For Public Comment, April 2008

One Total Maximum Daily Load for Bacteria in the Leon River Below Proctor Lake

For Segment 1221

Prepared by the:

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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This document is based in large part on the report titled
"Final Modeling Report for Fecal Coliform TMDL Development for
Leon River Below Proctor Lake, Segment 1221"
by James Miertschin & Associates, Inc.

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Executive Summary

This document describes a project developed to address water quality impairments related to bacterial indicators for pathogens in a portion of the Leon River Below Proctor Lake (Segment 1221). Segment 1221 is 173 miles long, and has a watershed of 1,375 square miles, located primarily in Comanche, Hamilton, and Coryell Counties. Segment 1221 was identified as impaired for recreational use in the 2000 *Texas Water Quality Inventory and 303(d) List.*

The goal for this total maximum daily load (TMDL) project is to determine the maximum bacteria loading the stream can receive and still allow support of the contact recreation use. Elevated levels of indicator bacteria such as Escherichia coli (*E. coli*), although not generally pathogenic, indicate a possible risk to public health. The criteria for support of the contact recreation use are based on indicator bacteria rather than direct measurements of pathogens.

The standards for water quality are defined in the *Texas Surface Water Quality Standards* (Chapter 307 of the Texas Administrative Code, Title 30). The criteria for assessing attainment of the contact recreation use are expressed as the number of colony-forming units (cfu) of bacteria per hundred milliliters (100 mL) of water. For *E. coli,* the number of colony-forming units may not exceed 394 cfu/100 mL in a single sample, nor 126 cfu/100 mL as a geometric mean of all samples over a range of time.

Based on analysis of the load allocation scenario, an overall TMDL allocation plan to meet the water quality standards applicable to the Leon River requires:

- 74 percent reduction in point source loading and
- 21 percent reduction in nonpoint source loading.

Introduction

Section 303(d) of the Federal Clean Water Act requires all states to identify water bodies that do not meet, or are not expected to meet, applicable water quality standards. The compilation of impaired water bodies is known as the 303(d) list. For each Category 5a listed water body, states must develop a TMDL for each pollutant that contributes to impairment. The Texas Commission on Environmental Quality (TCEQ) is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

In simple terms, a TMDL is like a budget that determines the amount of a particular pollutant that a water body can receive and still meet applicable water quality standards. In other words, TMDLs are the best possible estimates of the assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load with units of mass per period of time, but may be expressed in other ways. For bacteria TMDLs, loads are typically expressed as the number of cfu per period of time. TMDLs must also estimate how much the pollutant load must be reduced from current levels in order to achieve water quality standards.

The TMDL Program is a major component of Texas' overall process for managing surface water quality. The Program addresses impaired or threatened streams, reservoirs, lakes, bays and estuaries (water bodies) inside or bordering on the state of Texas. The primary objective of the TMDL Program is to restore and maintain the beneficial uses (such as drinking water supply, recreation, support of aquatic life, and fishing) of impaired water bodies. This TMDL addresses impairments to the contact recreation use due to elevated indicator bacteria in the Leon River.

Section 303(d) of the Clean Water Act and the implementing regulations of the US Environmental Protection Agency (EPA) (40 Code of Federal Regulations, Part 130) describe the statutory and regulatory requirements for acceptable TMDLs. Following these guidelines, this TMDL document describes key elements that are summarized in the following sections:

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

This TMDL document was prepared based upon the report titled "Final Modeling Report for Fecal Coliform TMDL Development for Leon River Below Proctor Lake, Segment 1221" prepared for the TCEQ by James Miertschin & Associates, Inc. (JMA 2006).

In accordance with the *Memorandum of Agreement Between the TCEQ and the Texas State Soil and Water Conservation Board (TSSWCB) Regarding TMDLs, Implementation Plans (I-Plans), and Watershed Protection Plans*, the TSSWCB approved this document on Month, Day, Year. The commission adopted this document on Month, Day, Year. Upon EPA approval, the TMDL will become an update to the state's Water Quality Management Plan.

Problem Definition

This document describes a project developed to address a water quality impairment related to bacterial indicators for pathogens in Leon River below Proctor Lake (Segment 1221). Segment 1221 was first identified as impaired for bacteria in the 2000 *Texas Water Quality Inventory and 303(d) List* (TCEQ 2000).

The watershed is depicted in detail in Figure 1. As shown, only a portion of the river segment (highlighted in red) was found to be impaired, based on the 2004 303(d) List. The impaired reaches extend from just below U.S. Highway 281 near Hamilton upstream to the confluence with Indian Creek, just above FM 1476 near Gustine. For this project, the TMDL will apply to all contributing tributaries in the impaired reaches of the watershed. In total, 44 miles of the Leon River have been designated as impaired.

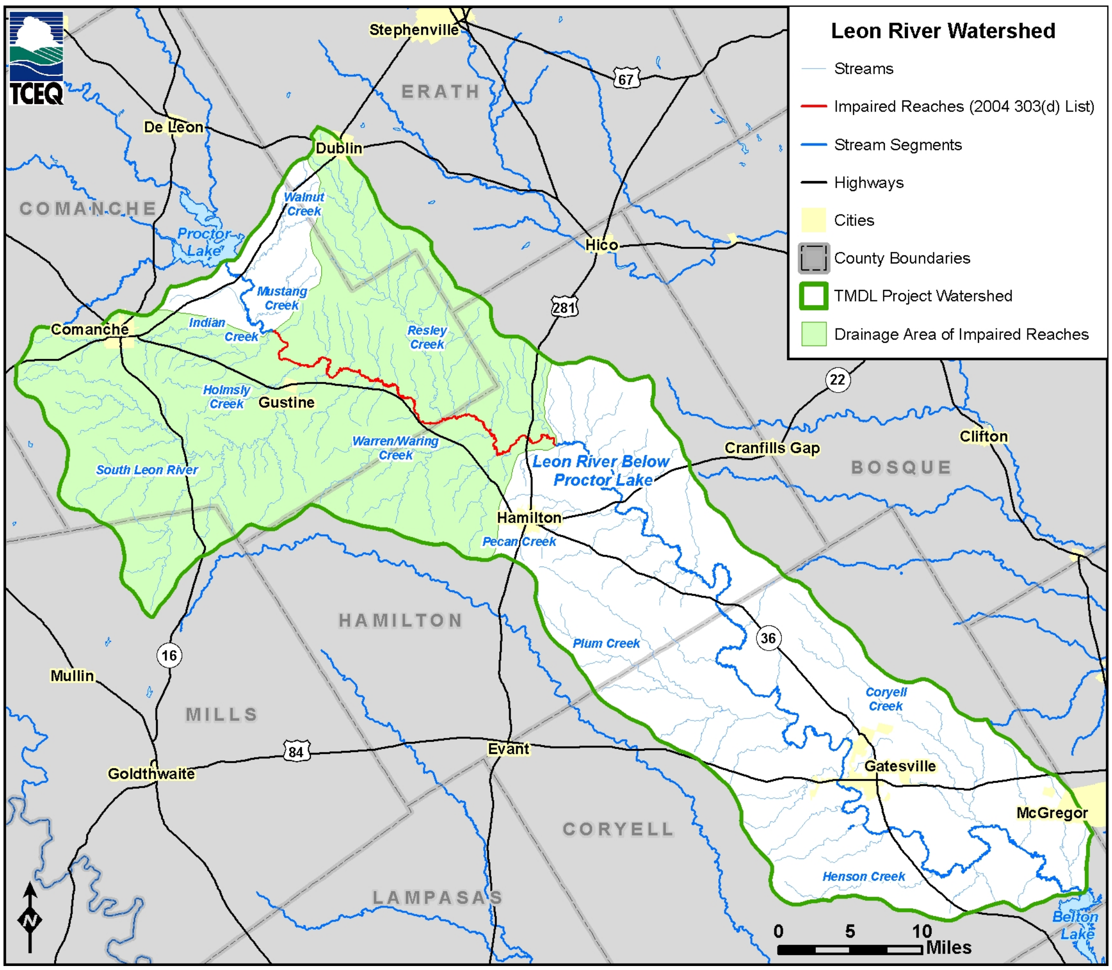

Figure 1: TMDL Watershed/Study Area

In response to the listing, the TCEQ initiated an investigation to identify possible point and nonpoint sources of bacteria and to quantify the appropriate reductions necessary to comply with established water quality standards (presented in the following section). Possible sources and/or causes of contamination include:

- discharges from wastewater treatment facilities
- storm water runoff from both urban and non-urban landscapes
- leaking sewer infrastructure
- wildlife and other warm-blooded animal deposition
- failing septic systems
- pet and livestock deposition

Designated Uses and Water Quality Standards

Segment 1221 is designated for contact recreation, public water supply, and high quality aquatic life uses. The *Texas Surface Water Quality Standards* (TCEQ 2000) provide numeric and narrative criteria to evaluate attainment of designated uses. *E. coli* is the preferred indicator bacteria for assessing the contact recreation use in freshwater, but fecal coliform bacteria may also be used since it was the preferred indicator in the past. The numeric criteria defined in the Standards for support of the contact recreation use are as follows.

- *E. coli*
  - The geometric mean of *E. coli* should not exceed 126 cfu/100 mL
  - Single samples of *E. coli* should not exceed 394 cfu/100 mL more than 25 percent of the time
- Fecal coliform
  - The geometric mean of fecal coliform should not exceed 200 cfu/100 mL
  - Single samples of fecal coliform should not exceed 400 cfu/100 mL more than 25 percent of the time

Description of Watershed

Segment 1221 is 173 miles long and flows through Comanche, Hamilton, and Coryell Counties before it reaches Belton Lake (Segment 1220). The Leon River receives flow releases from Proctor Lake (Segment 1222). The largest tributary of the Leon River is the South Leon River (Segment 1221B) located in southern Comanche County.

The watershed of Segment 1221 of the Leon River is approximately 1,375 square miles. This watershed is located predominantly in Comanche, Hamilton, and Coryell Counties, but also includes portions of Mills, Erath, and McLennan Counties. A map of the watershed/study area is presented in Figure 1.

Climate

The watershed/study area is located primarily within the North Central Texas climatic division. The climate of the region is classified as subtropical subhumid. Summers are usually hot and humid, while winters are often mild and dry. The hot weather is rather persistent from late May through September, accompanied by prevailing southeasterly winds. There is little change in the day-to-day summer weather except for the occasional thunderstorm, which produces much of the annual precipitation within the region. The cool season, beginning about the first of November and extending through March, is typically the driest season of the year as well. Winters are typically short and mild, with most of the precipitation falling as drizzle or light rain.

As with the rest of the interior of the State, maximum precipitation periods in the study area are typically late spring (May) and early autumn (September). Winter and summer periods are typically low precipitation periods. The maximum precipitation period in May is driven by the buildup of water vapor from the Gulf of Mexico from the prevailing winds from the south. Precipitation is caused by late season cold air migrations, warm season thunderstorms, and spring low-pressure troughs. In September, cold air converges with moistureladen southerly winds and late season convective thunderstorms drive the precipitation. It is not unusual for hurricanes to affect rainfall in the early autumn period. Summer drought conditions are common in the study area, due to strong high-pressure cells that result in lengthy dry spells. Mean annual precipitation in the watershed ranges from 27 to 32 inches per year.

Economy

Only the predominant counties—Comanche, Hamilton, and Coryell—are discussed in this section.

Comanche County

Comanche County covers 948 square miles, and has an estimated population (year 2000) (US Census 2006) of 13,709. The population has increased by about 2.5 percent since 1990. Approximately 52 percent of the population lives in urban areas. The largest urban area, by far, is the city of Comanche with a population of 4,302 (TAC 2006). The county's economy includes agribusiness and limited oil production (TSHA 2001).

Agribusiness is an important component of the county economy. There are 1,352 farms in the county with an average size of 402 acres (USDA 2002), accounting for 90 percent of the county's area. Cattle are the primary type of livestock raised in the county. There are also significant dairy operations. Harvested cropland accounts for 18 percent of the county's total farmland. Peanuts and other edible nuts account for a significant portion of the county's harvested crops.

Hamilton County

Hamilton County covers 837 square miles, and has an estimated population (year 2000) (US Census 2006) of 8,105. The population has increased by 4.8 percent since 1990. Approximately 54 percent of the population lives in urban areas. The largest urban area, by far, is the city of Hamilton with a population of 2,920 (TAC 2006). The county's economy includes agribusiness, manufacturing, and limited oil production (TSHA 2001).

Agribusiness is an important component of the economy. There are 996 farms in the county with an average size of 451 acres (USDA 2002), accounting for about 84 percent of the county's total area. Cattle are the primary type of livestock raised in the county. There are also dairy operations. Sheep are also raised. Harvested cropland accounts for just 11 percent of the county's total farmland.

Coryell County

Coryell County covers 1,052 square miles, and has an estimated population (year 2000) (US Census 2006) of 75,802. The population has increased by about 18 percent since 1990. Approximately 62 percent of the population lives in urban areas. The largest urban area is the city of Copperas Cove, located outside of the TMDL study area in the southern portion of the county, with a population of 30,205. The City of Gatesville is the second largest city, located within the TMDL study area, with a population of 15,651 (TAC 2006). The county's economy includes professional services, manufacturing, trade, public administration, and agribusiness (TSHA 2001). The U.S. Army Fort Hood military base also plays an important role in the county economy.

Agribusiness is still a significant component of the county's economy. There are 1,221 farms in the county with an average size of 404 acres (USDA 2002), accounting for about 73 percent of the county's total area. Cattle are the primary type of livestock raised in the county. Harvested cropland accounts for just 14 percent of the county's total farmland.

Geology and Hydrogeology

The underlying geology of the study area is dominated by Cretaceous period limestone formations belonging to the Trinity, Lower Washita, and Fredericksburg groups. Groundwater in the area is primarily associated with the Trinity aquifer system. Most of the study watershed is located over the outcrop zone of this aquifer, though some eastern portions of the watershed are located over the downdip zone. Sand and gravel layers in this aquifer can be up to 900 feet in thickness (Ashworth 1995).

Soils

Soil conditions vary throughout the study area based on geological and topographical characteristics. In the northern portion of the study area, including Comanche and parts of Hamilton County, soils are generally sandy and loamy. In the remainder of the study area, soil conditions vary widely, and include areas of clayey soils (TSHA 2001).

Land Use

Land use data for the watershed were based on the United States Geological Survey (USGS) National Land Cover Dataset (NLCD). Derived from the early to mid-1990s Landsat Thematic Mapper satellite data, the NLCD is a classification scheme for land cover applied consistently over the United States. The spatial resolution of the dataset is 30 meters. Land uses were grouped into six general categories for modeling. Land use for the watershed is shown in Figure 2, areas and percentages are shown in Table 1. Red numbers represent the subwatersheds of the stream segment.

Assessment of Pollutant Sources

The data used to assess sources affecting the impaired segment are discussed in the following sections. The inventory of data and information is outlined, along with monitoring, water quality, stream flow, and meteorological data.

Data and Information Inventory

A wide range of data and information was used in the development of the TMDL. Categories of data used include the following:

- Hydrographic data that describe the physical conditions of the stream, such as the stream reach network and connectivity, and the stream channel depth, width, slope, and elevation.
- Watershed physiographic data that describe the watershed's physical conditions such as topography, soils, and land use.

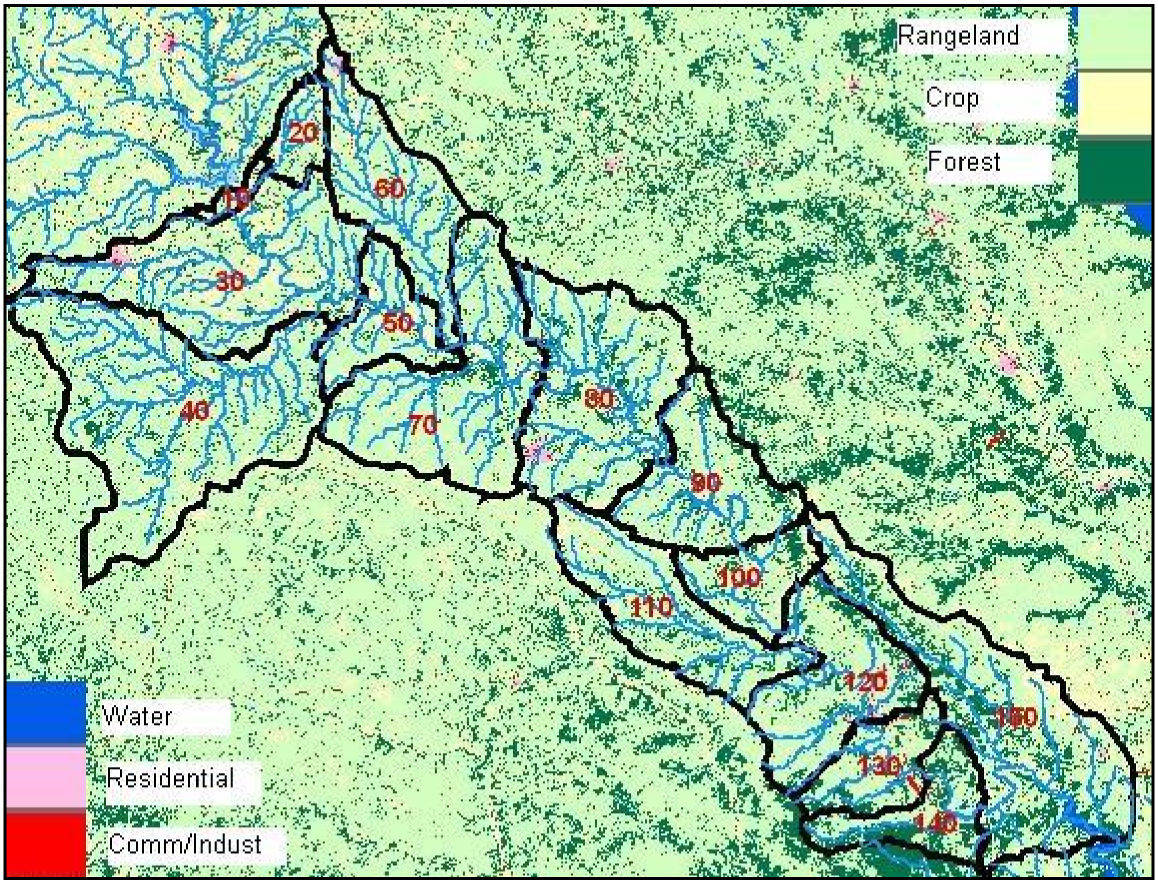

Figure 2: Land Use for Study Area

Table 1: Land Use Types and Areas

Land Use Type	Area (acres)	Percent of Total
Forest	144,029	16.3%
Crop/Pastureland	87,813	10.0%
Rangeland	627,906	71.2%
Residential	3,886	0.4%
Commercial/Industrial/Residential	5,238	0.6%
Waste Application Fields	13,503	1.5%
Total	**882,375**	**100%**

- Data and information related to the use of, and activities in, the watershed that can be used in the identification of potential bacterial sources.
- Environmental monitoring data that describe stream flow and water quality conditions in the stream.

Water Quality Monitoring

The Brazos River Authority (BRA) is responsible for coordinating the Clean Rivers Program's monitoring activities in the Leon River watershed for inclusion in the TCEQ's Surface Water Quality Monitoring (SWQM) program database. Data collected by BRA and other entities were used to assess the segment for compliance with water quality standards. This assessment has determined that elevated levels of both fecal coliform and *E. coli* are adversely affecting water quality in the impaired stream. Figure 3 shows the locations and numbers for stations where significant bacterial source tracking (BST) and bacteria sampling occurred throughout the period 1996-2004.

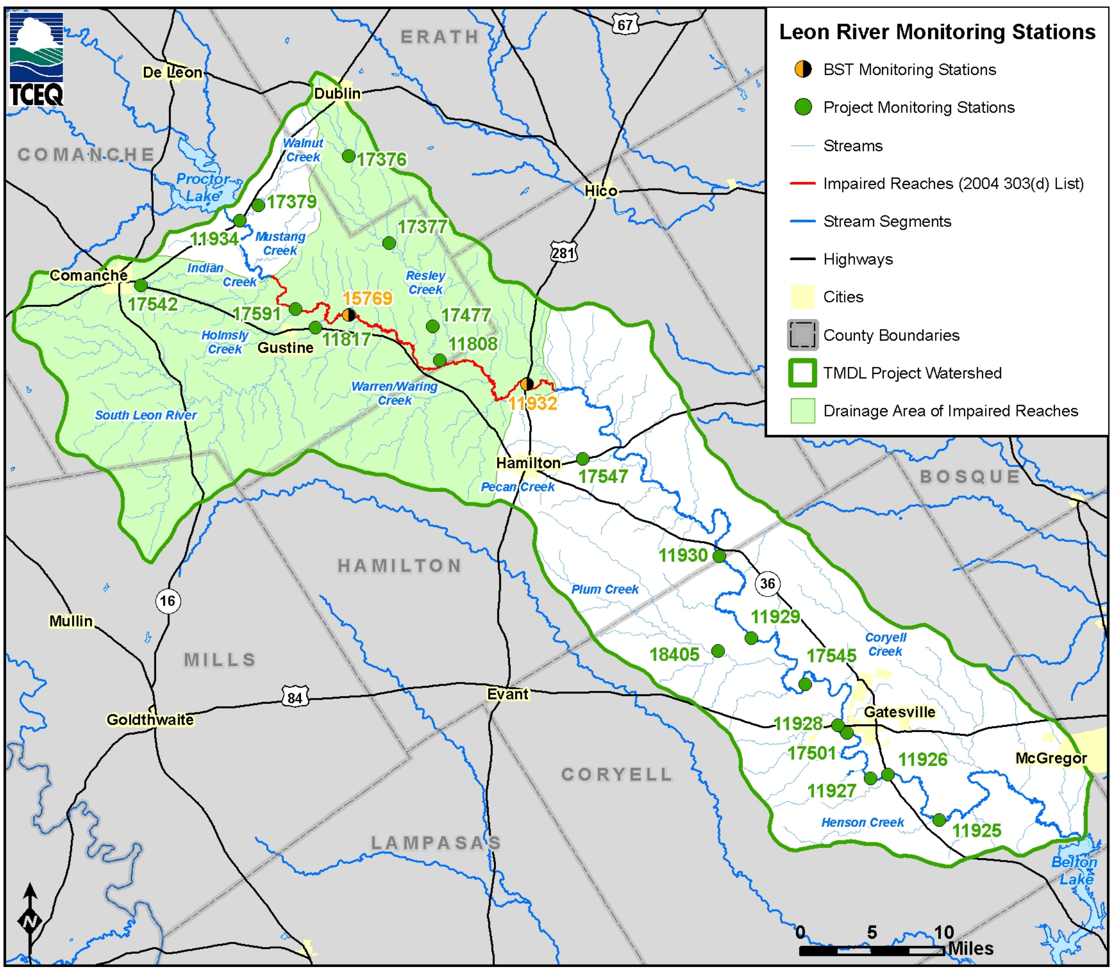

Figure 3: Leon River Watershed Sampling Stations

Water Quality Data

Review of the available water quality data reinforced earlier assessments, which concluded that the segment contains elevated levels of bacteria. Tables 2 and 3 summarize the available data (from routine and intensive surveys) collected for fecal coliform and *E. coli*, respectively. The tables include the number of samples collected, the number of samples that exceeded the grab sample criterion, and the geometric mean of the sampled concentrations.

Figures 4 and 5 show monitoring results for select stations with greater than 10 samples collected. The figures include the geometric mean, upper quartile (75th percentile) and lower quartile (25th percentile) of the individual sample concentrations at each station.

Table 2: Fecal Coliform Data for Leon River, (1996-2004)

			Fecal Coliform		
Station	**Stream**	**Location**	**No. of Samples**	**No. of Exceedances**	**Geomean (cfu/100mL)**
11934	Leon River	US 377	74	11	166
17379	Walnut Crk	FM 1476	29	11	411
17542	Indian Crk	Hwy 36	14	2	190
11818	Indian Crk	CR 304	15	7	497
17591	Leon River	CR 340	14	6	359
11817	South Leon River	Hwy 36	58	9	104
15769	Leon River	FM 1702	37	14	319
17376	Resley Crk	CR 322	30	14	370
17377	Resley Crk	FM 2823	31	6	162
17477	Resley Crk	CR 392	6	2	106
11808	Resley Crk	CR 394	32	13	276
11932	Leon River	US 281	48	12	207
17547	Pecan Crk	Hwy 22	14	3	127
11930	Leon River	CR 431	19	2	194
11929	Leon River	CR 183	-	-	-
18405	Plum Crk	CR 106	-	-	-
17545	Leon River	Moccasin Bend	12	1	75
11928	Leon River	US 84	-	-	-
17501	Leon River	F.L. Park	-	-	-
11927	Leon River	Unnamed Rd	23	5	177
11926	Leon River	Hwy 36	42	9	140
11925	Leon River	FM 1829	14	3	115

Table 3: *E. coli* Data for Leon River, (1996-2004)

			E. coli		
Station	**Stream**	**Location**	**No. of Samples**	**No. of Exceedances**	**Geomean (cfu/100mL)**
11934	Leon River	US 377	27	4	150
17379	Walnut Crk	FM 1476	38	23	580
17542	Indian Crk	Hwy 36	15	4	197
11818	Indian Crk	CR 304	21	18	760
17591	Leon River	CR 340	18	9	383
11817	South Leon River	Hwy 36	41	14	265
15769	Leon River	FM 1702	32	16	538
17376	Resley Crk	CR 322	26	13	480
17377	Resley Crk	FM 2823	49	7	149
17477	Resley Crk	CR 392	13	3	101
11808	Resley Crk	CR 394	35	15	341
11932	Leon River	US 281	39	10	186
17547	Pecan Crk	Hwy 22	17	4	142
11930	Leon River	CR 431	3	0	168
11929	Leon River	CR 183	12	6	480
18405	Plum Crk	CR 106	13	2	81
17545	Leon River	Moccasin Bend	16	5	112
11928	Leon River	US 84	4	1	417
17501	Leon River	F.L. Park	42	5	122
11927	Leon River	Unnamed Rd	4	1	256
11926	Leon River	Hwy 36	2	0	108
11925	Leon River	FM 1829	30	9	236

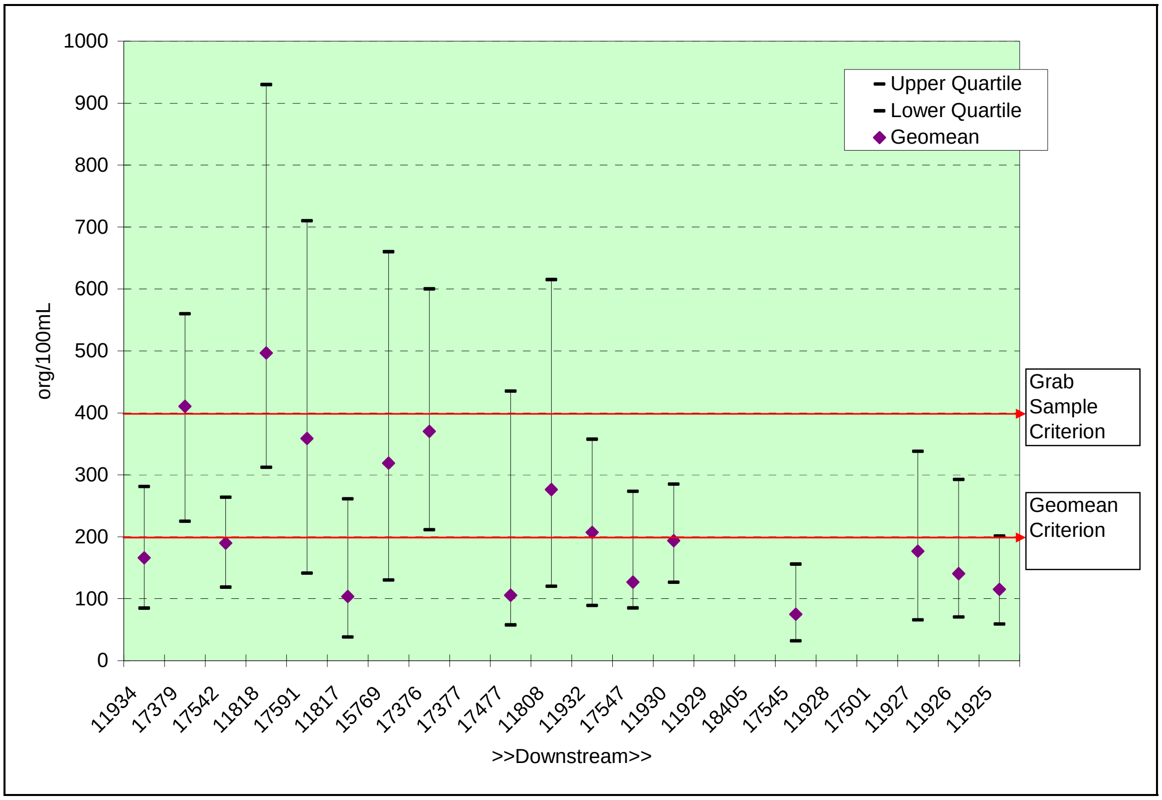

Figure 4: Fecal Coliform Sampling Results

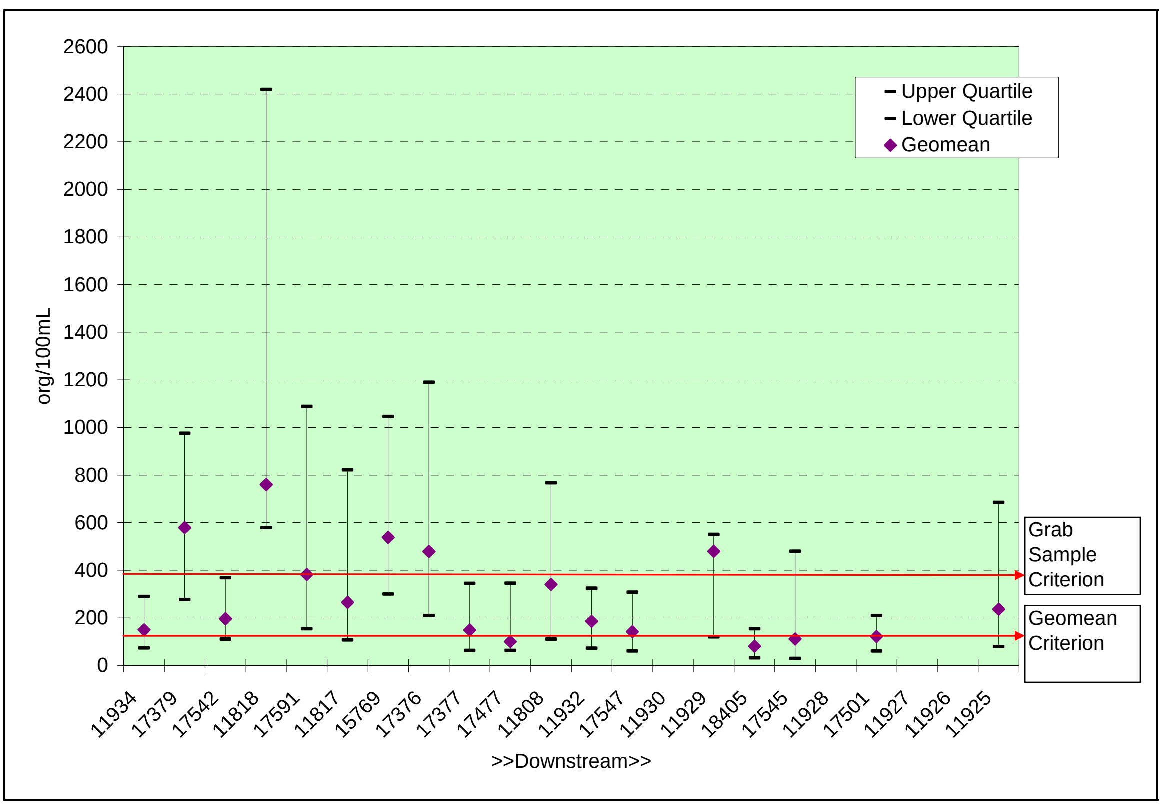

Figure 5: *E. coli* Sampling Results

Additionally, four tributaries of the impaired reaches of Segment 1221 were identified as impaired on the 2006 *Texas Water Quality Inventory and 303(d) List* (TCEQ 2006). Those segments are Resley Creek – Segment 1221a, South Leon River – Segment 1221b, Indian Creek – Segment 1221d, and Walnut Creek – Segment 1221f (Figure 3). Though these segments have been identified as impaired, only one TMDL endpoint rather than five will be proposed for adoption and approval. This will allow for watershed protection plan (WPP) and implementation plan (I-Plan) efforts, with coordination from stakeholders, the opportunity to address reduced loadings and to demonstrate that these segments can be de-listed without additional TMDL endpoints.

Stream Flow and Weather Data

Stream flow and precipitation records are necessary to calibrate watershed and water quality models, calculate loadings of pollutants from point and nonpoint sources, characterize transport processes, and evaluate impacts of pollutant loadings.

For the Leon River, continuous streamflow for the period of study is available at two locations. First, daily releases from Proctor Lake, at the upstream end of the segment, are available from the United States Army Corps of Engineers (USACE). Second, daily flow data are available for the USGS gage at US Hwy 84 (#8100500). USGS gage 08100500 is coincident with TCEQ SWQM station 11928. Other USGS gages are also present in the study area, but were not active for the period of this study.

Precipitation data employed in the present study were obtained from the National Weather Service (NWS). Records of daily rainfall for the NWS cooperative stations in Dublin, Hamilton, and Hurst Springs and records of hourly rainfall for the NWS cooperative stations in Flat and Proctor were the primary source of data for modeling. The daily rainfall stations were disaggregated using the hourly rainfall data from either the Flat or Proctor station.

Critical Condition

Federal regulations in 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loadings, and water quality parameters. The intent of this requirement is to ensure that the water quality is protected during times when the attainment of the use is most vulnerable. The critical condition is considered the “worst case scenario” of environmental conditions for the study segments.

If the TMDL is developed so that the water quality targets are met under the critical condition, then the water quality targets are most likely to be met under all other conditions as well. Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and help in identifying the actions that may have to be undertaken to meet the water quality standards.

Bacteria levels were found to vary significantly based on climatic conditions. Bacteria concentrations were observed to be highest typically under runoff conditions. Therefore, periods of frequent rainfall were found to be the periods with the highest average bacteria concentrations. To quantify this effect, bacteria samples from the historical database were classified as either runoff or baseflow samples. Samples were typically classified as runoff-related if collected during periods of rising or rapidly receding flow. The results of this analysis are presented in Table 4.

This analysis was important for calibrating the water quality model, as well as for determining critical conditions. These three mainstream stations were key accounting points, and hydrologic classifications were not developed for other stations. The median value was selected for calibration guidance. It is well suited for assessment of a lengthy time period of simulation results, since it is the midpoint of the range. The use of a geometric mean would not improve any of the objectives of calibration and it would not facilitate comparison of observed versus simulated values.

For the present analysis, simulations were conducted for the period 2001-2004. Through simulation of this multi-year period, all potential flow conditions are explicitly considered in development of the TMDL. The modeling period includes typical high flow and low flow periods throughout the study area watersheds, which encompass any critical conditions that need accounting. The critical condition may vary year to year and season to season, depending upon the unique combination of rainfall, streamflow, temperature, and bacteria loadings from variable sources at any point in time. For the period of simulation in this analysis, for example, the most critical condition was represented as the 91-day period with the highest simulated geometric mean bacteria concentration, which occurred in the spring of 2004.

Table 4: Hydrologic Classification of Historical Data

Station	Median Fecal Coliform (cfu/100mL)	
	Baseflow	Runoff
FM 1702 - RCH 41	173	820
US 281- RCH 70	113	900
SH 36 - RCH 130	100	1200

Consideration of Seasonal Variations

Exceedances currently occur throughout the impaired reaches irrespective of season. The water quality model accounts for seasonal affects by including temporal variations in climatic patterns, water temperature, and loading rates for some of the bacteria sources. Climatic variations have the greatest influence on bacteria levels in the streams, with periods of chronic wet weather typically resulting in the highest average bacteria concentrations.

Endpoint Identification

TMDLs must identify a quantifiable water quality target for each constituent that causes a body of water to appear on the 303(d) list. These water quality targets are based on the

Texas Surface Water Quality Standards (TCEQ 2000). The numeric criteria defined in the Standards for support of the contact recreation use are as follows.

- *E. coli*
  - The geometric mean of *E. coli* should not exceed 126 cfu/100 mL
  - Single samples of *E. coli* should not exceed 394 cfu/100 mL more than 25 percent of the time

The model was developed for fecal coliform simulation (as opposed to *E. coli* simulation) because most of the historic data and scientific literature were in terms of fecal coliform at the time of model development. However, the final allocation will be expressed in terms of *E. coli* since future assessment of the freshwater contact recreation use is based upon this indicator.

Source Identification

Pollutants may come from several sources, both point and nonpoint. The possible sources of bacteria in the impaired reaches are discussed in this section.

Point Sources

Point sources, such as municipal and industrial wastewater treatment facilities (WWTFs), can contribute bacteria loads to surface water through effluent discharges. These facilities are permitted through the Texas Pollutant Discharge Elimination System (TPDES) program that is managed by the TCEQ. Table 5 lists all permitted point sources in the entire watershed/study area. Those shaded in gray contribute bacteria loading within the impaired reaches.

The study area includes three permitted point sources that are not wastewater treatment facilities and are not expected to contribute any significant bacteria loading to the segment:

- the Upper Leon River Municipal Water District (MWD) discharge is for a drinking water treatment facility
- the U.S. Department of the Navy discharge is for a groundwater remediation facility
- the Comanche Pottery, Inc. discharge is for a plant that manufactures decorative clay pots

Manure production from CAFOs (Concentrated Animal Feeding Operations) was quantified as land based Waste Application Field (WAF) washoff loadings, and therefore is presented as a category of load allocation in the impaired reaches. WAFs are fields where dairy cattle manure is applied in solid or liquid form. WAF1 (Table 12) represents land surfaces that receive solid manure application. WAF2 (Table 12) represents land surfaces that receive sprinkler waste application. There were no data available with which to include retention control structure overflows in the model.

Table 5: Point Sources

Permittee	TCEQ Permit #	EPA NPDES #	Receiving Stream	Permitted Flow (MGD)**	Disinfection Requirement
Upper Leon Rv MWD	14206-001	0122203	Unnamed Trib.	0.249	n/a
City of Comanche	14445-001	0022730	Indian Crk	0.73	>1 mg/L Cl_2
Comanche Pottery	03931-000	0116041	Indian Crk	0.00035	n/a
City of Gustine	10841-001	0117722	South Leon Rv	0.082	>1 mg/L Cl_2
City of Dublin	10405-001	0054348	Resley Crk	0.45	<200 cfu/100mL*
City of Hamilton	10492-002	0026867	Pecan Crk	0.88	>1 mg/L Cl_2
City of Gatesville	10176-002	0111791	Stillhouse Br.	2.2	>1 mg/L Cl_2
City of Gatesville	10176-004	0024953	Leon River	1.0	>1 mg/L Cl_2
U.S. Dept of The Army	12096-001	0063606	Leon River	0.25	>1 mg/L Cl_2
City of Oglesby	10914-001	0100854	Station Crk	0.025	>1 mg/L Cl_2
U.S. Dept of The Navy	02335-000	0034321	Station Crk	n/a	n/a

* Fecal Coliform daily average limit in permit
** Million Gallons per Day

Gray shading indicates dischargers that contribute to bacteria loads in the impaired reaches.

Permitted point sources that process wastewater associated with fecal matter are typically required to provide disinfection. Chlorination is often utilized within a mechanical wastewater treatment plant to achieve this disinfection. This type of system is typically required to monitor effluent for a residual chlorine concentration. Other wastewater treatment facilities utilize facultative or oxidation lagoons for disinfection. These treatment facilities do not include chemical disinfection processes. Instead, 21 days of detention time within the pond system, where bacteria are degraded by solar radiation and other natural processes, substantially reduces bacteria (numbers/count). This type of pond system is required to monitor effluent for fecal coliform concentration.

Nonpoint Sources

In the Leon River watershed, both urban and rural nonpoint sources of fecal coliform bacteria were considered in the present analysis. According to the draft Texas 303(d) list for 2006, unknown nonpoint sources and confined animal feeding operations are the primary source of pathogens in the subject watershed. Figure 6 illustrates methods of nonpoint source loading.

Nonpoint source (NPS) loading typically enters the impaired segment through distributed, unspecific locations. Nonpoint sources can enter the impaired stream through two pathways: directly (not storm water) or indirectly (storm water). Nonpoint sources generally include background loads, failing septic systems, animal deposition, and leaking wastewater infrastructure. CAFO WAFs and OSSFs (On-Site Sewage Facilities) are both regulated by the TCEQ and considered NPS. Each of these sources can result in either direct or indirect nonpoint source pollution.

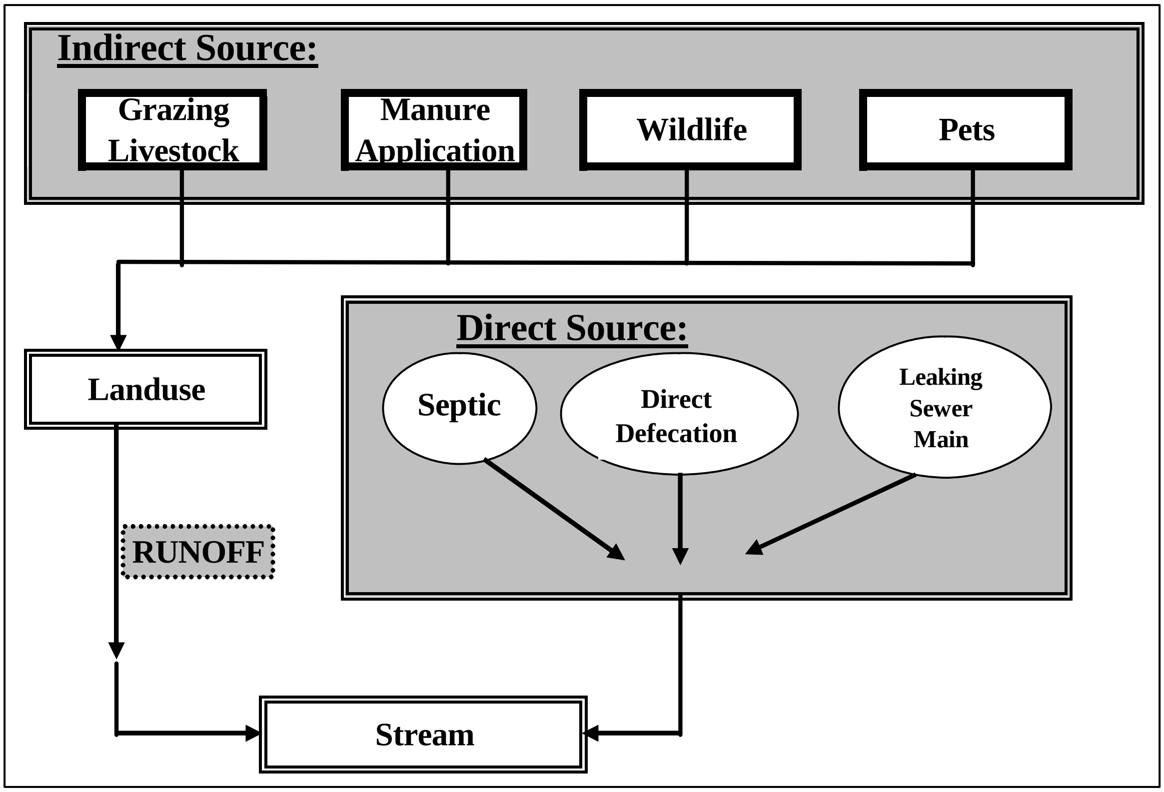

Figure 6: Mechanism of Nonpoint Source Loading

Failing Septic Systems

Private residential sewage treatment systems (OSSFs) typically consist of one or more septic tanks and a drainage or distribution field. A septic system failure can occur via two mechanisms. First, drainfield failures, broken pipes, or overloading could result in uncontrolled, direct discharges to the streams. Such failures could occur in reaches with older homes located near a watercourse or in remote areas. As a second mechanism, an overloaded drainfield could experience surfacing of effluent, and the pollutants would then be available for surface accumulation and subsequent washoff under runoff conditions.

The number of septic systems in the study area was estimated using information from the 1990 U.S. Census, which included a question regarding the means of household sewage disposal (US Census 2006). Unfortunately, this question was not posed in the 2000 Census. Based on the 1990 data, the number of septic systems in the study area was estimated by intersecting the geographic census blocks with the study area watershed. From 1990 to 2004, the total number of septic systems was estimated to have increased from 4,535 to 5,855. In addition, there were an estimated 7,808 sewer connections and 122 “other” (privies and outhouses) types of disposal.

Generally, only septic systems near streams have a high likelihood of contributing bacteria to the surface water. For this study, a riparian corridor of 300 feet (total width) was applied to all perennial steams in the study area. The overall watershed septic system density was applied to these corridor areas to obtain an estimate of near-stream septic systems. Of these systems, only a small percentage would be expected to be failing. According to a report by Reed, Stowe, and Yank (2001), about 12 percent of the septic systems in Hamilton and Coryell counties are chronically malfunctioning. For Comanche and Erath Counties, the failure rate is about 8 percent. For this analysis, only the potential direct discharges from failing septic systems were considered in the model. Fecal coliform loadings were calculated based upon a septic system fecal density of 10,000 cfu/100 mL and a household flow of 210 gal/day (3 persons per household, at 70 gal/capita/day) (EPA 2001).

Leaking Wastewater Infrastructure

Leaking wastewater sewer lines are difficult to detect, but are a potentially significant source of bacteria, especially in urbanized areas where most residences are served by a central sewage collection system. As with failing septic systems, only wastewater lines located close to streams have a high potential to act as bacterial sources. However, wastewater lines, especially large collection lines, tend to be installed along creeks and streams because the elevation profile along the waterway channel provides an economical arrangement for the gravity transport of collected sewage. In general, wastewater lines will only leak when their hydraulic grade line is higher than that of the stream to which they parallel. Also, sewers will typically only leak if there is a line blockage, they become cracked or are improperly installed.

Livestock and WAFs

Livestock population estimates for Comanche, Hamilton, Mills, McLennan, Erath, and Coryell Counties were based upon the federal 2002 Census of Agriculture (USDA 2002), TCEQ CAFO permit records (Frazier 2005), and TSSWCB Water Quality Management Plan (WQMP) records (TSSWCB 2005). The types of livestock explicitly included in the present analysis include cattle, horses/donkeys, sheep/goats, hogs, and chickens. Census numbers by county were converted to densities and were then used to estimate livestock population in each subwatershed based on the proportion of each county present. Dairy cattle numbers (Table 6) were based upon CAFO permits provided by TCEQ, and include permitted CAFOs in the entire watershed.

The actual cattle numbers at a CAFO are probably less than these permitted numbers but for the purposes of this analysis, the permitted numbers have been employed. Livestock population estimates are presented in Table 7. Other types of livestock have small populations compared to the major livestock species listed above, and therefore, the fecal loads from these other animal groups were assumed to be negligible compared to the predominant sources.

Non-grazing, or confined, animals considered in the present analysis were dairy cattle. It was assumed that waste from dairy cattle could be represented predominately as contained within confined facility areas. For ultimate disposition, the manure is applied in solid or liquid form to WAFs. Grazing animals contribute fecal coliform bacteria to the land surface that is subsequently available for washoff to surface waters during storm events. Also, livestock can deposit fecal material directly into the stream. Fecal coliform bacteria production rates for livestock in the Leon River watershed are displayed in Table 8. For the present study, all of the data regarding manure production rates and fecal coliform density were based upon values reported in literature (EPA 2001) (ASAE 2003).

Table 6: TCEQ Permitted CAFOs in Segment 1221 Watershed

Permit Name	Permit Number	Permitted Head
Indian Creek Dairy	TXG920034	990
XXX Dairy	TXG920040	6,000
Dutch Tex Dairy	TXG920070	699
Anderson Dairy	TXG920072	2,249
Billy Lasater Dairy	TXG920086	869
J&J Dairy	TXG920092	1,799
B&K Dairy	TXG920110	600
Lanting Dairy	TXG920149	990
Overwhere Dairy	TXG920150	1,784
Hoekman Dairy	TXG920152	1,700
Hoekman Rental Dairy	TXG920153	990
Rose Hill Dairy	TXG920166	600
Day Star Dairy	TXG920193	2,249
Jochum Schievink Dairy	TXG920211	1,200
Holy Cow Dairy	TXG920237	699
Medeiros Dairy	TXG920258	500
Aurora Organic Dairy Texas	TXG920263	4,500
Wild West Dairy	TXG920271	2,000
Buekeboom Dairy	TXG920274	1,865
Sundance Dairy	TXG920276	3,750
Wildcat Dairy	TXG920277	6,000
Mike Roberson Dairy	TXG920278	500
Brand Dairy	TXG920295	2,500
Indian Ridge Dairy	TXG920297	4,000
Dublin Dutch Dairy	TXG920299	5,200
Drentex Dairy	TXG920380	500
Carlina Dairy	TXG920641	4,000
Lazy D Dairy	TXG920729	990
Gore Dairy 4	TXG920767	400
Hillcrest Dairy	TXG920768	5,500
Aurora Organic Dairy 3	TXG920843	2,900
Wildcat Calf Ranch 2	TXG920928	1,500
Henry Dairy	TXG920963	2,000

Table 7: Livestock Population Estimates in the Watershed/Study Area

	Cattle & Calves	Dairy Cattle	Hogs and Pigs	Sheep	Horses & Donkeys
Total:	110,862	72,023	669	11,703	2,711

Table 8: Fecal Coliform Production Rates for Livestock and Wildlife

Animal	Fecal Coliform (10^9 cfu/day) (count/animal/day)
Dairy Cow	101
Beef Cow	104
Hog	11
Sheep	12
Horse	0.4
Chicken	0.1
Turkey*	0.1
Duck	2
Opossums	0.1
Deer	1
Feral Hogs	11
Raccoon	0.1

*domestic

Wildlife and Feral Animals

Representative wildlife species were included in the modeling analysis as potential sources of bacteria. The predominant wildlife species to be included in the modeling analysis were determined by wildlife biologists on the project team based on their experience, literature (Davis and Schmidly 1994; TPWD 2004), site visits, and consultation with Texas Parks and Wildlife Department staff (Cain 2004). The key species included deer, raccoons, opossums, feral hogs, and ducks. Of course, numerous other species of animals inhabit the watershed, but the species selected in the present analysis were chosen based upon population and fecal production potential. The population of each wildlife species was developed using estimated population densities per square mile of habitat and the total area of suitable habitat available in each subwatershed. This wildlife inventory is shown in Table 9.

To support water quality modeling, a general estimate of the overall load contribution from wildlife is needed. Since wildlife populations cannot be precisely known, all loading parameters that represent wildlife were subject to adjustment in the model calibration process.

There are two mechanisms considered for bacteria loadings from wildlife to be transported to the stream segment. First, wildlife deposit waste on land surfaces that accumulates and is subsequently available for washoff with runoff. Second, wildlife may deposit waste directly into the stream.

Table 9: Inventory of Wildlife

	Ducks	Deer	Raccoons	Opossums	Feral Hogs
Total	450	67,169	53,735	214,940	26,867

Linkage Analysis

Establishing the relationship between water quality targets in the stream and the source loadings of bacteria is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired water quality endpoint. The link can be established through a variety of techniques, ranging from qualitative assumptions based on scientific principles to sophisticated mathematical modeling techniques. In the development of the TMDL for the Leon River, the relationship was defined through computer modeling based upon data collected throughout the watershed. Monitored flow and water quality data were used to verify that the relationships developed through modeling were accurate.

The Hydrologic Simulation Program - Fortran (HSPF) water quality model was selected as the modeling framework to simulate existing conditions and to perform TMDL allocations. The HSPF model is a continuous simulation model for watershed hydrology and water quality. The model can account for both point and nonpoint source loadings in the watershed. HSPF includes simulation of the receiving stream that receives mass loadings from the watershed.

In order to develop a representative linkage between the sources and the water quality response in the streams in the Leon River watershed, model parameters were adjusted to accurately represent hydrology and streamflow as well as fecal coliform bacteria loading and instream concentrations. Hydrologic parameters in the model were set and adjusted based upon available soils, land use, topographic, and streamflow data.

Calibration of the water quality model entailed adjustment of bacteria-related parameters to achieve agreement of the simulated model results with the observed fecal coliform measurements. Several parameters were available for adjustment in the model. The model was calibrated for both baseflow and runoff conditions.

The bacterial loads associated with the model calibration can be readily examined in terms of load originating from the land use categories and point sources embodied in the analysis. Comparisons of simulated loads for the impaired reaches are compared graphically in Figure 7. The loads presented are the total annual average loads that enter the impaired stream, contributed by the various sources. The loads do not account for decay that occurs as the bacteria travel downstream.

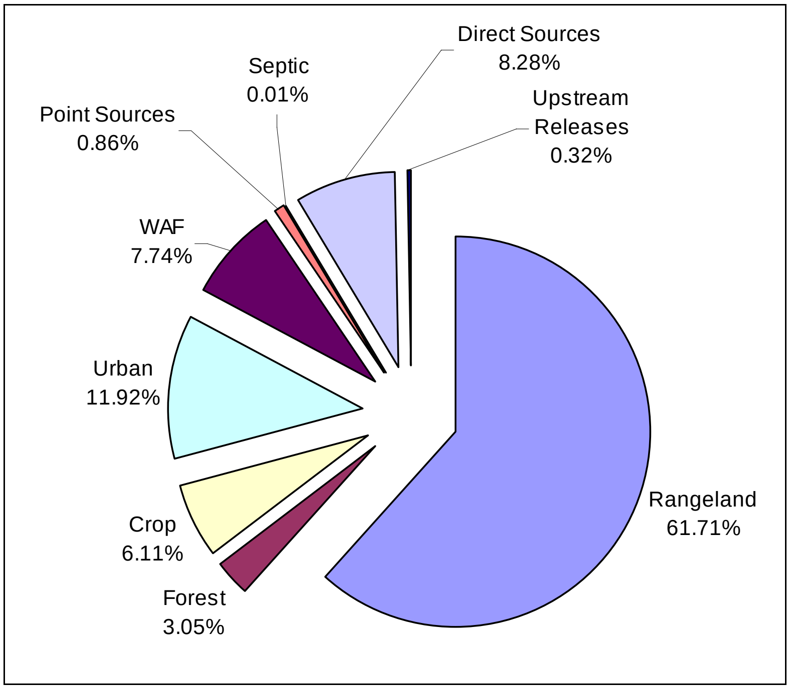

Figure 7: Comparison of Fecal Coliform Sources for Leon River

For the watershed/study area, the largest presumed source of fecal coliform bacteria is rangeland. This is attributable to the fact that rangeland is the largest land use category in terms of acreage. The next largest contribution is estimated to be urban land uses, and the third largest source is direct sources. The urban areas and WAF have relatively small acreages but their assumed loading parameters are relatively large.

Bacterial Source Tracking

Watersheds can be adversely affected by many different sources of microbial pollution. The primary potential sources of microbial pollution include human and animal populations. During the past decade, several methods have been proposed for identifying the sources of microbial pollution in the environment. BST is a tool to identify possible sources of bacteria. BST can be useful in the development of TMDLs as part of the source assessment, load allocation, and in the development of an implementation plan to target specific sources of bacteria entering a respective water body. For this project, BST was used to identify the presence of sources.

Currently, several research groups and commercial laboratories conduct source tracking and source identification studies using a variety of different methods and target organisms (EPA 2005). The methodologies that have been used to determine the sources of microbial contamination in the environment include phenotypic-based methods such as anti-microbial resistance analysis (ARA), and genotypic-based methods such as ribotyping, pulsed field gel electrophoresis (PFGE), polymerase chain reaction (PCR) based methods, and many others. ARA and ribotyping have been used far more than other BST methods, and are more developed with respect to their application to water quality studies.

Available BST methods were evaluated and two genetic fingerprinting methods were selected to meet the needs of this study: enterobacterial repetitive intergenic consensus sequence polymerase chain reaction (ERIC-PCR) and automated ribotyping (RiboPrinting). All BST laboratory work was conducted by the Texas A&M El Paso Agricultural Research and Extension Center (EP AREC) (Di Giovanni and Casarez 2006). The source identification portion of the method relies on generating genetic fingerprints of *E. coli* strains isolated from the contaminated sites and comparing the fingerprints to those of *E. coli* strains isolated from potential sources of fecal pollution.

The BST process involves two primary steps. First, a library of the genetic fingerprints of known sources is created. This was accomplished through the field collection of fecal matter samples from animals within the Leon River watershed. To achieve a higher rate of correct classification, a combined TCEQ-TSSWCB library utilizing fecal matter samples from other study watersheds was employed. As data were gathered, they were sent to EP AREC to be analyzed and added to the library of fingerprints. The genetic fingerprints are prepared by applying restriction enzymes (*Hin*d III) to the ribosomal RNA of bacteria.

The second step required that bacteria of unknown origin (*E. coli* isolates), collected in ambient water samples, be compared to the fingerprints in the library to determine source classification. For this project, ambient samples were collected at two stations listed in Table 10 and shown on Figure 3.

EP AREC employed two methods for comparison and classification of DNA fingerprints. First, the Bionumerics statistics software (Applied Maths, Austin, Texas) was used to assign a probable match between each isolate from the water samples and the isolates from the fecal source library. The second method was a visual assessment of each individual band, or DNA fingerprint, generated throughout the study. Only isolate matches with a confidence level of 85 percent or more were accepted as probable matches in the classification protocol for this TMDL. This conservative cut-off criterion was designed to avoid misclassification errors.

Table 10: BST Sampling Stations

Station No.	Location Description
11932	Leon River at US 281
15769	Leon River at FM 1702

The classification results indicate that the predominant sources of *E. coli* in the watershed include avian wildlife, non-avian wildlife, sewage, cattle, pet, non-avian livestock, and avian livestock. Overall results (for sampling stations 11932 and 15769 combined, Figure 3) for the BST are presented as follows:

- 22% of the isolates originated from avian wildlife
- 19% of the isolates originated from non-avian wildlife
- 17% of the isolates originated from sewage
- 14% of the isolates originated from cattle

- 8% of the isolates originated from pets
- 6% of the isolates originated from non-avian livestock
- 2% of the isolates originated from avian livestock
- 12% of the isolates were unidentified

The bacterial source composition results from the present study appear to be reasonable. The three predominant sources identified were avian wildlife, non-avian wildlife, and sewage. However, since samples were collected within a limited timeframe from only two sampling locations within a very large geographic area (1,375 square miles), the results must be interpreted with caution.

Pollutant Load Allocation

TMDL Calculation

TMDLs are the sum of the individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background conditions, and a margin of safety (MOS). The TMDL equation has historically been written as follows:

$$\text{TMDL} = \Sigma\text{WLA} + \text{LA} + \text{MOS}$$

where… $\sum$ WLA = Sum of Wasteload Allocations (Point Source Allocation)
$\sum$ LA = Sum of Load Allocations (Nonpoint Source Allocation)
MOS = Margin of Safety

In this equation, the "wasteload allocation" and "load allocation" represent the maximum allowable point and nonpoint source contributions, respectively. The margin of safety is included to account for any uncertainty concerning the relationship between effluent limitations and water quality.

Allocation Scenario Development

Several scenarios for best management practice (BMP) application were examined in order to assess various loading reduction scenarios. The scenarios constitute various combinations of BMPs applied to the bacteria loads that emanate from the watersheds that contribute to the stream. In the model, this was accomplished for washoff-based loadings by application of a module that allows the user to adjust the percent loading removed, by land use category. Direct sources of loadings were adjusted in the model with appropriate multipliers to effect reductions.

Wasteload Allocations

In the Leon River study area, there are point source discharges (Table 5). Three permitted domestic wastewater treatment point sources contribute loadings to the impaired reaches. Two of the municipal treatment facilities (Cities of Comanche and Gustine) are mechanical plants that include disinfection unit processes prior to discharge, which would ordinarily be expected to reduce bacteria concentrations to negligible amounts. However, disinfection is not adequate if operation and maintenance does not occur routinely. Secondly, incomplete disinfection occurs under conditions of high inflow, which put the greatest demands on the treatment system. These facilities also have occasional to frequent overflows and bypasses from their sewage collection lift stations and treatment works, as documented in TCEQ's discharge monitoring reports.

The third WWTF in the upper reaches is the City of Dublin treatment facility which consists of facultative lagoons. This type of treatment facility does not include a chemical disinfection unit process. Twenty-one days detention time within the pond system, where bacteria are degraded by solar radiation and other natural processes, substantially reduces bacteria (numbers/count). These types of treatment facilities may not be able to provide sufficient hydraulic retention time under conditions of rainfall-induced peak flows; therefore, there is no mechanism for controlling the concentration of bacteria discharged. Self-reporting monitoring data for this facility do indicate that fecal coliform bacteria are discharged.

The present analysis indicates that substantial reduction in fecal coliform loading to the Leon River from a variety of sources is necessary in order to achieve compliance with stream criteria. Therefore, it is prudent to impose a WLA reduction for the three domestic WWTFs that discharge to the impaired reaches in order to meet the overall WLA. A 74 percent reduction in existing load has been assigned to the domestic wastewater point sources, based upon consideration of several loading control scenarios. This reduction would apply to any periodic overflows from the plant or collection system. The WLAs determined for the study area are displayed in Table 11.

Table 11: WLAs for Fecal Coliform in Impaired Reaches (10^6 cfu/day)

Point Source	Existing FC Load	Overflow FC Load**	Total FC Load	Percent Reduction	FC WLA*
City of Dublin WWTF	422	23,562	23,984	85.8	3,407
City of Comanche WWTF	8	11,781	11,789	53.1	5,526
City of Gustine WWTF	38	1,110	1,148	45.9	621
Totals	468	36,453	36,921	74	9,554

*permitted flow x water quality standard

**(for days receiving >0.5" of rain) three times reported daily flow x 6hr period x 30,000 cfu/100 mL

While the magnitude of the bacteria loads from point sources may be small relative to the land-based washoff bacteria loads, their contribution is important particularly under base-flow conditions in the impaired reach of the Leon River. In addition, the likelihood that wastewater effluent contains pathogens is high, compared to non-human nonpoint source loads.

Load Allocations

In the model, load allocations (LA) for nonpoint sources include land-based washoff loadings and direct discharge nonpoint source loadings. Exact removals employed in the modeling analysis for each specific land use category serve only as guidance and a demonstration that reductions in washoff-based loading are necessary. The total LA is shown in Table 12. The total LA is the sum of the various individual LAs for the specific land use categories, based upon hypothetical removals applied to corresponding existing loads. Then, the overall composite reduction in NPS load was calculated, which is applicable to the total estimated existing NPS load. The breakdown of land use in the model serves only to illustrate that hypothetical removals can accomplish compliance with the bacteria criteria. This outcome is a reflection of the degree of uncertainty regarding the magnitude of any of the specific bacterial sources. Instead, it will be more appropriate for these more specific nonpoint source-based removals to be developed during the TMDL implementation phase in concert with the WPP and affected stakeholders in the watershed. During implementation, the TCEQ and stakeholders can assign removals based on the WPP to specific sources such that the overall load reductions are achieved.

Table 12: LAs for Fecal Coliform in Impaired Reaches (10^6 cfu/day)

Total NPS Load Existing	Overall NPS Load Reduction (%)	Total NPS Load Allocation
4,256,048	21.2	3,353,131

Margin of Safety

The MOS is a required component of the TMDL to account for any uncertainty concerning the relationship between effluent limitations and water quality. According to EPA guidance (EPA 1991), the MOS can be incorporated into the TMDL using two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

This TMDL has an implicit MOS which reflects conservative factors incorporated into the TMDL development process. The most important factor was the use of a 91-day period for assessing model results. The 91-day period is based on quarterly sampling on an annual basis, which is consistent with TCEQ methodology. TCEQ typically uses a seven-year period for assessing compliance with Water Quality Standards.

TMDL Summary

Table 13 summarizes the TMDL fecal coliform loading allocations for the Leon River. The WLA includes all of the allocated point sources and the LA is comprised of un-permitted washoff sources, direct nonpoint sources, septic system sources, and various background sources.

The proposed TMDL is expected to be protective for Texas water quality criteria for *E. coli*. A ratio of 0.63 was applied in the present study to convert fecal coliform to *E. coli*. This ratio is based on comparison of the criterion for *E. coli* compared to the criterion for fecal coliform (126/200 = 0.63). Similar ratios have been reported in other studies. Therefore, development of a TMDL to achieve compliance with a fecal coliform concentration of 200 cfu/100 mL should be protective down to an *E. coli* concentration of 126 cfu/100mL (200x0.63 = 126). This corresponds to the *E. coli* criterion of 126 cfu/100 mL as a geometric mean. Table 14 shows the TMDL summary expressed in terms of *E. coli* bacteria loadings.

Table 13: Summary of Fecal Coliform TMDL for Impaired Reach (10^6 cfu/day)

	TMDL	WLA	LA
Leon River	3,362,685	9,554	3,353,131

Table 14: Summary of *E. coli* TMDL for Impaired Reach (10^6 cfu/day)

	TMDL	WLA	LA
Leon River	2,118,491	6,019	2,112,472

Public Participation

The TCEQ maintains an inclusive public participation process and from the inception of the investigation, the project team sought to ensure that stakeholders were informed and involved. The project team also recognized that communication and comments from the stakeholders in the watershed would strengthen the project and its implementation.

An official steering committee of stakeholders was established. Notices of meetings were posted on the TMDL program's web calendar. Two weeks prior to scheduled meetings, media releases were initiated and steering committee stakeholders were formally invited to attend. To ensure that absent stakeholders and the public were informed of past meetings and pertinent material, a project web page was established to provide meeting summaries, presentations, ground rules, and a list of official steering committee stakeholders. The project web page is available at: <www.tceq.state.tx.us/implementation/water/tmdl/34-leon_group.html>.

Throughout the term of the project, from 2003 to 2007, eight meetings were held. At each meeting, the project team received and responded to a number of questions and comments. The objectives of the first meeting in August of 2003 were to:

- Introduce the project team and summarize the public participation process.
- Define what the project intended to accomplish.

- Provide information on TMDL process.
- Provide information on prior data assessment.
- Discuss plans for data collection.

The objectives of the second stakeholder meeting in August of 2004 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Review historical data and monitoring results.
- Provide details on monitoring plans.
- Discuss the next phases.

The objectives of the third stakeholder meeting in October of 2005 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Provide information on bacteria source tracking results.
- Discuss modeling phase.

The objectives of the fourth stakeholder meeting in January of 2006 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Provide information on modeling results.

The objectives of the fifth stakeholder meeting in February of 2006 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Provide information on modeling results.

The objectives of the sixth stakeholder meeting in June of 2006 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Discuss results of model sensitivity analysis.
- Discuss stakeholder comments and responses.

The objectives of the seventh stakeholder meeting in October of 2007 were to:

- Discuss outstanding issues, such as the Bacteria TMDL Task Force Report, water quality standards, OSSFs, wildlife, and additional segments.
- Discuss the next phase of the project, specifically, release of the draft TMDL report for public comment, TCEQ adoption/EPA approval, implementation, and TSSWCB-sponsored projects in the watershed.

The objectives of the eighth stakeholder meeting in December of 2007 were to:

- Discuss issues, such as additional segments now impaired, general permit vs. individual permits for CAFOs, the adoption process of the TMDL, and implementation of the TMDL. Coordination of the Leon River WPP with the TMDL I-Plan, and the role stakeholders play in the process were discussed in depth to answer questions and solicit involvement.

Implementation and Reasonable Assurances

The TMDL development process involves the preparation of two documents:

1) a TMDL, which determines the amount of pollutant a water body can receive and continue to meet applicable water quality standards, and
2) an I-Plan, which is a detailed description and schedule of regulatory and voluntary management measures necessary to achieve the pollutant reductions identified in the TMDL. It is the policy of the commission and of the TSSWCB to develop implementation plans for all TMDLs adopted by the State, and to assure the plans are implemented. Implementation plans are not subject to EPA approval.

During TMDL implementation, the State works with stakeholders to develop the management strategies needed to restore water quality to an impaired water body. This information is summarized in the TMDL I-Plan, which is separate from the TMDL document.

A WPP is being developed under the auspices of the *Texas NPS Management Program* which is jointly administered by the TCEQ and the TSSWCB. Through a CWA §319(h) NPS Grant, from the EPA and administered by the TSSWCB, the BRA is facilitating the WPP development process and providing technical guidance to stakeholders, including:

- a forum for stakeholders to meet and reach consensus on the measures necessary to reduce bacterial loads in the basin.
- investigation of best management practices and treatment alternatives for bacterial sources in the watershed.
- additional water quality monitoring to determine the magnitude and location of sources of bacteria.
- enhancements to the water quality model to improve model resolution and to reflect data gathered during the WPP process.

Specific components of the WPP will be used as the basis for development of the I-Plan for Segment 1221. Furthermore, additional sampling at appropriate locations and frequencies will allow progress toward the targeted and primary endpoints to be tracked and evaluated. These steps will provide reasonable assurances that the regulatory and voluntary activities necessary to achieve the pollutant reductions will be implemented. Preparation of the I-Plan for Segment 1221 will begin upon Commission approval of the TMDL. The I-Plan will detail any activities such as mitigation measures, permit actions, best management practices, and additional sampling and monitoring determined to be necessary to restore water quality.

Implementation Processes to Address the TMDL

Together, a TMDL and a TMDL I-Plan direct the correction of unacceptable water quality conditions that exist in an impaired surface water body in the state. A TMDL broadly identifies the pollutant load goal after assessment of existing conditions and the impact on those conditions from probable or known sources. A TMDL identifies a total loading from the combination of point sources and nonpoint sources that would allow attainment of the established water quality standard.

A TMDL I-Plan specifically identifies required or voluntary implementation actions that will be taken to achieve the pollutant loading goals of the TMDL. Regulatory actions identified in the I-Plan could include:

- adjustment of an effluent limitation in a wastewater permit,
- a schedule for the elimination of a certain pollutant source,
- identification of any nonpoint source discharge that would be regulated as a point source,
- a limitation or prohibition for authorizing a point source under a general permit, or
- a required modification to a storm water management program (SWMP) and pollution prevention plan (PPP).

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

The TMDL document and the underlying assumptions, model scenarios, and assessment results are not and should not be interpreted as required effluent limitations, pollutant load reductions that will be applied to specific permits, or any other regulatory action necessary to achieve attainment of the water quality standard. The I-Plan developed by stakeholders and approved by the State, will direct implementation efforts to certain sources contributing to the impaired water.

The I-Plan will be developed through effective coordination with stakeholders affected by or interested in the goals of the TMDL. In determining which sources need to accomplish what reductions, the I-Plan may consider factors such a:

- cost and/or feasibility,
- current availability or likelihood of funding,
- existing or planned pollutant reduction initiatives such as watershed-based protection plans,
- whether a source is subject to an existing regulation,
- the willingness and commitment of a regulated or unregulated source, and
- a host of additional factors.

Ultimately, the I-Plan will identify the commitments and requirements to be implemented through specific permit actions and other means.

An exception would include an I-Plan that identifies a phased implementation that takes advantage of an adaptive management approach. It is not practical or feasible to approach all TMDL implementation as a one-time, short-term restoration effort. This is particularly true when a challenging wasteload reduction or load reduction was required by the TMDL, high uncertainty with the TMDL analysis exists, there is a need to reconsider or revise the established water quality standard, or the pollutant load reduction would require costly infrastructure and capital improvements. Instead, activities contained in the first phase of implementation may be the full scope of the initial I-Plan and include strategies to make substantial progress towards source reduction and elimination, refine the TMDL analysis, conduct site-specific analyses of the appropriateness of an existing use, and monitor in stream water quality to gage the results of the first phase. Ultimately, the accomplishments of the first phase would lead to development of a phase two or final I-Plan or revision of TMDL. This adaptive management approach is consistent with established guidance from EPA (see August 2, 2006 memorandum from EPA relating to clarifications on TMDL revisions).

The TCEQ maintains an overall water quality management plan (WQMP) that directs the efforts to address water quality problems and restore water quality uses throughout Texas. The WQMP is continually updated with new, more specifically focused WQMPs, or "water quality management plan elements" as identified in federal regulations (40 Code of Federal Regulations (CFR) Sec. 130.6(c)). Consistent with federal requirements, each TMDL is a plan element of a WQMP and Commission adoption of a TMDL is state certification of the WQMP update.

Because the TMDL does not reflect or direct specific implementation by any one pollutant discharger, the TCEQ certifies additional "water quality management plan elements" to the WQMP once the I-Plan is adopted by the Commission. Based upon the TMDL and I-Plan, the TCEQ will propose and certify WQMP updates to establish required water-quality-based effluent limitations necessary for specific TPDES wastewater discharge permits. The TCEQ would normally establish BMPs, which are a substitute for effluent limitations in TPDES MS4 storm water permits as allowed by the federal rules where numeric effluent limitations are infeasible (see November 22, 2002 memorandum from EPA relating to establishing TMDL WLAs for storm water sources). Thus, TCEQ would not identify specific implementation requirements applicable to a specific TPDES storm water permit through an effluent limitation update. However, the TCEQ would revise a storm water permit, require a revised SWMP or PPP, or implement other specific revisions affecting storm water dischargers in accordance with an adopted I-Plan.

The TSSWCB is the lead agency in Texas responsible for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural nonpoint sources of water pollution (Texas Agriculture Code §201.026). In collaboration with local soil and water conservation districts, the TSSWCB works with landowners to develop and implement water quality management plans on agricultural or silvicultural lands. A TSSWCB-certified water quality management plan is a site-specific plan that includes appropriate land treatment practices, production practices, management measures, and technologies that are based on criteria established by the USDA Natural Resources Conservation Service. Water quality management plans are designed to achieve a level of pollution prevention or abatement determined by the TSSWCB to be consistent with the state's water quality standards.

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