 2010 Census (USCB and TNRIS, 2011), there are an estimated 8,071 people in the project watershed, indicating a population density of 1,127 people/square mile. The entire population of the project watershed lives within either Pasadena (3,242), Houston (2,776) or La Porte (2,053), as shown in Figure 5. Approximately 45 percent of the area of the project watershed is included within the Pasadena city limits, 17 percent is within the Houston city limits, 9 percent is within the La Porte city limits, and 28 percent is located outside of any city limits.

Also, according to the 2010 Census, there are an estimated 125,844 people in the entire Armand Bayou watershed, indicating a population density of 2,128 people/square mile. The majority of the population (47,248 people, or 38 percent) live within the Houston city limits; the remaining residents live within Pasadena (27 percent), La Porte (17 percent), Deer Park (16 percent), Taylor Lake Village (2 percent), and Webster (0.3 percent), as shown in Figure 5. Approximately 10 percent of the area of the entire Armand Bayou watershed is located outside of any city limits.

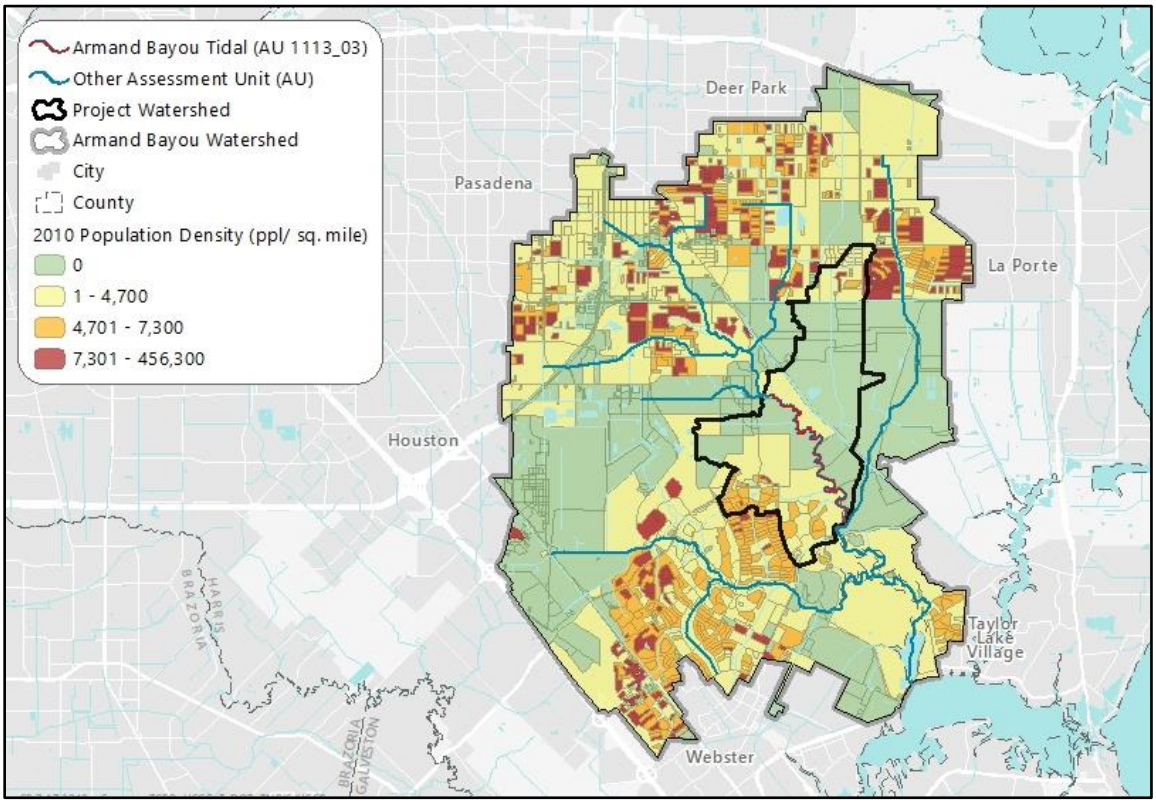

Figure 5. Population density map showing 2010 population by census block within the project watershed and the entire Armand Bayou watershed.

Population projection data, available through the state water planning process via the Office of the State Demographer and the Texas Water Development Board (TWDB, 2013), is based on areas known as Water User Groups (WUGs). Geospatial analysis based on WUGs, which allows a refinement of county and city-level projections, reveals that populations are predicted to increase 70.2 percent in the project watershed (compared to 31.0 percent for the entire Armand Bayou watershed) between 2010 and 2050 (Table 4).

Table 4. 2010 population and 2050 population projections for the project watershed and full Armand Bayou watershed.

Location	2010 U. S. Census	2050 Population Projection	Projected Population Increase (2010-2050)	Percent Change
Project Watershed	8,071	13,737	5,666	70.2%
Full Armand Bayou Watershed	125,844	164,837	38,993	31.0%

Endpoint Identification

The endpoint for the TMDL is to maintain the concentration of Enterococci below the geometric mean criterion of 35 MPN/100mL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2010 TSWQS (TCEQ, 2010).

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

Currently, no wastewater treatment facilities (WWTFs) exist within or upstream of the project watershed. There are currently three permitted WWTFs (five outfalls) within the greater Armand Bayou watershed, which are shown in Figure 6; the permits were described in the previously completed TMDL (TCEQ, 2015a).

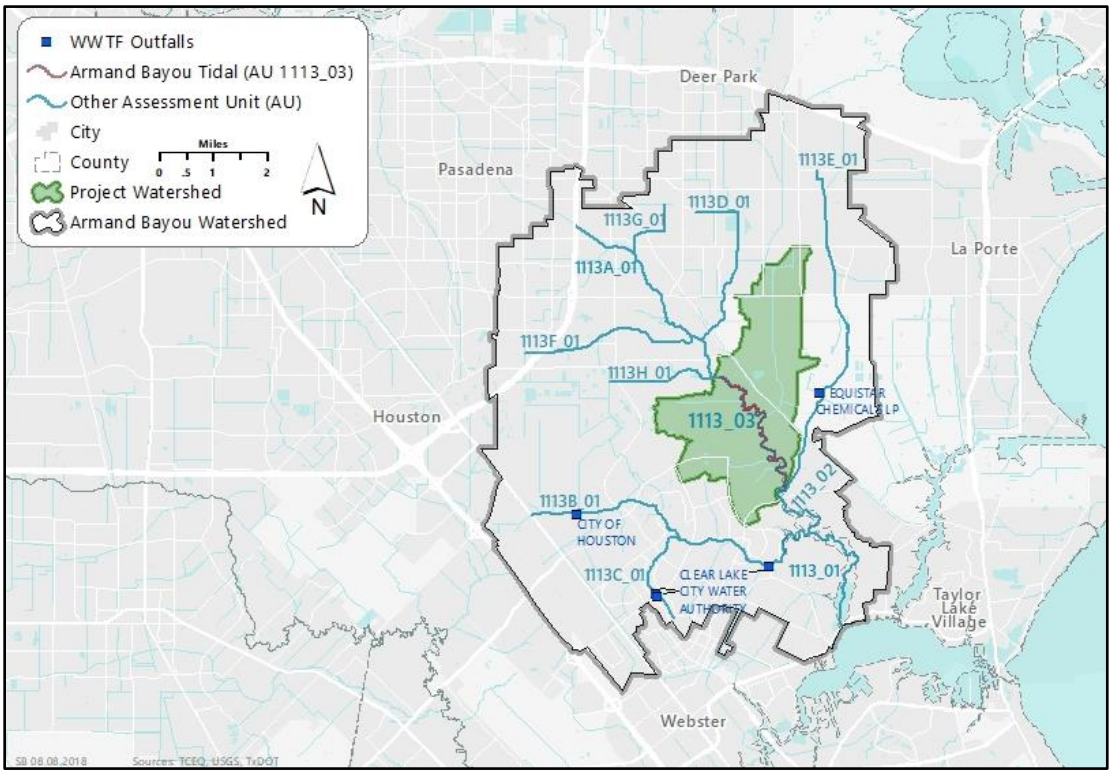

Figure 6. Map showing WWTF outfalls within the greater Armand Bayou watershed, labeled by permittee.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party. The TCEQ Region 12 Office maintains a database of 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. For the period between January 2016 and December 2017, there were zero SSOs reported within the project watershed. A summary of the reports of SSO events that were determined to have occurred within the full Armand Bayou watershed between January 2016 and December 2017 are shown in Table 5.

Table 5. Summary of SSO incidences reported in the project watershed and full Armand Bayou watershed in 2016 and 2017.

Watershed	No. of Incidents	Total Volume (gallons)	Average Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
Project Watershed	0	-	-	-	-
Entire Armand Bayou Watershed	6	56,567	9,428	0.0001	34,325

TPDES-Regulated Stormwater

TPDES general permits cover stormwater discharges from Phase II Municipal Separate Storm Sewer Systems (MS4s; General Permit number TXR040000), industrial facilities (General Permit number TXR050000; also known as a multi-sector general permits (MSGPs)), concrete production facilities (General Permit number TXG110000), petroleum bulk stations and terminals (General Permit number TXG340000), and construction sites over one acre (General Permit number TXR150000).

In addition, Phase I MS4 permits are individual permits for large and medium-sized communities with populations exceeding 100,000, whereas Phase II permits are for smaller communities within a USEPA-defined urbanized area that are regulated by a general permit.

Three of these permits (MS4, MSGP, and construction) pertain solely to stormwater discharges. The other two (concrete production facilities and petroleum bulk stations and terminals) also authorize the discharge of process wastewater.

The area of the project watershed is covered by both Phase I and II MS4 permits; the associated permits match 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 2010 Census urbanized area.

For the Armand Bayou project watershed entities with Phase I individual permits and Phase II general permits, the areas included under these MS4 permits were used to estimate the regulated stormwater areas for construction, industrial, and MS4 permits. For the project watershed, there is essentially 100 percent coverage by the urbanized area. For this reason, the urbanized area will be used as a surrogate for the area for all regulated stormwater in the project watershed. However, even in highly urbanized areas such as this one, there remain small areas that are not strictly regulated by stormwater permits and which may receive bacteria loadings from unregulated sources such as wildlife and feral hogs. To account for these small unregulated areas in each

impaired watershed, the surface area within the channel of the bayou is excluded from the urbanized area and represents an area of unregulated stormwater contribution. This estimation of an area subject to unregulated direct deposition results in an area regulated by MS4 of 4,561.46 acres or 99.58% of the watershed (Figure 7).

A review of Phase I permits and a review of the TCEQ central registry for Phase II MS4 permit coverage in the entire Armand Bayou watershed revealed one Phase I permit and four Phase II permits (Table 6; TCEQ, 2018). For the entire Armand Bayou watershed, the total area under MS4 permits is 35,536.90 acres, or 93.91% of the watershed (Figure 7).

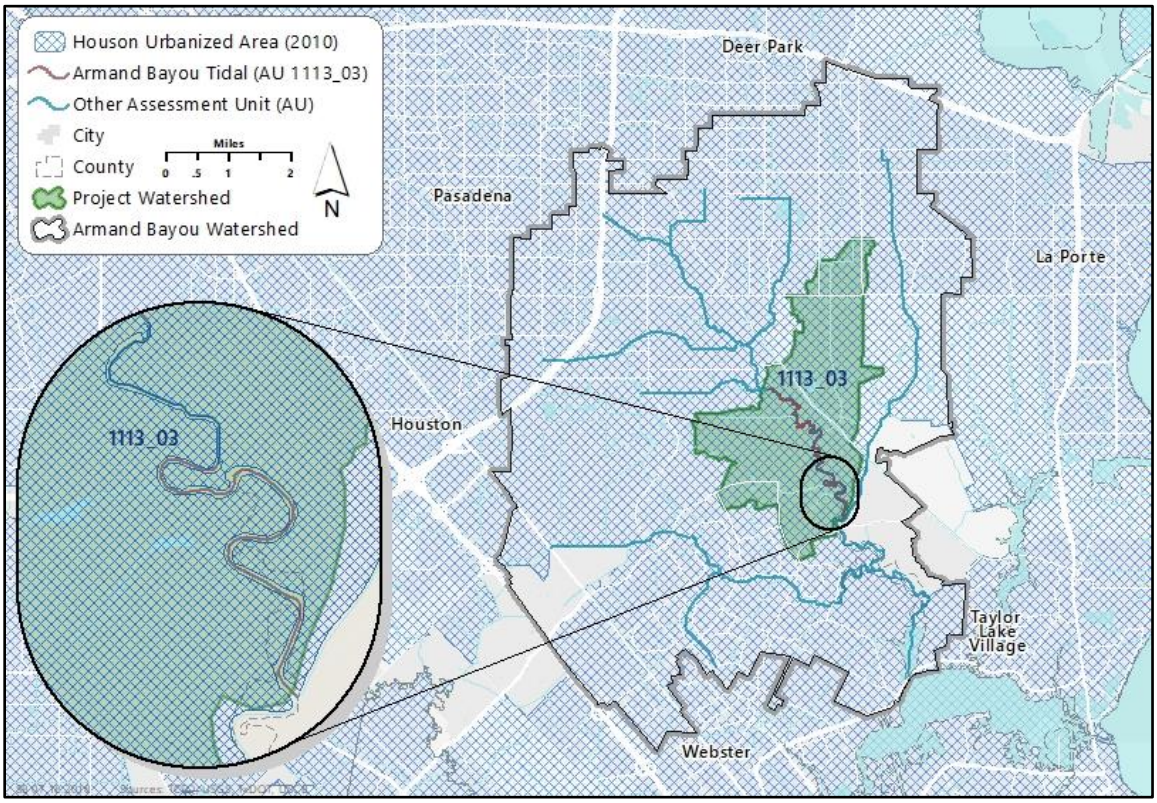

Figure 7. Map showing the regulated stormwater area based on Phase I and Phase II MS4 permits within the Armand Bayou watershed.

Table 6. TPDES and NPDES MS4 permits associated with the Armand Bayou watershed.

Entity/ Permittee	Permitted Area	TPDES Permit	NPDES Permit
City of Houston/Harris County/Harris County Flood Control District/Texas Department of Transportation	Houston	Phase 1	TXS001201
City of Deer Park	Deer Park	Phase II General Permit	TXR040388
City of La Porte	La Porte	Phase II General Permit	TXR040117
National Aeronautics and Space Administration	Houston	Phase II General Permit	TXR040214
Clear Lake City Water Authority	Pasadena, Houston, Webster and Taylor Lake Village	Phase II General Permit	TXR040388

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

Indicator bacteria inhabit the intestines of all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify the potential for bacteria contributions from wildlife. Riparian corridors of streams and rivers naturally attract wildlife. With direct access to the stream channel, direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Wildlife also deposit fecal bacteria onto land surfaces, where rainfall runoff may wash bacteria into nearby streams.

Unfortunately, quantitative estimates of wildlife are rare, 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.

For feral hogs, the Texas A&M Institute of Renewable Natural Resources (IRNR), recently renamed as the Texas A&M Natural Resources Institute, reported a range of feral hog densities within Texas of 1.33 to 2.45 hogs/square mile (IRNR, 2013). The average hog density (1.89 hogs/square mile) was multiplied by the hog habitat area in the project watershed (3.74 square miles). Habitat deemed suitable for hogs followed as closely as possible to the land use selections of the IRNR study and include from the 2015 H-GAC Land Cover dataset: Forest/Shrubs, Pasture/Grasslands, Cultivated Crops, and Wetlands. Using this methodology, there are an estimated 7 feral hogs in the project watershed. For the entire Armand Bayou watershed, the hog habitat was estimated using the same methodology; there is an estimated 15.69 square miles of hog habitat within the entire watershed, resulting in an estimate of 30 feral hogs.

For deer, the Texas Parks and Wildlife Department (TPWD) publishes data showing deer population-density estimates by Deer Management Unit (DMU) for monitored white-tailed deer range across the state (TPWD, 2017). The entire Armand Bayou watershed, as well as the project watershed, is located within the Urban Houston DMU, one of the few regions for which deer-density estimates were not published. Similarly, both the entire Armand Bayou watershed and the project watershed are not located within the monitored white-tailed deer range. While a quantitative estimate for deer within the project watershed could not readily be calculated, indications are that undeveloped areas along Armand Bayou would provide habitat suitable for a small population of deer (City of Houston, 2018).

Domesticated Animals

Livestock are a potential source of bacteria in the project watershed. The number of livestock that are found within the Armand Bayou watershed was estimated from county-level data obtained from the 2012 Census of Agriculture (USDA-NASS, 2014). The county-level data were refined to better reflect actual numbers within the impaired AU watersheds. The refinement was performed by dividing the total area of the project watershed by the total area of Harris County. This ratio was then applied to the county-level livestock data and presented in Table 7. The livestock numbers below are provided to demonstrate that livestock are a potential source of bacteria in the project watershed. 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 project watershed and full Armand Bayou watershed, based on proportional area.

Watershed	Cattle and Calves	Deer and Elk (Domestic)	Goats and Sheep	Horses, Ponies, Mules, Burros, and Donkeys	Poultry
Project Watershed	144	8	15	26	40
Full Armand Bayou Watershed	1,189	65	126	218	329

Table 8 summarizes the estimated number of dogs and cats within the Armand Bayou 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 (AVMA) 2012 U.S Pet Statistics (AVMA, 2015). The actual contribution and significance of indicator bacteria loads from pets reaching the segments of the Armand Bayou watershed is unknown.

Table 8. Estimated households and pet populations for the project watershed and full Armand Bayou watershed.

Watershed	Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
Project Watershed	2,708	1,581	1,728
Full Armand Bayou Watershed	49,499	28,907	31,580

On-site Sewage Facilities

Estimates of the number of OSSFs in the Armand Bayou watershed were determined using data supplied by H-GAC for Harris County. The H-GAC data indicate that there are no OSSFs located within the project watershed, and only one in the full Armand Bayou 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 existing and TMDL loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). An adaptation of the LDC method to tidal waters has been successfully developed and applied by the State of Oregon (ODEQ, 2006); this approach is known as the modified LDC method. 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., 2018) 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 covered by this report incorporates an explicit MOS of 5 percent of the total TMDL allocation.

Pollutant Load Allocation

The TMDL component for the impaired AU covered in this report was derived using the median flow within the High Flows regime (or 10 percent flow) of the LDC developed for the sampling station located within the AU watershed.

Based on the LDC to be used in the pollutant load allocation process with historical Enterococci data added to the graph (Figure 8), the following broad linkage statements can be made. For the project watershed, the historical Enterococci data show a pattern of increasing tendency for the Enterococci event data to plot below the geometric mean criterion allowable loading curve as flows decrease, which is indicated in a left to right direction along the graph. This pattern of decreasing occurrence of exceedances in the event data are summarized by the geometric means of the existing data plotted for each of the three flow regimes as compared to the allowable load line for the geometric mean criterion.

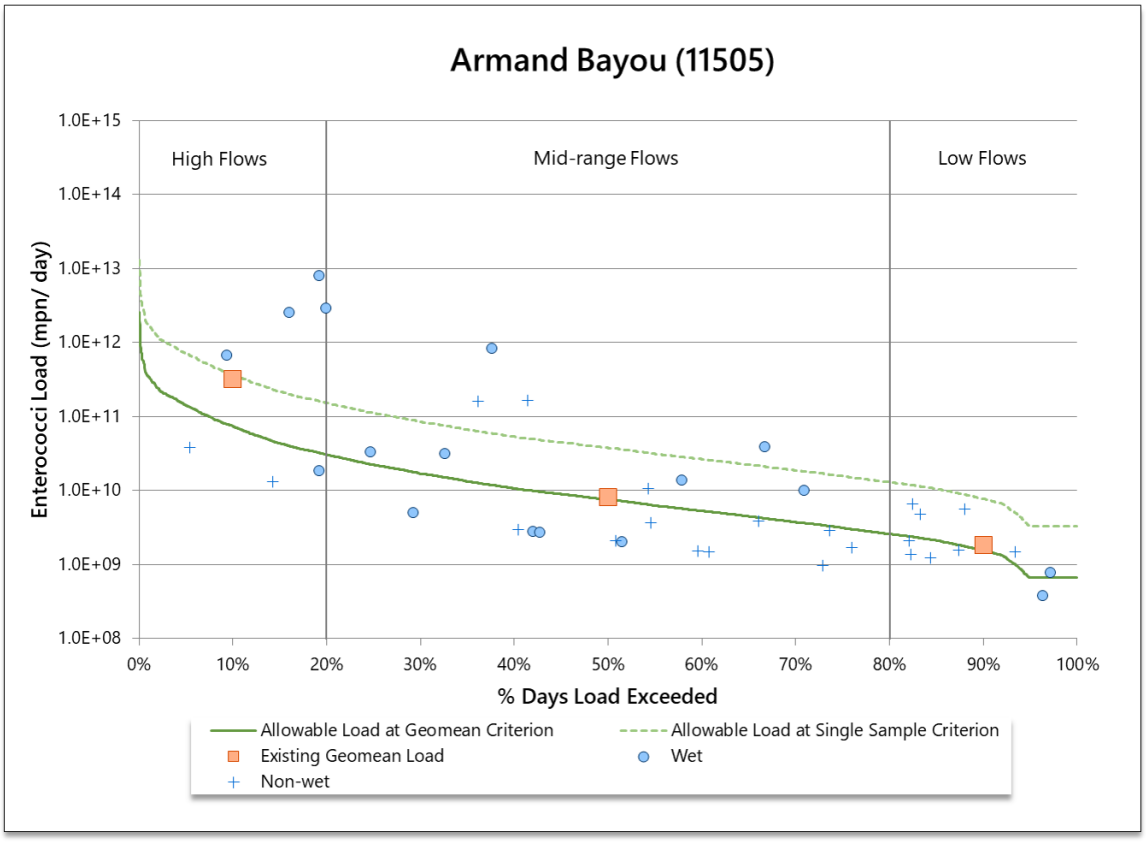

Figure 8. LDC for Armand Bayou AU 1113_03 (Station 11505)

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 within tidal reaches of the original TMDL watershed were allocated a daily wasteload (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by a reduced portion of the instream geometric mean criterion for Enterococci. This reduction of the water quality criterion (23 MPN/100mL) was used as the WWTF target to provide instream and downstream load capacity. Due to the absence of any permitted dischargers in the project watershed, the WLA_{WWTF} term 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 US 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. The percentage of land under the jurisdiction of stormwater permits in the project watershed was 99.58 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 contact recreation standard.

The calculation of a future growth component is typically based on population projections and current permitted wastewater dischargers for the project watershed. Because there are no dischargers to or upstream of impaired AU 1113_03, another method was used. According to Rule Section 217.32 of Texas Administrative Code (TAC), new WWTFs are to be designed for a daily wastewater flow of 75-100 gallons per capita per day (TAC, 2008). Conservatively taking the higher daily wastewater flow capacity (100 gallons) and multiplying it by a potential population change gives an estimated permitted flow for FG. Based on the information in Table 4, the projected population increase for the subject watershed for the 2010 through 2050 time period is 5,666. At the time of this report, only 28% of the project watershed is unincorporated, so a slightly reduced future new service population of 5,000 was assumed. Multiplying that value by the higher daily wastewater flow capacity yields a value of 0.50 million gallons per day. This value would be considered the full permitted discharge of a potential future WWTF. To maintain

consistency with the existing TMDLs in Armand Bayou, a reduced Enterococci geometric mean limit for WWTFs of 23 MPN/100 mL was used to calculate the FG component.

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 designated uses and conform to Texas antidegradation policy.

TMDL Calculations

Table 9 summarizes the TMDL calculation for Armand Bayou Tidal AU 1113_03. The TMDL was calculated based on the median flow in the 0-20 percentile range (10 percent exceedance, High Flows flow regime) for flow exceedance from the LDC developed for the SWQM station 11505. Allocations are based on the current geometric mean criterion for Enterococci of 35 MPN/100 mL for each component of the TMDL, with the exception of the WLA_{WWTF} and FG terms, which used 23 MPN/100 mL.

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}.

In the event that the criterion changes due to a change in the designated recreational use, Appendix A provides guidance for recalculating the allocations in Table 10.

Table 9. TMDL allocation summary for Armand Bayou Tidal AU 1113_03.
All loads expressed as billion MPN/day Enterococci

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	FG	MOS
Armand Bayou Tidal	1113_03	73.838	0	69.418	0.293	0.435	3.692

Table 10. Final TMDL allocations for Armand Bayou Tidal AU 1113_03.
All loads expressed as billion MPN/day Enterococci

Water Body	AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
Armand Bayou Tidal	1113_03	73.838	0.435	69.418	0.293	3.692

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 Enterococci concentrations obtained from 11 years (2006 through 2017) of routine monitoring collected in the warmer months (May through September) against those collected during the cooler months (October through April). Differences in Enterococci concentrations obtained in warmer versus cooler months were then evaluated by performing a t-test on the natural log-transformed dataset. This analysis of Enterococci data indicated that there was no significant difference in indicator bacteria

between cool (M = 3.98, SD = 3.30) and warm (M = 4.03, SD = 3.62) weather seasons for Armand Bayou Tidal at station 11505 (two-sample $t(37) = -0.0772$, $\alpha = 0.05$, $p = 0.0938$).

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the TMDL study, the TCEQ 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.

The technical support document for this TMDL addition (Brady et al., 2018) was posted on the TMDL project page at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/89armand/89C-ArmandBayou-TSD-Final.pdf> on August 10, 2018. A presentation on this addendum was given at the annual spring meeting of the Bacteria Implementation Group (BIG) in Houston on June 5, 2018. The public will have an opportunity to comment on this addendum during a 30-day Water Quality Management Plan update public comment period (November 9 through December 11, 2018). 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 online news page at <www.tceq.texas.gov/waterquality/tmdl/tmdlnews.html>, and the document will be posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html>. TCEQ accepted public comments on the original TMDL during the period February 8, 2015 through March 9, 2015. Two comments were submitted, and none of them referred directly to the AU in this TMDL addendum.

Implementation and Reasonable Assurance

The segment covered by this addendum is within the existing bacteria TMDL watershed of Armand Bayou. That TMDL watershed is within the area covered by the Implementation Plan developed by the BIG for bacteria TMDLs throughout the greater Houston area, approved by the TCEQ on January 30, 2013. It outlines an adaptive management approach in which measures are periodically assessed for efficiency and effectiveness. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals and expresses stakeholder commitment to the process. Please refer to the original TMDL document for additional information regarding implementation and reasonable assurance.

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Appendix A

Equations for Calculating TMDL Allocations for Contact Recreation Standard Changes

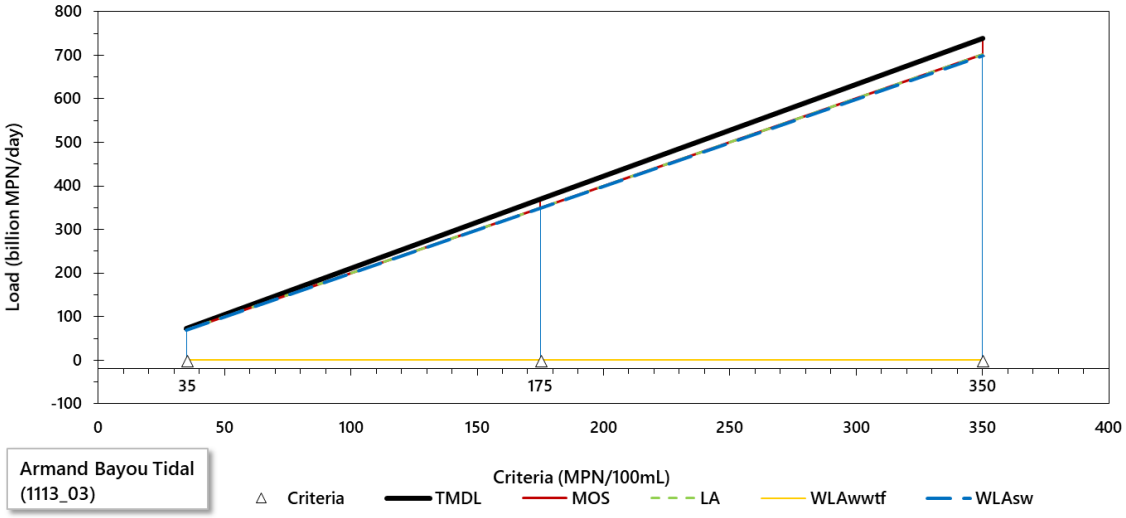

Figure A-1. Allocation loads for Enterococci for Armand Bayou Tidal (1113_03) as a function of water quality criteria.

Equations for calculating new TMDL and allocations (in billion MPN/day Enterococci):

TMDL = 2.10965398 * Std
MOS = 0.10548255 * Std
LA = 0.00841747 * Std - 0.00182787
WLA_{WWTF} = 0.435
WLA_{sw} = 1.99575396 * Std - 0.43317213

Where:

Std = Revised contact recreation standard
MOS = Margin of safety
LA = Total load allocation (unregulated sources)
WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)
WLA_{SW} = Waste load allocation (permitted stormwater)

Table A-1. TMDL allocations for the Armand Bayou Tidal (1113_03) watershed for potential changed contact recreation standards.

All loads expressed as billion MPN/day Enterococci

Std (MPN/100mL)	TMDL	WLA_{WWTF}[1]	WLA_{SW}	LA	MOS
35	73.8380	0.4350	69.4180	0.2930	3.6920
175	369.1895	0.4350	348.8238	1.4712	18.4595
350	738.3790	0.4350	698.0807	2.9443	36.9190

[1] WLA_{WWTF} includes the future potential allocation to WWTFs.

Appendix VII. Addendum Two to Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries

One Total Maximum Daily Load for Indicator Bacteria in Mary's Creek Bypass
For Segment 1102F
Assessment Unit 1102F_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries: Segments 1101, 1101B, 1101D, 1102, 1102A, 1102B, 1102C, 1102D, and 1102E (TCEQ, 2008)* on September 10, 2008. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency on March 6, 2009. 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 Clear Creek. Concentrations of indicator bacteria in this AU exceed the criteria 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: Bacteria Total Maximum Daily Load for the Mary's Creek Bypass Watershed: Segment 1102F_01* (University of Houston, 2016). Refer to the original, approved TMDL document for details related to the overall Clear Creek watershed as well as the methods and assumptions used in developing the original TMDLs.

The addendum watershed was addressed in the original TMDL. 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 within the Mary's Creek Bypass segment included within this addendum in the 2014 edition of the *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303 (d)* (2014 Integrated Report; TCEQ, 2015). Table 1 provides a summary for the 2014 Integrated Report (the most recent approved version). The impaired AU is Mary's Creek Bypass (1102F_01), as shown in Figure 1. The Mary's Creek Bypass segment has only one AU. The project watershed is located within Brazoria and Galveston counties. Figure 1 also shows the Mary's Creek Bypass watershed in relation to the entire watershed of the original TMDLs.

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

Table 1. Synopsis of the 2014 Integrated Report for Mary's Creek Bypass.

Integrated Report Year	Segment	AU	Parameter	Contact Recreation Use	Year First Impaired	Category
2014	1102F	1102F_01	*E. coli*	Nonsupport	2014	5a

Table 2 summarizes the ambient water quality data for the TCEQ surface water quality monitoring (SWQM) stations on Mary's Creek Bypass, as reported in the 2014 Integrated Report. The data from the assessment indicate nonsupport of the primary contact recreation use for Mary's Creek Bypass, because the geometric mean concentration of *E. coli* exceeds the geometric mean criterion of 126 most probable number (MPN)/100 milliliters (mL) of water. Recent environmental monitoring within the Mary's Creek Bypass watershed has occurred at TCEQ monitoring stations 17917 (Mary's Creek Bypass at Dixie Farm) and 18639 (Mary's Creek Bypass at FM 518) (Figure 2).

Description of the Study Area

Mary's Creek Bypass is located in the southern portion of the greater Houston area within the Clear Creek watershed. The Clear Creek watershed encompasses approximately 180 square miles of land located just southeast of the City of Houston, Texas. The Clear Creek watershed is part of the San Jacinto-Brazos Coastal Basin. Clear Creek flows into Clear Lake (Segment 2425) that, in turn, feeds into Upper Galveston Bay (Segment 2421). Mary's Creek Bypass is a flood control diversion of the main channel of Mary's Creek (Segment 1102B). Mary's Creek Bypass is 2.37 miles long and has a drainage area of 1309.6 acres.

The 2014 Integrated Report (TCEQ, 2015) provides the following segment description (which is the same as the AU description) for the water body considered in this document:

- Mary's Creek Bypass (AU 1102F_01): From the Mary's Creek confluence NE of FM 518 to a point 0.96 km (0.60 mi) upstream to the Mary's Creek confluence (northwest of County Road 126).

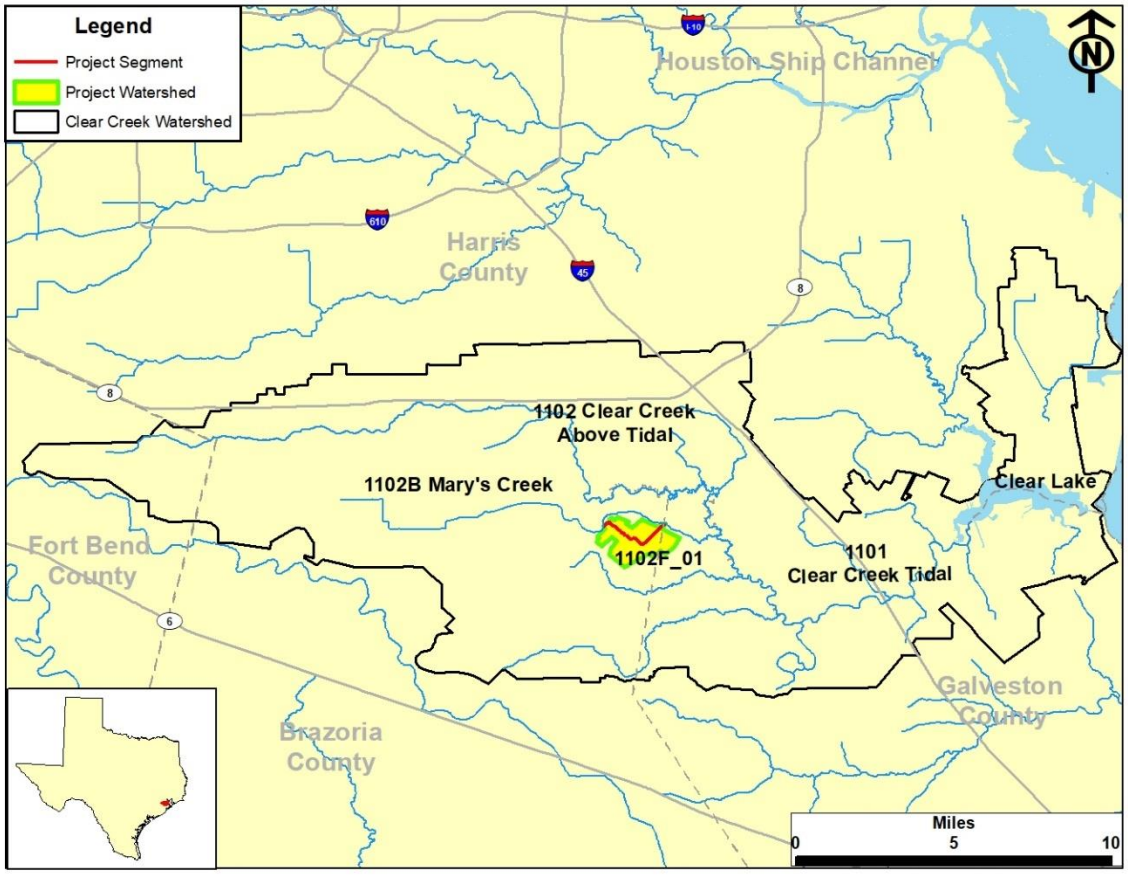

Figure 1. Location map for Mary's Creek Bypass in the Clear Creek watershed.

Table 2. 2014 Integrated Report summary for the Mary's Creek Bypass watershed.
(The geometric mean criterion for *E. coli* for primary contact recreation use is 126 MPN/100 mL of water.)

Integrated Report Year	AU	Parameter	Stations	Number of Samples	Data Range	*E. coli* Geometric Mean (MPN/100 mL)
2014	1102F_01	*E. coli*	17917, 18639	20	2005–2012	159.39

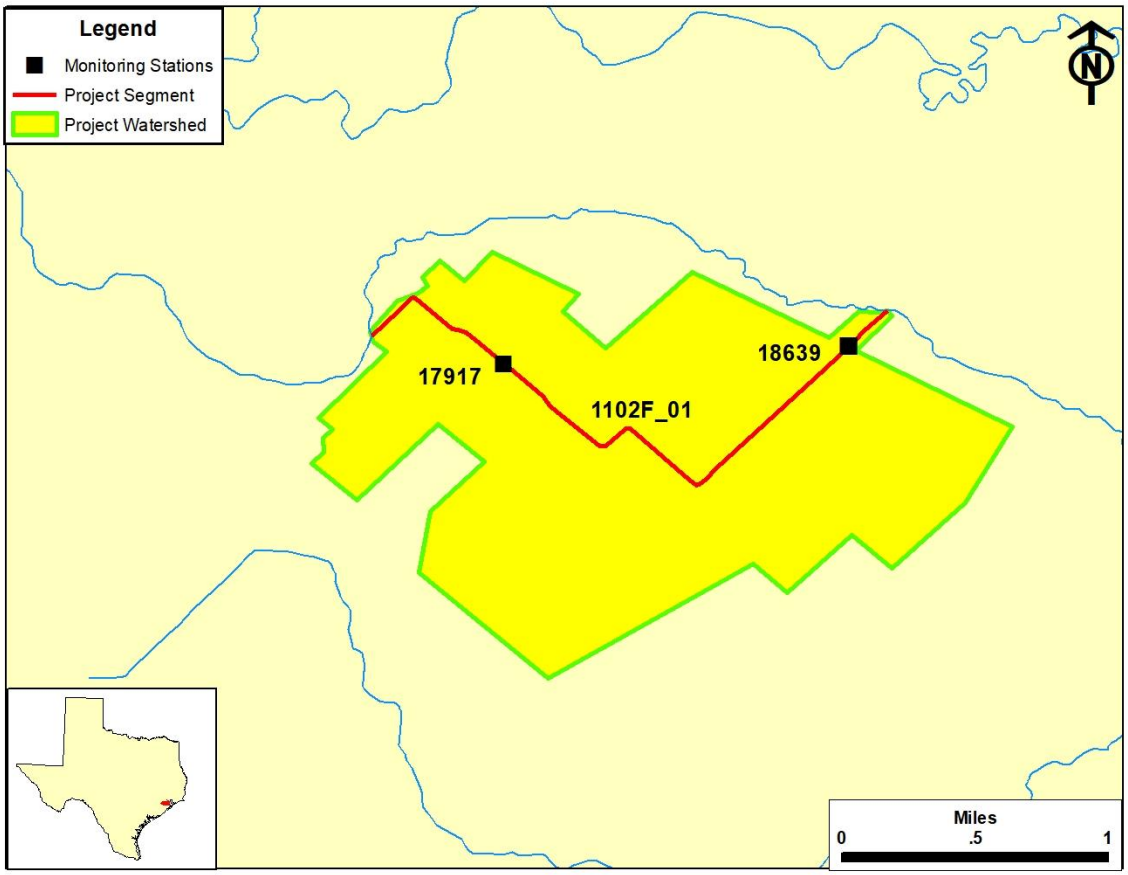

Figure 2. Mary's Creek Bypass watershed showing TCEQ monitoring stations used to assess primary contact recreation.

Watershed Climate

The climate of the region is subtropical humid, with very hot and humid summers and mild winters (USACE, 1985). July is the hottest month with an average high of 34.2 degrees Celsius (93.4 degrees Fahrenheit), while January is the coldest month with an average low of 7.3 degrees Celsius (45 degrees Fahrenheit). Table 3 provides climate (temperature) normals (NOAA, 2010).

Summer rainfall is dominated by sub-tropical convection, winter rainfall by frontal storms, and fall and spring months by combinations of these two (Burian, 2005), with an annual precipitation total of approximately 51 inches. Average annual rainfall from 2005 to 2015, based on the Harris County Office of Homeland Security and Emergency Management (HCOEM), is summarized in Table 4.

Monthly rainfall totals are fairly consistent throughout the year, with slightly more rainfall falling in July and October (approximately six and a half inches), compared to the remainder of the year (generally three to five inches). High-intensity rainfall often causes localized street flooding and occasional out-of-bank conditions. The study watershed is located near the Gulf Coast, and is potentially subject to hurricanes between June 1 and November 30 every year, although the chance of tropical weather declines dramatically in October.

Table 3. NOAA climate normals, 1981-2010.

Month	Daily Max (ºC)	Daily Min (ºC)	Daily Mean (ºC)	Classification
January	17.4	7.3	12.4	Cool
February	19.5	9.2	14.3	Cool
March	23.1	12.7	17.9	Cool
April	26.3	15.9	21.1	n/a
May	29.9	20.1	25	Warm
June	32.8	23.1	27.9	Warm
July	34.2	24.1	29.2	Warm
August	34.1	24.1	29.1	Warm
September	31.8	22	26.9	Warm
October	27.8	16.8	22.3	n/a
November	22.5	11.9	17.2	Cool
December	18.6	8.2	13.4	Cool

Table 4. Monthly rainfall averages in the Mary's Creek Bypass watershed.

Month	Average Monthly Rainfall (inches)
January	3.8
February	2.5
March	3.4
April	3.3
May	5.1
June	4.0
July	6.5
August	4.2
September	4.6
October	6.4
November	3.2
December	4.1
Average Annual Rainfall (inches)	51.1

Land Use

Table 5 summarizes the areas and the corresponding percentages of the land use categories within the Mary's Creek Bypass watershed. The land cover data were retrieved from the National Oceanic and Atmospheric Administration (NOAA, 2011) land cover database obtained from the Houston-Galveston Area Council (H-GAC) and are displayed in Figure 3. The total acreage of each land cover/land use type in Table 5 corresponds to the watershed delineation in Figure 3. The predominant land use/land cover category in this watershed is developed land (90.9 percent as the sum of all developed classes).

Table 5. Land use/land cover within the Mary's Creek Bypass watershed.

Aggregated Land Cover Category	Area (Acres)	Percent (%)
Open Water	4.0	0.31%
Developed, Open Space	384.8	29.38%
Developed, Low Intensity	395.7	30.21%
Developed, Medium Intensity	378.5	28.90%
Developed, High Intensity	31.4	2.40%
Barren Land	0.2	0.02%
Deciduous Forest	28.3	2.16%
Evergreen Forest	15.8	1.21%
Mixed Forest	4.0	0.31%
Shrub/Scrub	1.8	0.14%
Herbaceous	57.5	4.39%
Hay/Pasture	4.7	0.36%
Woody Wetlands	2.9	0.22%
Total	1,309.6	100%

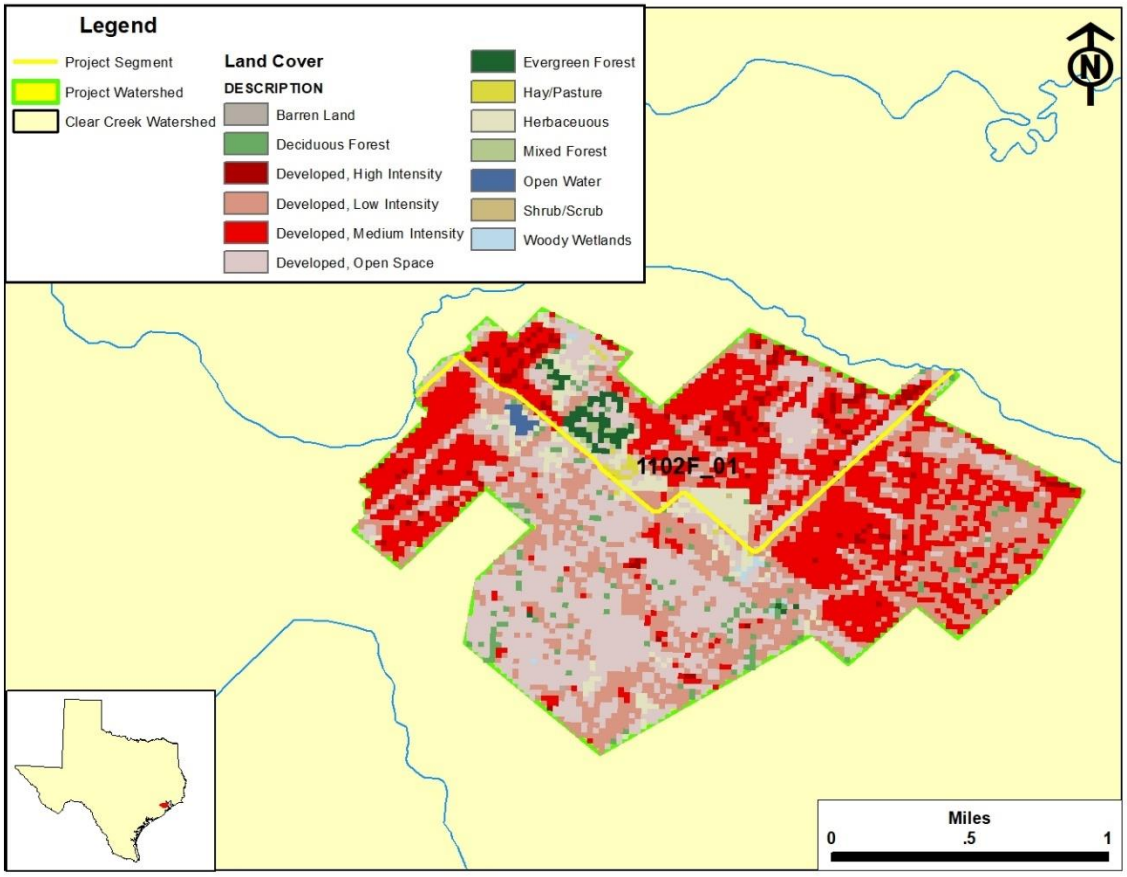

Figure 3. Land use/land cover map for Mary's Creek Bypass.

Watershed Population and Population Projections

The watershed has two incorporated cities within its boundaries—Friendswood and Pearland. From 2010 to 2030, these cities are anticipated to grow by 23% and 37% respectively according to the Texas Water Development Board (TWDB). Census 2010 block populations were used to estimate the population within the Mary's Creek Bypass watershed including unincorporated areas. According to the 2010 Census data, the Mary's Creek Bypass watershed has an estimated population of 2,960 (U.S. Census Bureau, 2010). Table 6 provides a summary of the 2010 population and 2030 population projection.

Table 6. 2010 Population and 2030 population projections for the Mary's Creek Bypass watershed.

Location	2010 U. S. Census	2030 Population Projection	Projected Population Increase (2010-2030)	Percent Change
Mary's Creek Bypass Watershed	2,960	3,993	1,033	34.9%

Endpoint Identification

The endpoint for the TMDL is to maintain the concentration of *E. coli* below the geometric mean criterion of 126 MPN/100mL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2010 TSWQS (TCEQ, 2010).

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 wastewater treatment facility (WWTF) outfalls in the Mary's Creek Bypass watershed. The City of Pearland and the Gulf Coast Waste Disposal Authority provide wastewater service to the Mary's Creek Bypass watershed but do not discharge to Mary's Creek Bypass itself. The City of Pearland facility also provides wastewater service to the area within Brazoria County Municipal Utility District (MUD) #18, which is located within the watershed.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party. TCEQ Region 12-Houston provided a database for SSO data in the Mary's Creek Bypass watershed (Laird, 2016). The locations and magnitudes of all the reported SSOs from 2001 to 2016 within the Mary's Creek Bypass watershed are summarized in Table 7 and displayed in Figure 4.

Table 7. Mary's Creek Bypass watershed SSO summary, 2001 through 2016.

Facility Name	NPDES Permit No.	Facility ID	Number of Occurrences	Date	Amount (Gallons)
City of Pearland	TX0032743	10134-010	1	12/13/2001	22,000
Gulf Coast Waste Disposal Authority	TX0069728	11571-001	1	4/17/2008	300

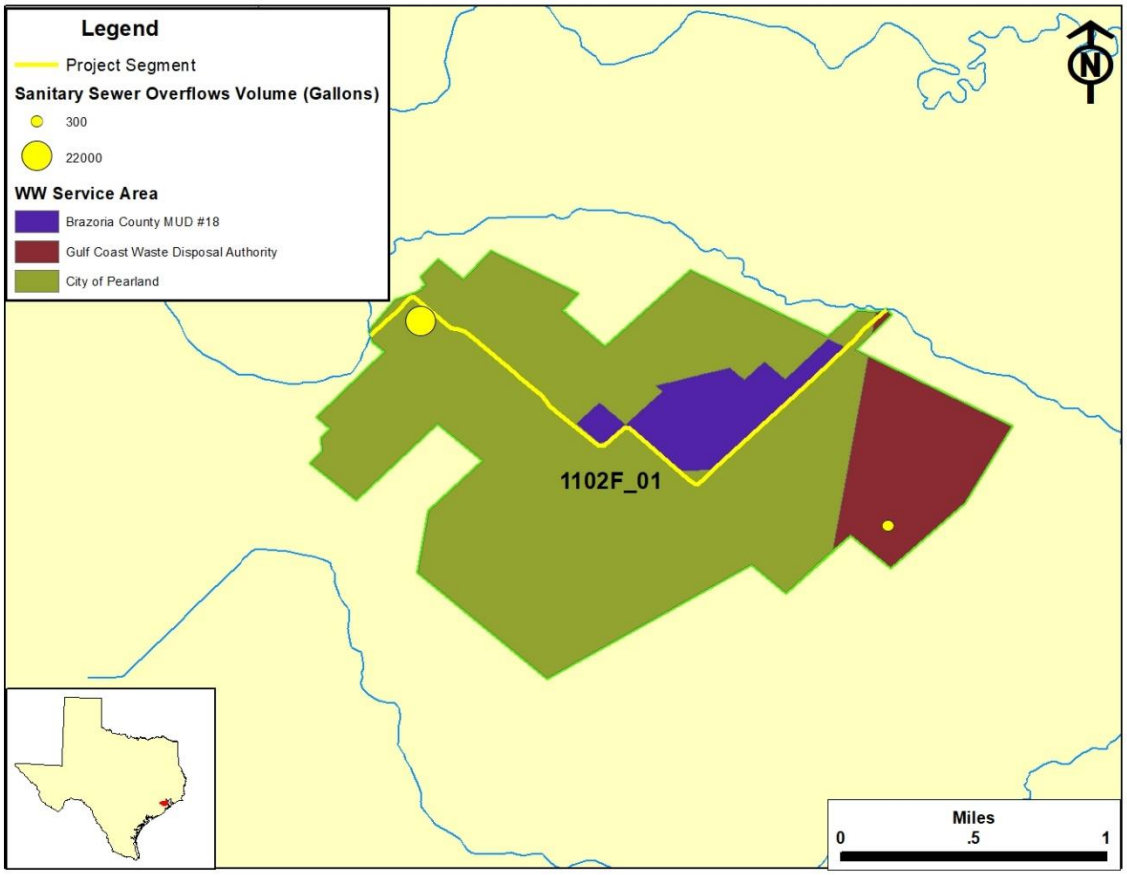

Figure 4. SSO locations and WWTF service areas.

TPDES-Regulated Stormwater

TPDES general permits cover stormwater discharges from Phase II Municipal Separate Storm Sewer Systems (MS4s; General Permit number TXR040000), industrial facilities (General Permit number TXR050000; also known as a multi-sector general permits (MSGPs)), concrete production facilities (General Permit number TXG110000), petroleum bulk stations and terminals (General Permit number TXG340000), and construction sites over one acre (General Permit number TXR150000).

Three of these permits (MS4, MSGP, and construction) pertain solely to stormwater discharges. The other two (concrete production facilities and petroleum bulk stations and terminals) also authorize the discharge of process wastewater. The geographic region of the Mary's Creek Bypass watershed covered by MS4 permits is that portion of the Mary's Creek Bypass watershed defined by the 2010 Census as being an urbanized area (Figure 5). The watershed is almost completely covered under the 2010 Census urbanized area. Therefore, the urbanized area will be used as a surrogate for the area for all regulated stormwater in the watershed. Table 8 shows a summary of MS4 permit area coverage present in the Mary's Creek Bypass watershed.

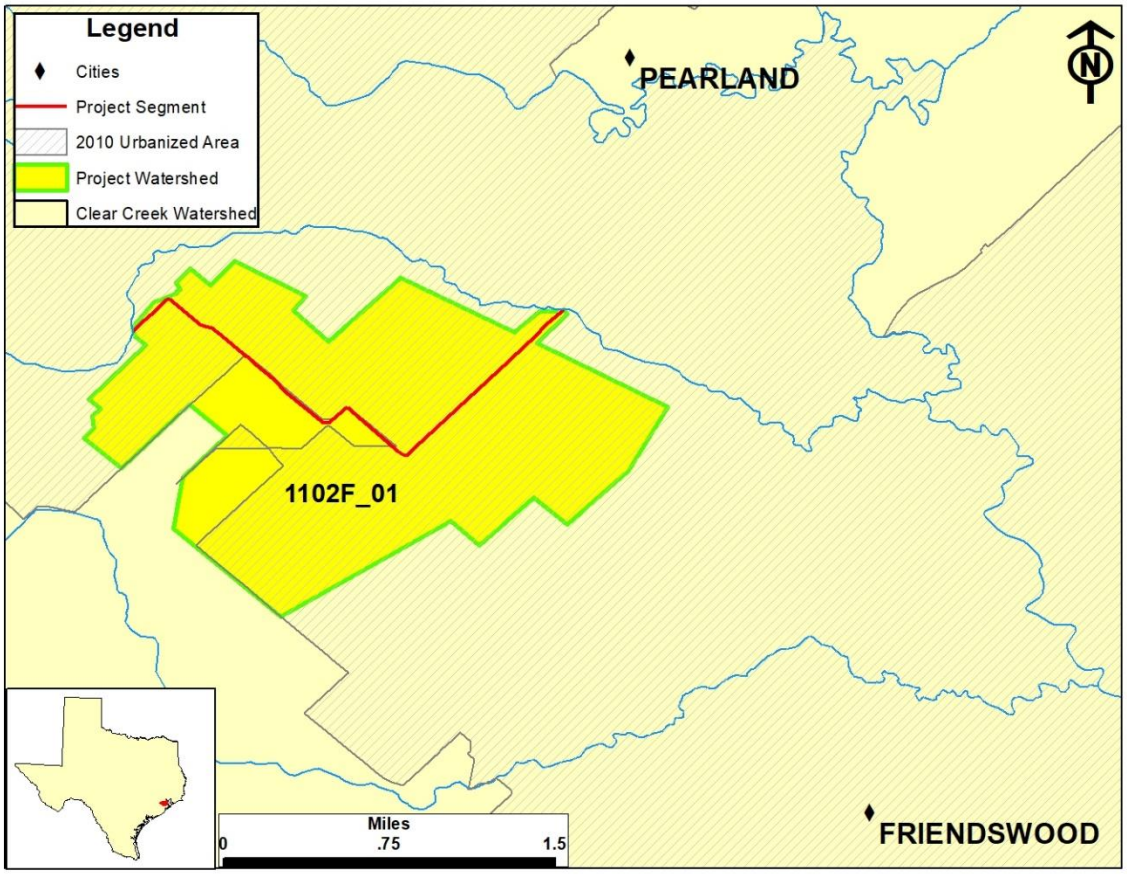

Figure 5. 2010 urbanized area.

Table 8. Percentage of Permitted Stormwater in the Mary's Creek Bypass watershed.

Regulated Entity Names and Stormwater Permit Numbers	Total Watershed Area (Acres)	Area under MS4 Permit (Acres)	Percent of Watershed Under MS4 Jurisdiction
Brazoria Drainage District 4 (TXR040144), City of Pearland MS4 (TXR040208), City of Friendswood (TXR040233), and Galveston County Consolidated Drainage District (TXR040067)	1309.6	1149.1	87.7%

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

Indicator bacteria inhabit the intestines of all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify the potential for bacteria contributions from wildlife. Riparian corridors of streams and rivers naturally attract wildlife. With direct access to the stream channel, direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Wildlife also deposit fecal bacteria onto land surfaces, where rainfall runoff may wash bacteria into nearby streams.

As is typical of coastal watersheds, a significant population of avian species frequent the Mary's Creek Bypass watershed and its riparian corridors. However, currently there are insufficient data available to estimate populations and spatial distribution of wildlife and avian species within the watershed. Consequently, it is difficult to assess the magnitude of indicator bacteria contributions from wildlife species as a general category.

Domesticated Animals

Livestock, if present, are not considered to be a significant source of bacteria, because most of the watershed is urbanized.

Table 9 summarizes the estimated number of dogs and cats within the Mary's Creek Bypass 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 (AVMA) 2012 U.S Pet Statistics (AVMA, 2015). The actual contribution and significance of indicator bacteria loads from pets reaching the water bodies of the Mary's Creek Bypass watershed is unknown.

Table 9. Estimated households and pet populations for the Mary's Creek Bypass watershed.

Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
1,117	652	713

On-site Sewage Facilities

Estimates of the number of OSSFs in the Mary's Creek Bypass watershed were determined using data supplied by H-GAC for Brazoria and Galveston counties. The H-GAC data indicate that there are 82 OSSFs located within the Mary's Creek Bypass watershed (Figure 6).

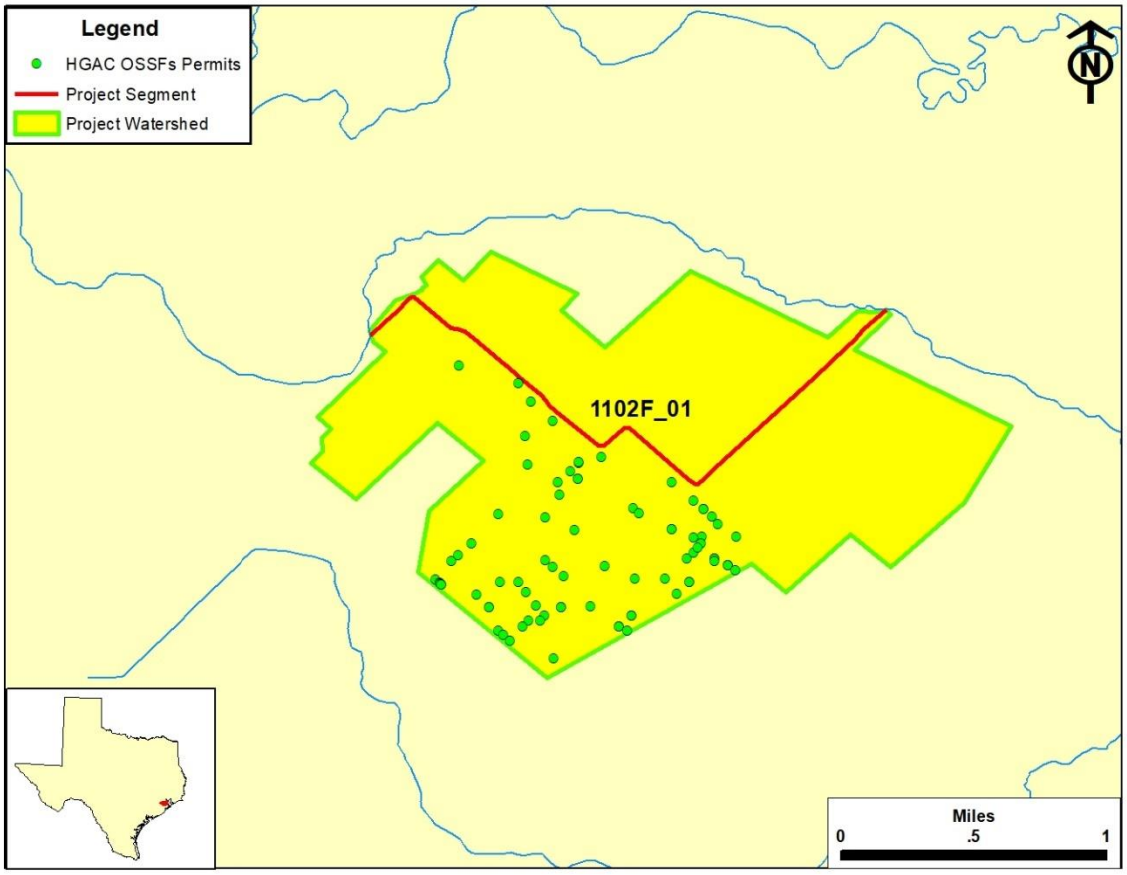

Figure 6. OSSF locations within the Mary's Creek Bypass watershed.

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 existing and 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 (University of Houston, 2016) 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 TMDLs covered by this report incorporate an explicit MOS of 5 percent of the total TMDL allocation.

Pollutant Load Allocation

The TMDL component for the impaired AU covered in this report was derived using the median flow within the Highest Flows regime (or 10 percent flow) of the LDC developed for the sampling stations located within the AU watershed.

The LDC for Mary's Creek Bypass segment 1102F_01 (Figure 7) is based on *E. coli* bacteria measurements at SWQM stations 17917 and 18639. The LDC indicates that *E. coli* levels exceed the instantaneous water quality criterion during high flow conditions. This analysis also indicates that the *E. coli* observations in the highest flow range may be wet weather influenced.

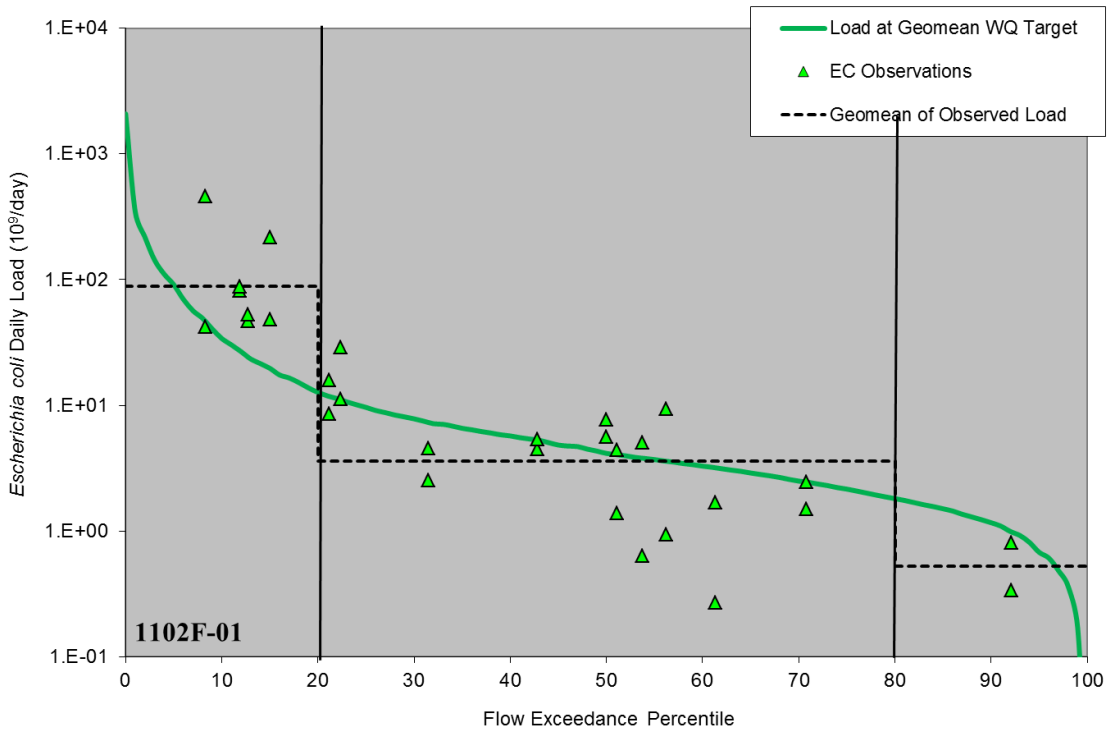

Figure 7. LDC for Mary's Creek Bypass AU 1102F_01

Wasteload Allocation

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

Wastewater Treatment Facilities

There are no TPDES-permitted WWTFs which discharge in the watershed.

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 Mary's Creek

Bypass watershed that is under the jurisdiction of stormwater permits (defined as the area designated as urbanized area in the 2010 US 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. The percentage of land under the jurisdiction of stormwater permits in the Mary's Creek Bypass watershed is 87.7 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 contact recreation standard.

Because, the drainage area of Mary's Creek Bypass is entirely serviced by WWTFs whose outfall locations lie outside the watershed boundaries, no estimated future flow increase is necessary. If a new WWTF discharge is located within the project watershed in the future, it will be addressed through a routine Water Quality Management Plan (WQMP) update.

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 designated uses and conform to Texas antidegradation policy.

TMDL Calculations

Table 10 summarizes the TMDL calculation for Mary's Creek Bypass AU 1102F_01. The TMDL was calculated based on the median flow in the 0-20 percentile range (10 percent exceedance, Highest Flows flow regime) for flow exceedance from the LDC developed for SWQM stations 17917 and 18639. Allocations are based on the current geometric mean criterion for *E. coli* of 126 MPN/100 mL for each component of the TMDL. This is the final TMDL allocation needed to comply with the requirements of 40 Code of Federal Regulations (CFR) Section 103.7. An additional table with a future growth allocation is not included in this document. See the FG section for more information.

In the event that the criterion changes due to a change in the designated recreational use, Appendix A provides guidance for recalculating the allocations in Table 10.

Table 10. TMDL allocation summary for Mary's Creek Bypass AU 1102F_01.
All loads expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
1102F_01	35.82	0.00	29.86	4.17	1.79

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. Seasonality was examined for this TMDL by using more than five years of water quality data and by using the longest period of United States Geological Survey flow records when estimating flows to develop flow exceedance percentiles. Though there was insufficient data in the Mary's Creek Bypass watershed to assess seasonal impacts, previous analysis in the Clear Creek watershed published in 2012 concluded that there was no difference in *E. coli* concentration between the warmer and colder months (TCEQ, 2012).

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the TMDL study, the TCEQ 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.

The technical support document for this TMDL addition (University of Houston, 2016) was posted on the TMDL project page at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/68ccbact/68-ccbacteria-addendum2-tsd2016-08.pdf> on May 25, 2018. A presentation on this addendum was given at the annual spring meeting of the Bacteria Implementation Group (BIG) in Houston on June 5, 2018. The public will have an opportunity to comment on this addendum during a 30-day WQMP update public comment period (November 9 through December 11, 2018). 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 online news page at <www.tceq.texas.gov/waterquality/tmdl/tmdlnews.html>, and the document will be posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html>. TCEQ accepted public comments on the original TMDL during the period June 6 through July 5, 2008. Twenty-five comments were submitted, and none of them referred directly to the AU in this TMDL addendum.

Implementation and Reasonable Assurance

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

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Appendix A.

Equations for Calculating TMDL Allocations for Contact Recreation Standard Changes

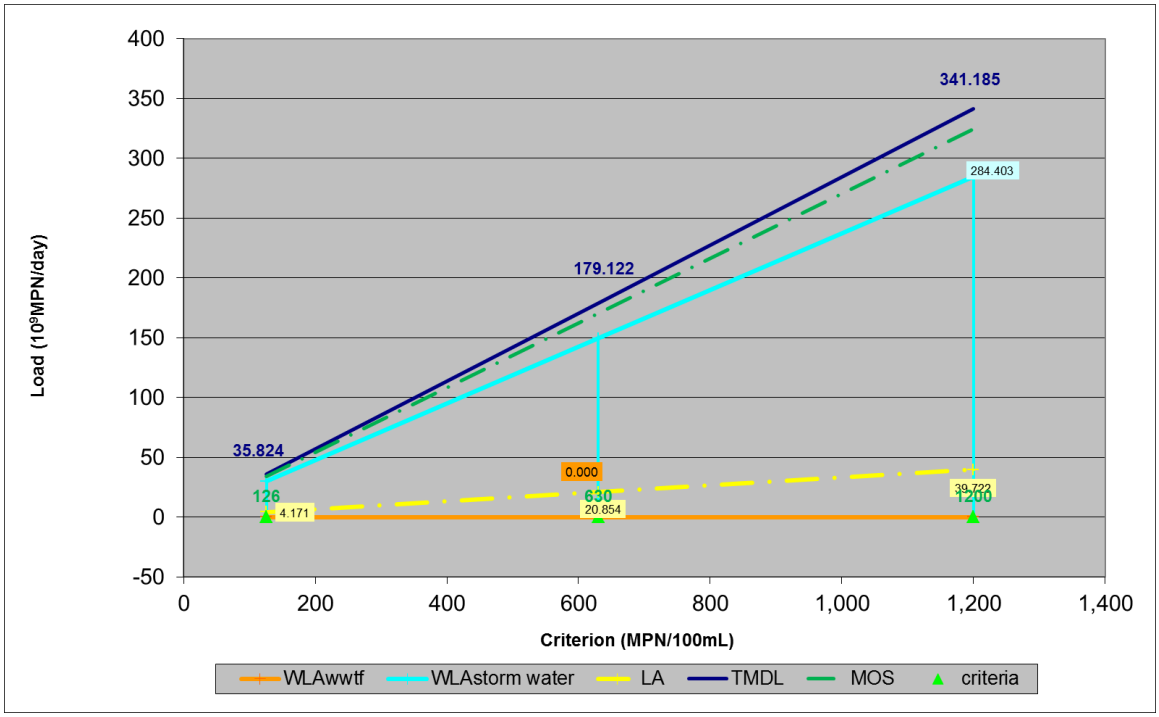

Figure A-1. Allocation loads for *E. coli* for the Mary's Creek Bypass watershed (1102F_01) as a function of water quality criteria.

Equations for calculating new TMDL and allocations (in billion MPN/day *E. coli*):

TMDL = 0.28432 * Std
MOS = 0.01421 * Std
LA = 0.03310 * Std
WLA_{WWTF} = 0.0
WLA_{sw} = 0.23700 * Std

Where:

Std = Revised contact recreation standard
MOS = Margin of safety
LA = Total load allocation (unregulated sources)
WLA_{WWTF} = Wasteload allocation (permitted WWTF load + future growth)
WLA_{SW} = Wasteload allocation (permitted stormwater)

Table A-1. TMDL allocations for the Mary's Creek Bypass watershed for potential changed contact recreation standards.

- All loads expressed as billion MPN/day *E. coli*

Std (MPN/100mL)	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
126	35.824	0.000	29.862	4.171	1.791
630	179.122	0.000	149.312	20.854	8.956
1200	341.184	0.000	284.403	39.722	17.059

Appendix VIII. Addendum One to Seven Total Maximum Daily Loads for Indicator Bacteria in Lake Houston, East Fork San Jacinto River, West Fork San Jacinto River, and Crystal Creek Watersheds

One Total Maximum Daily Load for Indicator Bacteria in Mound Creek
For Segment 1015A
Assessment Unit 1015A_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *Seven Total Maximum Daily Loads for Indicator Bacteria in Lake Houston, East Fork San Jacinto River, West Fork San Jacinto River, and Crystal Creek Watersheds: Segments 1002, 1003, 1004, and 1004D* (TCEQ, 2016) on August 24, 2016. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency (USEPA) on October 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 the West Fork San Jacinto River. That TMDL project also included TMDLs for Lake Houston, the East Fork San Jacinto River, and Crystal Creek. Concentrations of indicator bacteria in this additional AU exceed the criteria 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 Total Maximum Daily Load for Indicator Bacteria for Mound Creek: Segment 1015A* (Millican, 2018). Refer to the original, approved TMDL document for details related to the overall Lake Houston, East Fork San Jacinto River, West Fork San Jacinto River, and Crystal Creek watershed as well as the methods and assumptions used in developing the original TMDLs.

The addendum watershed and the regulated facilities within it were addressed in the original TMDL or in subsequent updates to the state's Water Quality Management Plan (WQMP). 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 within the Mound Creek segment included within this addendum in the 2014 edition of the *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303 (d)* (2014 Integrated Report; TCEQ, 2015). Table 1 provides a summary for the 2014 Integrated Report (the most recent approved version). The impaired AU is Mound Creek (1015A_01), as shown in Figure 1. The Mound Creek segment has two AUs, and the upstream AU (1015A_02) is not impaired. The project watershed is located entirely within Montgomery County (Figure 2). Figure 2 also shows the Mound Creek watershed in relation to the entire watershed of the original TMDLs.

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

Table 1. Synopsis of the 2014 Integrated Report for Mound Creek.

Integrated Report Year	Segment	AU	Parameter	Contact Recreation Use	Year First Impaired	Category
2014	1015A	1015A_01	*E. coli*	Nonsupport	2014	5c

Table 2 summarizes the ambient water quality data for the TCEQ surface water quality monitoring (SWQM) station on Mound Creek, as reported in the 2014 Integrated Report. The data from the assessment indicate nonsupport of the primary contact recreation use for Mound Creek, because the geometric mean concentration for *E. coli* exceeds the geometric mean criterion of 126 most probable number (MPN)/100 milliliters (mL) of water. Recent environmental monitoring within the Mound Creek watershed has occurred at TCEQ monitoring station 17937 (Figure 3).

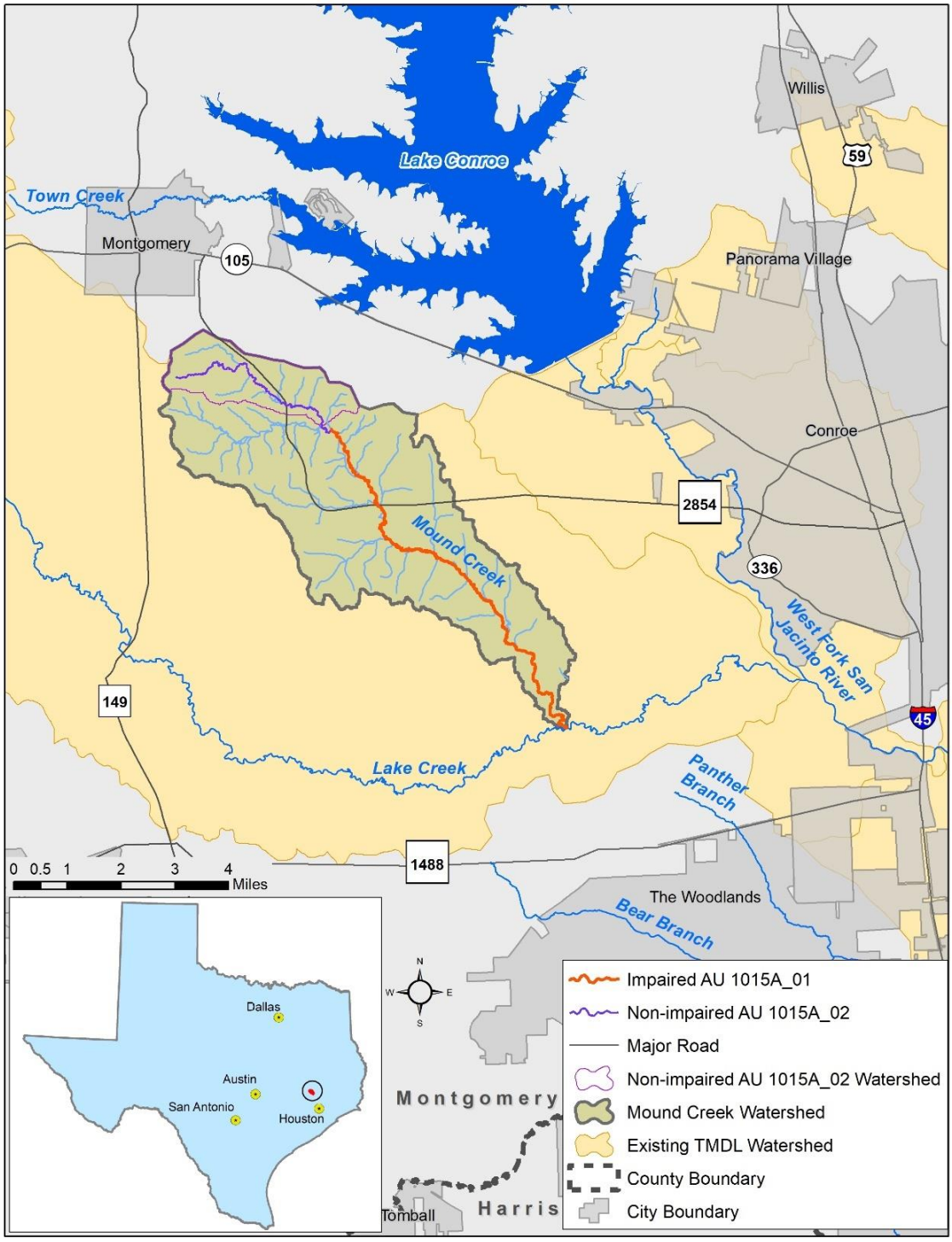

Figure 1. Overview map showing the total contributing drainage area for the Mound Creek watershed and separate drainage areas of its two AUs.

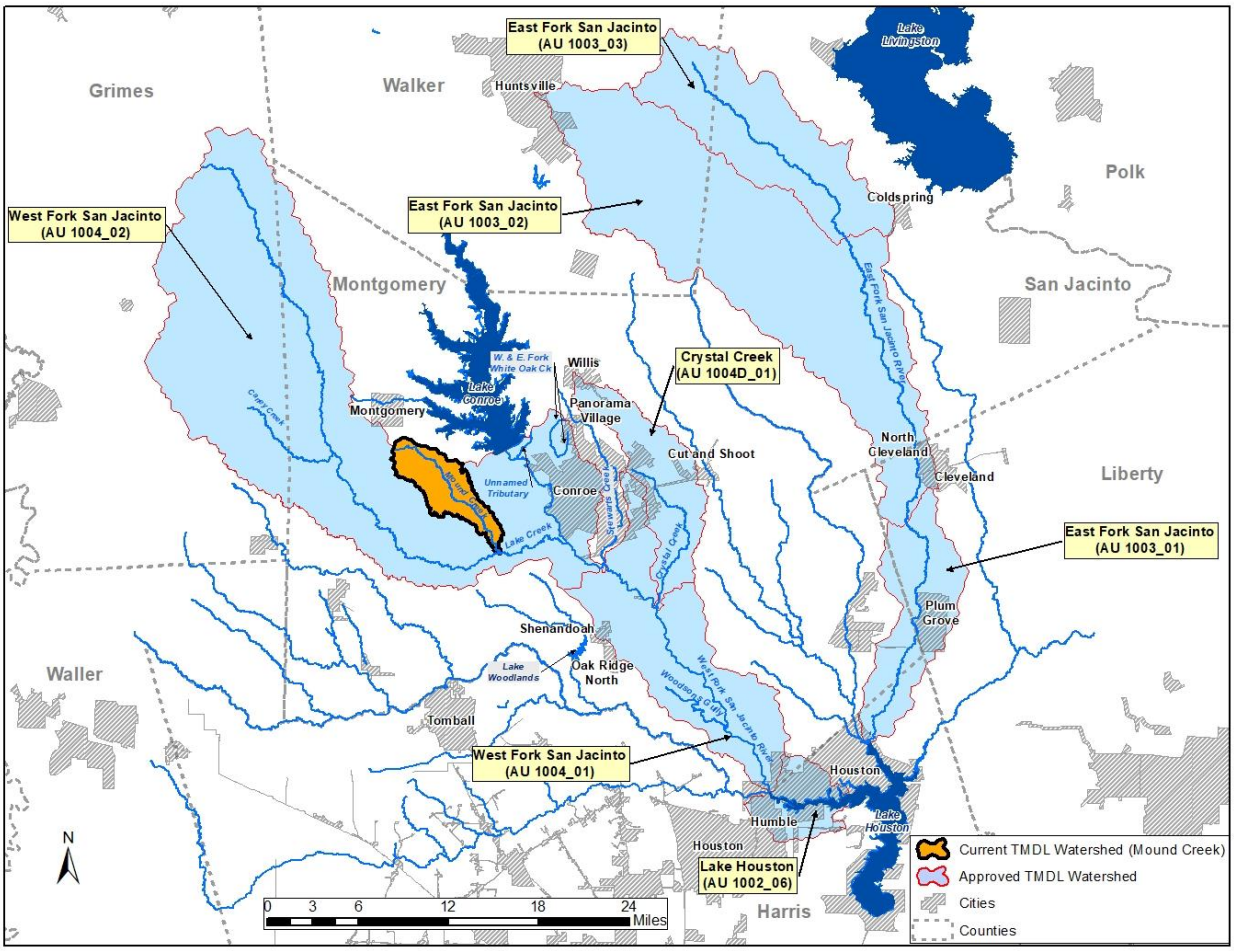

Figure 2. Map showing the seven approved TMDL watersheds and the current Mound Creek watershed considered in this addendum.

Table 2. 2014 Integrated Report summary for the Mound Creek watershed.
(The geometric mean criterion for *E. coli* for primary contact recreation use is 126 MPN/100 mL of water.)

Integrated Report Year	AU	Parameter	Station	Number of Samples	Data Range	*E. coli* Geometric Mean (MPN/100 mL)
2014	1015A_01	*E. coli*	17937	21	2005–2012	386.55

Description of the Study Area

The Mound Creek watershed is located in a predominantly rural area west of the City of Conroe. Mound Creek is a perennial freshwater stream that is a tributary of Lake Creek (Segment 1015), which in turn is a tributary of the West Fork San Jacinto River (Segment 1004). The Mound Creek watershed has a drainage area of 13,422 acres. Segment 1015A is 15.41 miles long and comprises two AUs. AU 1015A_01 has a stream length of 10.77 miles and AU 1015A_02 has a stream length of 4.64 miles.

The 2014 Integrated Report (TCEQ, 2015) provides the following segment and AU description for the water body considered in this document:

- Segment 1015A (Mound Creek) - From the confluence with Lake Creek to a point 0.69 km east of FM 149 near Conroe
    - 1015A_01 – Perennial stream from the confluence with Lake Creek upstream to the confluence with an unnamed tributary approximately 0.75 km downstream of Rabon-Chapel Road

Watershed Climate

The Mound Creek watershed is within the Upper Coast and East Texas climatic divisions. The Gulf of Mexico is the principal source of moisture that drives precipitation in the region. For the period from 1981 through 2010, average annual precipitation in the Mound Creek watershed was 47.8 inches (Prism, 2012).

For the more recent 15-year period from 2002 through 2016, weather data were obtained from the National Climatic Data Center for the Conroe North Houston Regional Airport (NOAA, 2017). Data from this 15-year period indicates that the average high temperatures typically peak in August (89.4 °F). During winter, the average low temperature generally occurs in January (36.8 °F). The wettest month is October (5.7 inches), while August (2.8 inches) is the driest month, with rainfall occurring throughout the year (Figure 4).

Figure 3. Mound Creek watershed showing TCEQ monitoring station used to assess primary contact recreation.

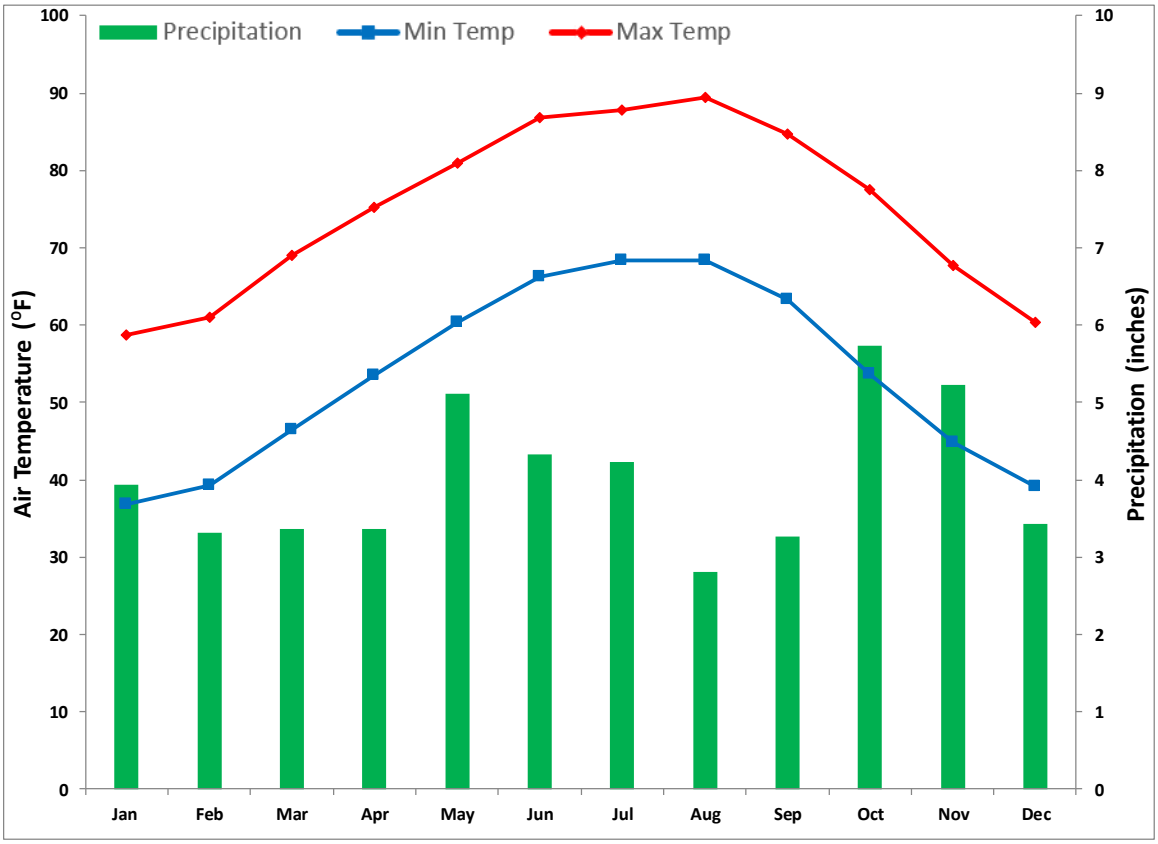

Figure 4. Average minimum and maximum air temperature and total precipitation by month from 2002 through 2016 for Conroe North Houston Regional Airport.

Land Use

The land use/land cover data for the Mound Creek watershed are from the National Oceanic and Atmospheric Association (NOAA) Coastal Change Analysis Program (C-CAP) as obtained from the Houston-Galveston Area Council (H-GAC). The data are for the year 2011 (NOAA, 2011) and are displayed in Figure 5.

A summary of the land use/land cover data for the Mound Creek watershed provided in Table 3 indicates that grassland/scrub/shrub and forest are the dominant land covers, comprising approximately 55 percent of the total land cover.

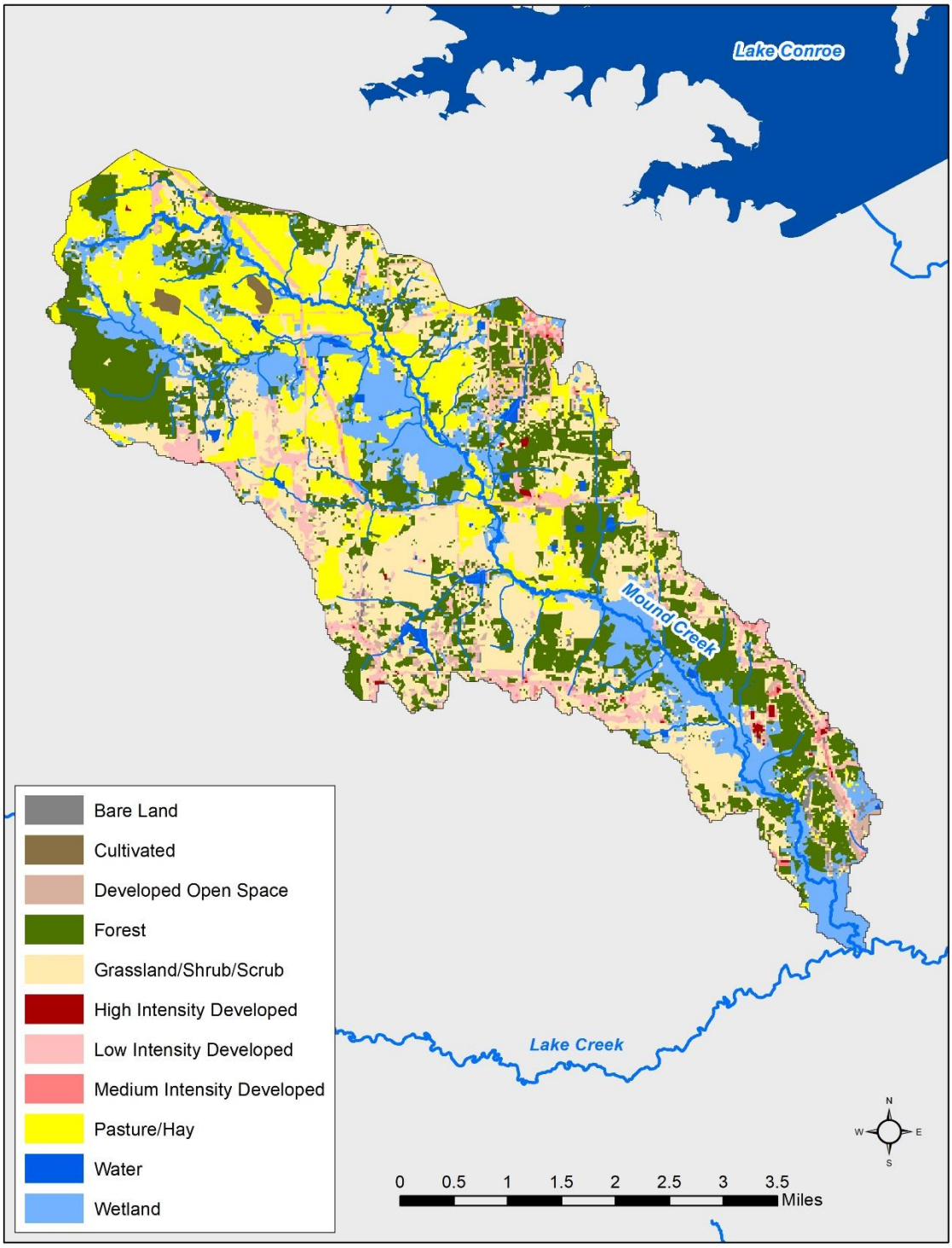

Figure 5. Land use/land cover within the Mound Creek watershed.

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

Classification	Area (Acres)	Percent of Total
Grassland/Scrub/Shrub	3,917	29.2%
Forest	3,436	25.6%
Pasture/Hay	2,496	18.6%
Wetland	2,051	15.3%
Low Intensity Developed	957	7.1%
Developed Open Space	150	1.1%
Water and Unconsolidated Shore	137	1.0%
Bare Land	106	0.8%
Medium Intensity Developed	81	0.6%
Cultivated	56	0.4%
High Intensity Developed	35	0.3%
Total	13,422	100%

Watershed Population and Population Projections

As depicted in Figure 2, the Mound Creek watershed is geographically located entirely within Montgomery County, and outside of any municipal boundaries. The area is relatively rural, with a population density of zero to two people per acre through most of the watershed (Figure 6). According to the 2010 Census data (USCB, 2017), the Mound Creek watershed has an estimated population of 3,102 people.

Population projections from 2010 through 2040 were developed by using data from the 2010 U.S. Census and the H-GAC 2040 regional growth forecast (H-GAC, 2017). According to the growth projections, a population increase of 329.6 percent is expected in the Mound Creek watershed by 2040. Table 4 provides a summary of the 2010 population and 2040 population projection.

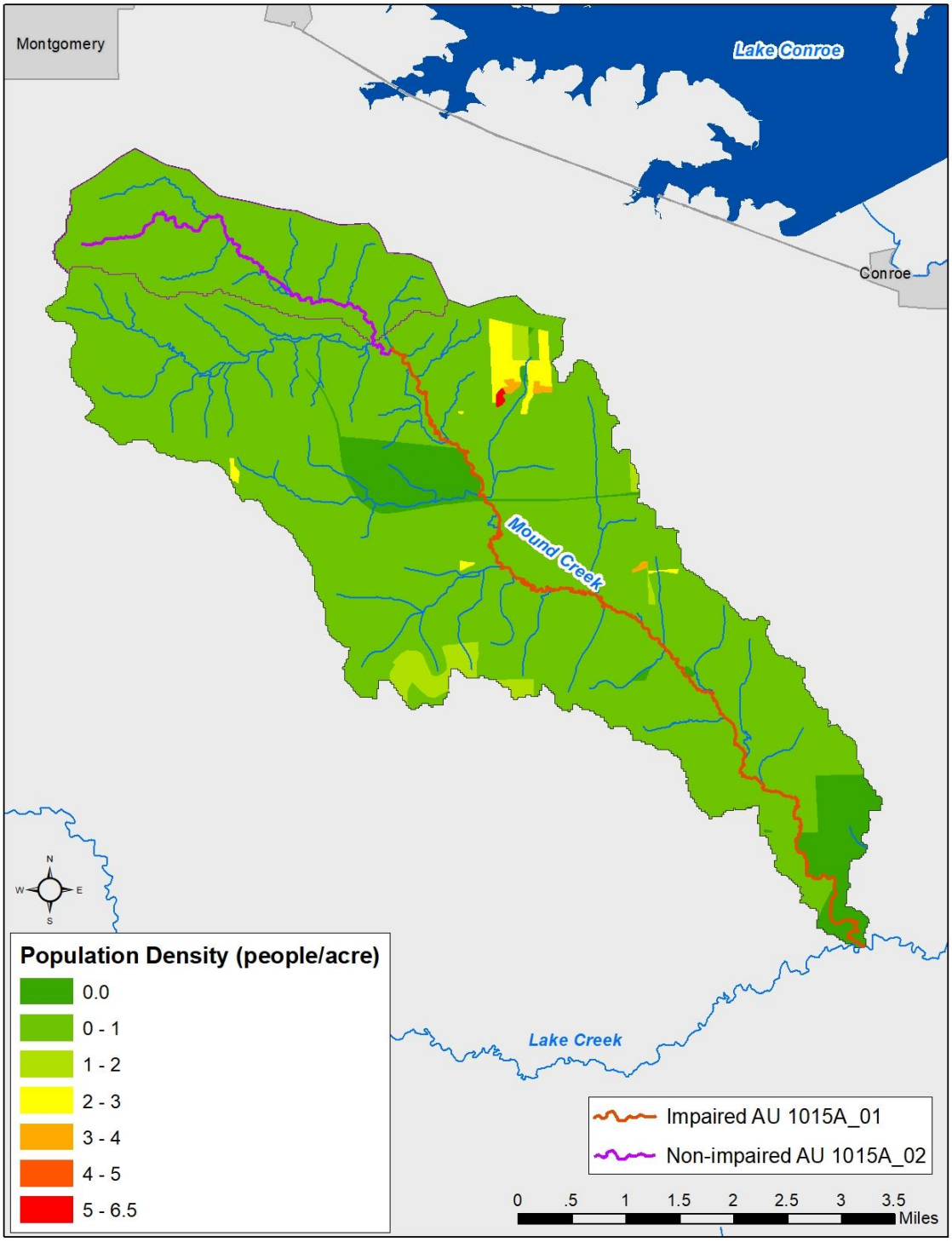

Figure 6. Population density for the Mound Creek watershed based on the 2010 U.S. Census blocks.

Table 4. 2010 population and 2040 population projections for the Mound Creek watershed.

Location	2010 U. S. Census	2040 Population Projection	Projected Population Increase (2010-2040)	Percent Change
Mound Creek Watershed	3,102	13,326	10,224	329.6%

Endpoint Identification

The endpoint for the TMDL is to maintain the concentration of *E. coli* below the geometric mean criterion of 126 MPN/100mL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2010 TSWQS (TCEQ, 2010).

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

As of February 2018, there were three domestic wastewater treatment facilities (WWTFs) with TPDES/NPDES permits within the Mound Creek watershed and no industrial dischargers (Figure 7 and Table 5). Recent discharge data in million gallons per day (MGD) are presented in Table 5 (USEPA, 2018).

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party. A summary of SSO incidents that occurred during a two-year period from 2016 through 2017 in Montgomery County was obtained from the TCEQ Central Office in Austin. These SSO data typically contain estimates of the total gallons spilled, responsible entity, and a general location of the spill. The summary data indicated no SSO incidents were reported for any locations within the Mound Creek watershed.

Figure 7. Mound Creek watershed showing WWTFs.

Table 5. Permitted domestic WWTFS in the Mound Creek watershed.

Permittee	Facility	TPDES No.	NPDES No.	Permitted Discharge (MGD)	Recent Discharge: 2014 through 2017 (MGD)
Crane Co.	Crane Co. WWTF	12456-002	TX0138461	0.005	0.00003
MSEC Enterprises Inc.	MSEC WWTF No. 1	14638-001	TX0128121	0.02	0.0025
MSEC Enterprises Inc.	MSEC WWTF No. 2	15341-001	TX0136191	0.130	0.00275[1]

[1] Only the most recent seven months of data (June 2017 through December 2017) were available for this facility since it was just recently permitted to discharge.

TPDES-Regulated Stormwater

TPDES general permits cover stormwater discharges from Phase II Municipal Separate Storm Sewer Systems (MS4s; General Permit number TXR040000), industrial facilities (General Permit number TXR050000; also known as a multi-sector general permits (MSGPs)), concrete production facilities (General Permit number TXG110000), petroleum bulk stations and terminals (General Permit number TXG340000), and construction sites over one acre (General Permit number TXR150000).

Three of these permits (MS4, MSGP, and construction) pertain solely to stormwater discharges. The other two (concrete production facilities and petroleum bulk stations and terminals) also authorize the discharge of process wastewater. A review of active stormwater general permit coverage (TCEQ, 2017) in the Mound Creek watershed as of December 12, 2017, found one active industrial MSGP facility and 13 active construction permits. There are currently no Phase II MS4s, concrete production facilities, or petroleum bulk stations and terminals in the Mound Creek watershed. Table 6 summarizes the area covered by general stormwater permits in the Mound Creek watershed.

Table 6. Stormwater general permit areas (in acres) within the Mound Creek watershed.

AU	MS4 Gen-eral Permit	Multi-sector General Permit	Construc-tion Activities	Concrete Produc-tion Facilities	Petro-leum Bulk Stations	Total Area of Permits	Water-shed Area	Percent of Water-shed Under Storm-water Permits
1015A_01	-	9	98.95	-	-	107.95	13,422	0.80%

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

Indicator bacteria inhabit the intestines of all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify the potential for bacteria contributions from wildlife. Riparian corridors of streams and rivers naturally attract wildlife. With direct access to the stream

channel, direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Wildlife also deposit fecal bacteria onto land surfaces, where rainfall runoff may wash bacteria into nearby streams.

Unfortunately, quantitative estimates of wildlife are rare, 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. However, population estimates for feral hogs and deer are readily available for the Mound Creek watershed.

For feral hogs, the Texas A&M Institute of Renewable Natural Resources (IRNR), recently renamed as the Texas A&M Natural Resources Institute, reported a range of feral hog densities within Texas of 1.33 to 2.45 hogs/square mile (IRNR, 2013). The average hog density (1.89 hogs/square mile) was multiplied by the hog habitat area in the Mound Creek watershed (18.7 square miles). Habitat deemed suitable for hogs followed as closely as possible to the land use selections of the IRNR study and include from the NOAA 2011 land use: forest, cultivated crops, wetlands, pasture/hay, and grasslands. Using this methodology, there are an estimated 35 feral hogs in the Mound Creek watershed.

For deer, the Texas Parks and Wildlife Department (TPWD) publishes data showing deer population-density estimates by deer management unit (DMU) across the state (TPWD, 2017). The Mound Creek watershed is located within DMU 12, for which the deer density in 2016 was estimated to be 32.1 deer/square mile. Applying this value to the area of the entire watershed returns an estimated 674 deer within the Mound Creek watershed.

Domesticated Animals

Livestock are a potential source of bacteria in the project watershed. The number of livestock within the Mound Creek watershed was estimated from county level data obtained from the 2012 Census of Agriculture (USDA NASS, 2014). The county-level data were refined to better reflect actual numbers within the Mound Creek watershed. The refinement was performed by dividing the total area of the Mound Creek watershed by the total area of Montgomery County. 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 Mound Creek watershed, based on proportional area.

Cattle and Calves	Hogs and Pigs	Sheep and Lambs	Goats	Horses and Ponies	Mules, Burros, and Donkeys	Poultry	Deer (captive)
382	10	13	54	98	12	140	11

Table 8 summarizes the estimated number of dogs and cats within the Mound 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 (AVMA) 2012 U.S Pet Statistics (AVMA, 2015). The actual contribution and significance of indicator bacteria loads from pets reaching the water bodies of the Mound Creek watershed is unknown.

Table 8. Estimated households and pet populations for the Mound Creek watershed.

Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
1,084	633	692

On-site Sewage Facilities

Estimates of the number of OSSFs in the Mound Creek watershed were determined using data supplied by H-GAC for Montgomery County. The H-GAC data indicate that there are 631 OSSFs located within the Mound Creek watershed (Figure 8).

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 existing and 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, 2018) 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 covered by this report incorporates an explicit MOS of 5 percent of the total TMDL allocation.

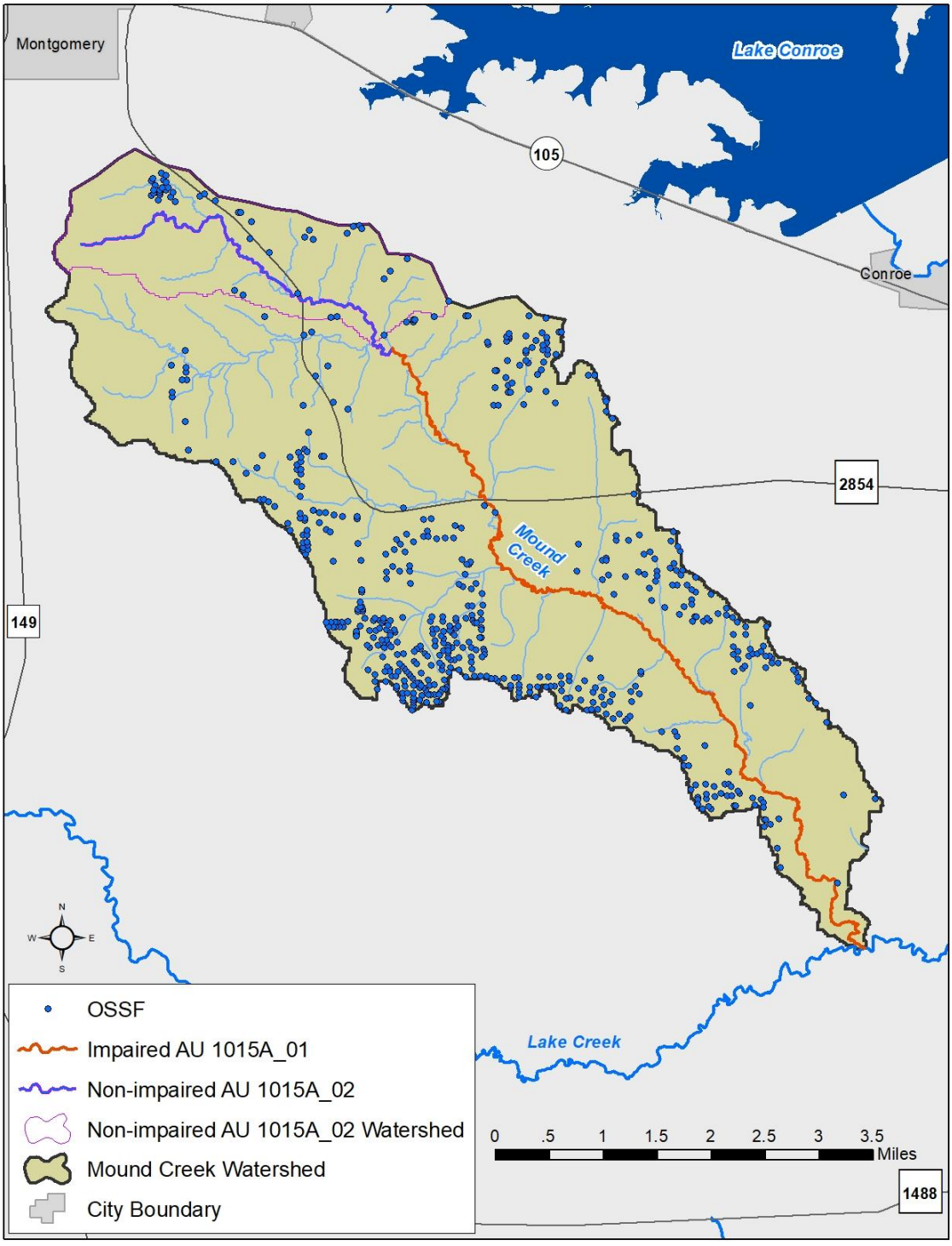

Figure 8. OSSF locations within the Mound Creek watershed.

Pollutant Load Allocation

The TMDL component for the impaired AU covered in this report was derived using the median flow within the Wet Conditions (highest flow) regime (or 15 percent flow) of the LDC developed for the sampling station located within the AU watershed.

Based on the LDC to be used in the pollutant load allocation process with historical *E. coli* data added to the graph (Figure 9), the following broad linkage statements can be made. For the Mound Creek watershed, the historical *E. coli* data indicate that elevated bacteria loadings occur under all three flow regimes. There is some moderation of the elevated loadings under moderate and dry conditions. On Figure 9, the geometric means of the measured data for each flow regime generally support these observations of decreasing concentration with decreasing flow.

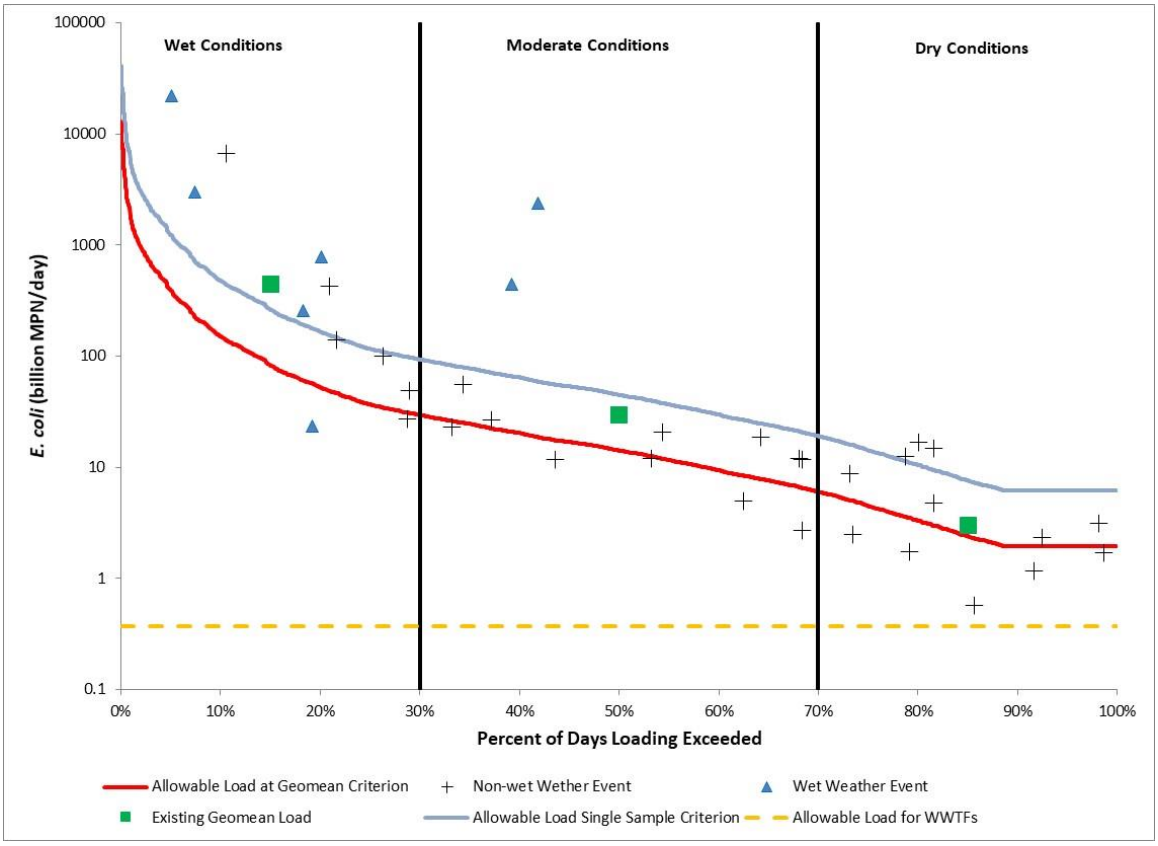

Figure 9. LDC for Mound Creek AU 1015A_01 (Station 17937)

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 MPN/100mL *E. coli*) is used as the WWTF target to provide instream and downstream load capacity. Table 9 presents the WLA for each WWTF in the Mound Creek watershed and the resulting total allocation for AU 1015A_01.

Table 9. Wasteload allocations for TPDES-permitted facilities in the Mound Creek watershed.

TPDES Permit No.	NPDES Permit No.	Facility	Full Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (Billion MPN/day)
WQ0012456002	TX0138461	Crane Co. WWTF	0.005	0.012
WQ0014638001	TX0128121	MSEC WWTF	0.02	0.048
WQ0015341001	TX0136191	MSEC WWTF No. 2	0.130	0.310
			Total	0.370

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}). A simplified approach for estimating the WLA for these areas 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 the land area included in the Mound Creek 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. The percentage of land under the jurisdiction of stormwater permits in the Mound Creek watershed is 0.80 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 contact recreation standard.

The future growth component of impaired AU 1015A_01 was based on population projections and current permitted wastewater dischargers for the entire Mound Creek watershed. Recent population and projected population growth between 2010 and 2040 for the Mound Creek watershed 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 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 designated uses and conform to Texas antidegradation policy.

TMDL Calculations

Table 10 summarizes the TMDL calculation for Mound Creek AU 1015A_01. The TMDL was calculated based on the median flow in the 0-30 percentile range (15 percent exceedance, Wet Conditions flow regime) for flow exceedance from the LDC developed for the monitoring station 17937. Allocations are based on the current geometric mean criterion for *E. coli* of 126 MPN/100 mL for each component of the TMDL (with the exception of the WLA_{WWTF} and FG terms, which used one-half the criterion).

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}.

In the event that the criterion changes due to a change in the designated recreational use, Appendix A provides guidance for recalculating the allocations in Table 11.

Table 10. TMDL allocation summary for Mound Creek AU 1015A_01.
All loads expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	FG	MOS
1015A_01	82.431	0.370	0.614	76.106	1.219	4.122

Table 11. Final TMDL allocations for Mound Creek AU 1015A_01.
All loads expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}[1]	WLA_{SW}	LA	MOS
1015A_01	82.431	1.589	0.614	76.106	4.122

[1] WLA_{WWTF} includes the future potential allocation to WWTFs

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 eleven years (2007 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 no significant difference (α =0.05) in indicator bacteria between cool and warm weather seasons for Mound Creek AU 1015A_01 (α =0.7361).

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the TMDL study, the TCEQ 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.

The technical support document for this TMDL addition (Millican, 2018) was posted on the TMDL project page at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/82sanjacinto/82c-moundcreek-tsd-final.pdf> on July 19, 2018. A presentation on this addendum was given at the annual spring meeting of the Bacteria Implementation Group (BIG) in Houston on June 5, 2018. The public will have an opportunity to comment on this addendum during a 30-day WQMP update public comment period (November 9 through December 11, 2018). 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 online news page at <www.tceq.texas.gov/waterquality/tmdl/tmdlnews.html>, and the document will be posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html>. TCEQ accepted public comments on the original TMDL during the period March 6 through April 4, 2016. Six comments were submitted, and none of them referred directly to the AU in this TMDL addendum.

Implementation and Reasonable Assurance

The segment covered by this addendum is within the existing bacteria TMDL watershed of Lake Houston, East Fork San Jacinto River, West Fork San Jacinto River, and Crystal Creek. That TMDL watershed is within the area covered by the Implementation Plan developed by the BIG for bacteria TMDLs throughout the greater Houston area, approved by the TCEQ on January 30, 2013. It outlines an adaptive management approach in which measures are periodically assessed for efficiency and effectiveness. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals, and expresses stakeholder commitment to the process. Please refer to the original TMDL document for additional information regarding implementation and reasonable assurance.

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Appendix A

Equations for Calculating TMDL Allocations for Contact Recreation Standard Changes

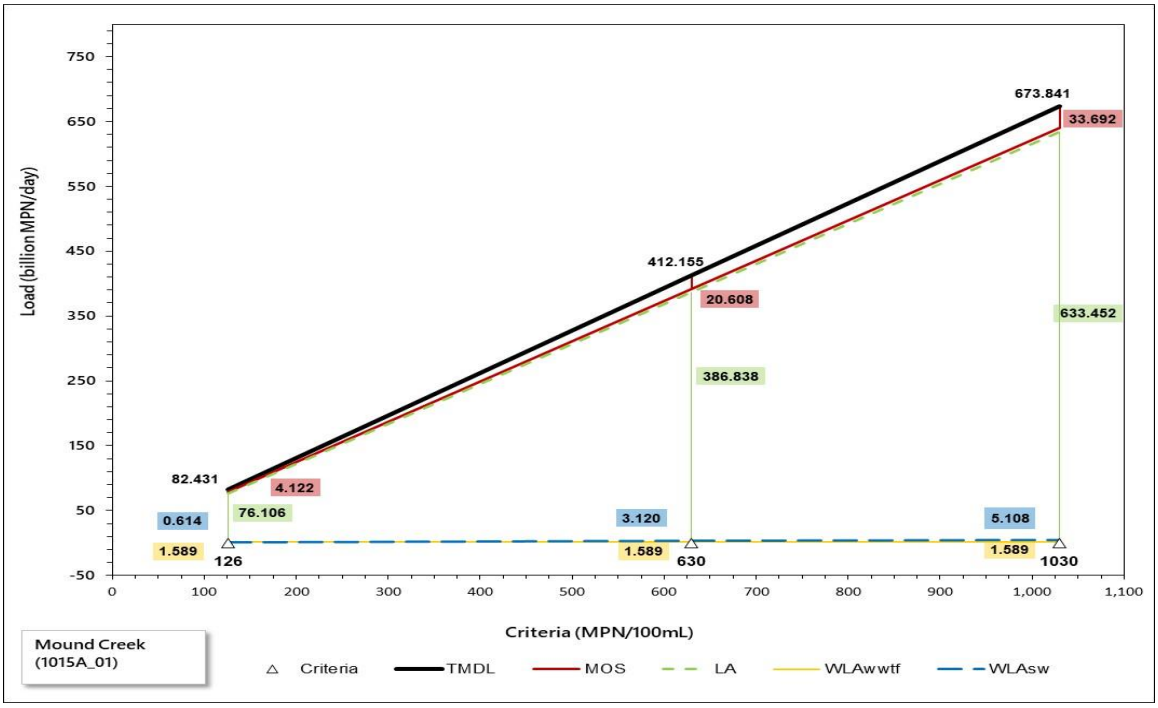

Figure A-1. Allocation loads for *E. coli* for the Mound Creek watershed (1015A_01) as a function of water quality criteria.

Equations for calculating new TMDL and allocations (in billion MPN/day *E. coli*):

TMDL = 0.6542146 * Std
MOS = 0.0327102 * Std + 0.0005377
LA = 0.6165331 * Std - 1.5773868
WLA_{WWTF} = 1.589
WLA_{sw} = 0.0049713 * Std - 0.0122358

Where:

Std = Revised contact recreation standard
MOS = Margin of safety
LA = Total load allocation (unregulated sources)
WLA_{WWTF} = Wasteload allocation (permitted WWTF load + future growth)
WLA_{SW} = Wasteload allocation (permitted stormwater)

Table A-1. TMDL allocations for the Mound Creek watershed for potential changed contact recreation standards. All loads expressed as billion MPN/day *E. coli*

Std (MPN/100mL)	TMDL	WLA_{WWTF}[1]	WLA_{SW}	LA	MOS
126	82.431	1.589	0.614	76.106	4.122
630	412.155	1.589	3.120	386.838	20.608
1030	673.841	1.589	5.108	633.452	33.692

[1] WLA_{WWTF} includes the future potential allocation to WWTFs.