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Three Total Maximum Daily Loads for Bacteria in the San Antonio Area

For Segment Numbers:
1910 – Salado Creek
1910A – Walzem Creek
1911 – Upper San Antonio River

Prepared by the:
Chief Engineer's Office, Water Programs, TMDL Section
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"Modeling Report for Bacteria TMDL Development: Salado Creek, Segment 1910; Walzem Creek, Segment 1910A; Upper San Antonio River, Segment 1911,"
by James Miertschin & Associates, Inc.

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Executive Summary

This document describes a project developed to address water quality impairments related to bacteria for three streams located in and around the City of San Antonio—Salado Creek, Segment 1910; Walzem Creek, Segment 1910A; and the Upper San Antonio River, Segment 1911. Salado Creek and the Upper San Antonio River (USAR) were first identified as impaired due to bacteria in the 2000 *Texas Water Quality Inventory and 303(d) List* (TCEQ 2000). Walzem Creek was added to the list in 2002.

Salado Creek, located in Bexar County, is approximately 45 miles long, with a drainage area of 223 square miles. Walzem Creek, located inside the Salado Creek watershed, is approximately 3.1 miles long and drains 2.8 square miles. The USAR, located in Bexar and Wilson Counties, is approximately 85 miles long, and is joined by two major tributaries—Salado Creek and the Medina River (Segment 1903). The drainage area specific to the USAR, excluding the Salado Creek watershed, is approximately 530 square miles.

The goal of this TMDL project was to determine the maximum bacteria loading the stream can receive and still allow support of the contact recreation use. Indicator bacteria such as *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 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 organisms (org) of bacteria per hundred milliliters (100 mL) of water. The number of organisms may not exceed certain concentrations in a single sample, nor as a geometric mean of all samples over a range of time.

Based on field assessments and analysis of load allocation scenarios, attaining the water quality standards requires:

- 90 percent reduction in nonpoint source loading to Salado and Walzem Creeks
- 60 percent reduction in urban storm water loading to Salado and Walzem Creeks
- 99.9 percent reduction in baseflow loading from the San Antonio Zoo to the USAR
- 50 percent reduction on nonpoint source loading to the USAR
- 30 percent reduction in urban storm water loading to the USAR

Overall, a 59 percent reduction in bacterial loading is required for Salado and Walzem Creeks, and a 31 percent reduction in bacterial loading is required for the USAR.

Introduction

Section 303(d) of the federal Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. The compilation of subject water bodies is known as the 303(d) list. For each listed water body, states must develop a TMDL for each pollutant that contributes to an impairment. The 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 its 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 organisms (or colony forming units) 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. These TMDLs address impairments to contact recreation from bacterial indicators for pathogens in Salado Creek, Walzem Creek, and the USAR.

Section 303(d) of the Clean Water Act and the implementing regulations of the U.S. Environmental Protection Agency (EPA) in Title 40, Code of Federal Regulations, Part 130 (40 CFR 130) describe the statutory and regulatory requirements for acceptable TMDLs. The EPA provides further direction for developing TMDLs in its *Guidance for Water Quality-Based Decisions: The TMDL Process* (USEPA 1991). This TMDL document has been prepared in accordance with those regulations and guidelines. The TCEQ must consider certain elements in developing a TMDL; they are described in the following sections:

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

This document is based on the "Modeling Report for Bacteria TMDL Development: Salado Creek, Segment 1910; Walzem Creek, Segment 1910A; Upper San Antonio River, Segment 1911," prepared for the TCEQ by James Miertschin & Associates, Inc. (JMA 2006).

The commission adopted this document on July 25, 2007. Upon EPA approval, this TMDL will become an update to the state's Water Quality Management Plan.

Problem Definition

This document describes a project to develop TMDLs for three streams located in and around the City of San Antonio—Salado Creek (Segment 1910), Walzem Creek (Segment 1910A), and the USAR (Segment 1911). Salado Creek and the USAR were first identified as impaired for bacteria in the 2000 *Texas Water Quality Inventory and 303(d) List* (TCEQ 2000). Walzem Creek was added to this list in 2002.

The study area is depicted in Figure 1. Only the red portions were found to be impaired, as indicated in the 303(d) List and confirmed through an additional assessment of historic data (JMA and PES 2002). Salado Creek is impaired from 1.5 miles upstream of Loop 410-N to the confluence with the USAR. Walzem Creek is impaired from 1.5 miles upstream of Walzem Road to its confluence with Salado Creek. The USAR is impaired from its headwaters at San Antonio Springs to Wilson County Road 125; and from 2.5 miles upstream of FM 536 to 4 miles below FM 541. Possible sources and/or causes of contamination include:

- discharges from wastewater treatment facilities and other institutions
- discharges from urban storm sewer systems
- runoff from undeveloped lands
- wildlife deposition
- pets and livestock deposition
- leaking sewer infrastructure
- failing septic systems

Designated Uses and Water Quality Standards

The *Texas Surface Water Quality Standards* (TCEQ 2000) provide numeric and narrative criteria to evaluate attainment of designated uses. At the time these TMDLs were under development, the standard to support contact recreation was in transition, so both *E. coli* and fecal coliform were in place. The TMDLs were developed for fecal coliform, and converted to *E. coli*. 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 organisms per 100 milliliters (126 org/100 mL)
  - Single samples of E. coli should not exceed 394 org/100 mL
- Fecal coliform
  - The geometric mean of fecal coliform should not exceed 200 org/100 mL
  - Single samples of fecal coliform should not exceed 400 org/100 mL

Salado Creek and the USAR are designated for contact recreation and high aquatic life uses. Salado Creek is also designated for domestic water supply use, and the portion of the creek located over the contributing, transition, and recharge zones of the Edwards

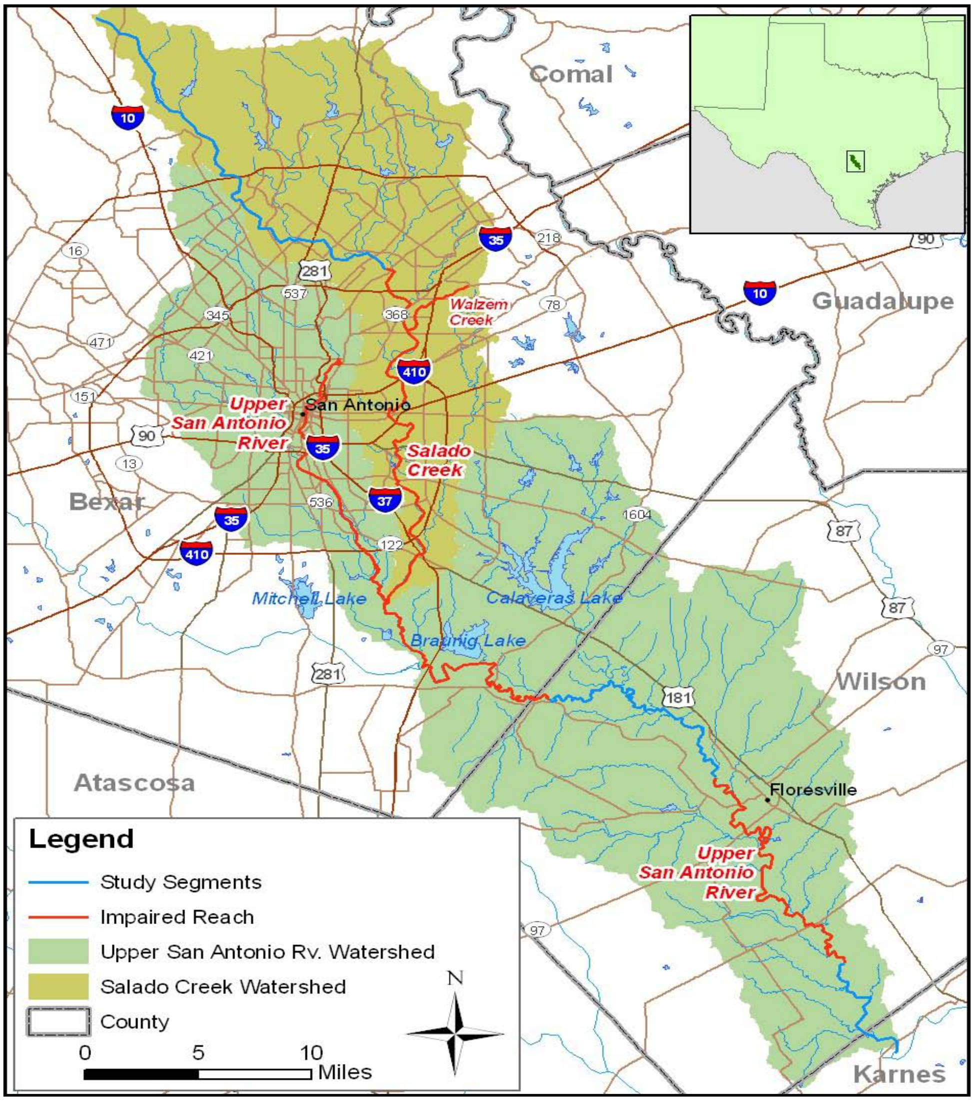

Figure 1: TMDL Watersheds

Aquifer is designated for aquifer protection use. As an unclassified intermittent stream, Walzem Creek has presumed uses for contact recreation and limited aquatic life.

Description of Watershed

The three impaired streams addressed by this study are located inside and around the greater San Antonio area. Salado Creek, located in Bexar County, is approximately 45 miles long with a drainage area of 223 square miles. Walzem Creek, located inside the Salado Creek watershed, is approximately 3.1 miles long and drains 2.8 square miles. The USAR, located in Bexar and Wilson Counties, is approximately 85 miles long, and is joined by two major tributaries—Salado Creek and the Medina River. The drainage area specific to the USAR, excluding the Salado Creek watershed, is approximately 530 square miles. The southern half of the USAR watershed is located in the largely rural Wilson County, downstream of the City of San Antonio (Figure 1).

Climate

The Gulf of Mexico is the principal source of moisture that drives precipitation in the study area. The amount of precipitation is influenced by the distance from the Gulf of Mexico and by topography. The study area is located primarily within the Edwards Plateau climatic division, though the lower portion of the San Antonio River basin is located within the south central plains province.

As with the rest of the interior of the state, maximum precipitation periods are typically late spring (May) and early autumn (September). Winter and summer periods typically have low precipitation. The maximum precipitation period in May is driven by the buildup of water vapor from the Gulf of Mexico carried by the prevailing winds from the south. Springtime precipitation is caused by late season cold air migrations, warm season thunderstorms, and spring low-pressure troughs. In September, cold air converges with moisture-laden southerly winds and late season convective thunderstorms drive the precipitation. It is also 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. For the 30-year period of 1970–2000, the annual rainfall in the study area, as measured in San Antonio, has ranged from 30.2 to 35.5 inches. The average annual rainfall for this period was 32.2 inches.

Economy

Bexar County

Bexar County covers 1,247 square miles, and has an estimated population in 2005 of 1,518,370. The population has increased by about 28 percent since 1990. Approximately 90 percent of the population lives in urban areas. The largest urban area, by far, is the City of San Antonio, with a population of 1,256,506 (TAC 2006). The county's economy includes agribusiness, tourism, oil production, manufacturing, construction, and professional services (TSHA 2001).

Tourism is an important component of the economy and is the top provider of nongovernmental jobs in Bexar County. The tourist industry is a result of the county's historical background as a battleground during the Texas Revolution. In addition, there are two major theme parks located in the county (TSHA 2001).

Agribusiness is also an important component of the county economy. There are 2,385 farms in the county with an average size of 185 acres (USDA 2002). Total land area for farms decreased by 6 percent from 1997 to 2002, but farmland still accounts for about 55 percent of the county's total area. Cattle are the primary type of livestock raised in the county. Harvested crops account for only a small portion of the county's agribusiness, and just 17 percent of the total farmland. Most of the county's agricultural land is located outside of the TMDL study area.

Wilson County

Wilson County covers 807 square miles, and has an estimated population in 2005 of 37,529. The population has increased by about 66 percent since 1990. Approximately 32 percent of the population lives in urban areas. The largest urban area, by far, is the city of Floresville, with a population of 7,024 (TAC 2006). The county's economy includes agribusiness, oil and gas field services, and manufacturing (TSHA 2001).

Production of crude oil is an important component of the Wilson County economy. Oil was first discovered in 1941 and production has gradually grown. In 1990, 1,973,734 barrels of crude oil were produced (TSHA 2001). Agribusiness is also an important component of the economy. There are 2,157 farms in the county with an average size of 207 acres (USDA 2002). Total land area for farms decreased by 3 percent from 1997 to 2002, but farmland still accounts for 86 percent of the county's total area. Cattle are the primary type of livestock raised in the county. As in Bexar County, harvested cropland accounts for 17 percent of the county's total farmland.

Geology and Hydrogeology

The northwest corner of Bexar County is dominated by the Cretaceous-period limestone formations of the Edwards plateau. Moving southeast, through the rest of the study area, there are a series of progressively younger formations, dating primarily from the Tertiary Period. These formations vary considerably in composition and include materials such as chalk, clay, sand, and sandstone.

Groundwater in the area is primarily associated with the Edwards and Carrizo-Wilcox aquifer systems. The Edwards Aquifer outcrop (recharge zone) cuts across the northern portion of Bexar County, and its downdip zone dominates the central portion of the county. Water bearing layers in this aquifer range from 200 feet to 600 feet in thickness. The Carrizo-Wilcox Aquifer outcrop cuts across southern Bexar and northern Wilson County. This aquifer's downdip zone is dominant in the rest of Wilson County. The thickness of sand and gravel layers in the Carrizo-Wilcox aquifer range from less than 200 feet to 3,000 feet (Ashworth 1995).

Soils

Soil conditions vary throughout the study area based on geological and topographical characteristics. The northern portion of Bexar County consists of shallow to deep loamy soils. In the remainder of the study area, the soils are generally loamy with clayey subsoils (TSHA 2001).

Land Use

The San Antonio metropolitan area dominates the northern portion of the USAR watershed and much of the Salado Creek watershed. The southern portion of the USAR watershed is dominated by farms and ranches.

Land use characterization for the TMDL study watersheds (Figure 2) was based on the most recent National Land Cover Data (NLCD) developed by the U.S. Geological Survey (USGS 1992). Where possible, the NLCD data were updated with more recent zoning and parcel data. Based on these data, the Salado Creek watershed is 36.5 percent developed (commercial, industrial, and residential). Above the confluence with Salado Creek, the

USAR watershed is 85.5 percent developed, and below the confluence it is 3.7 percent developed. Undeveloped lands in the northwestern portion of the study area are primarily forest; to the southeast, undeveloped lands are primarily agricultural (range and cropland).

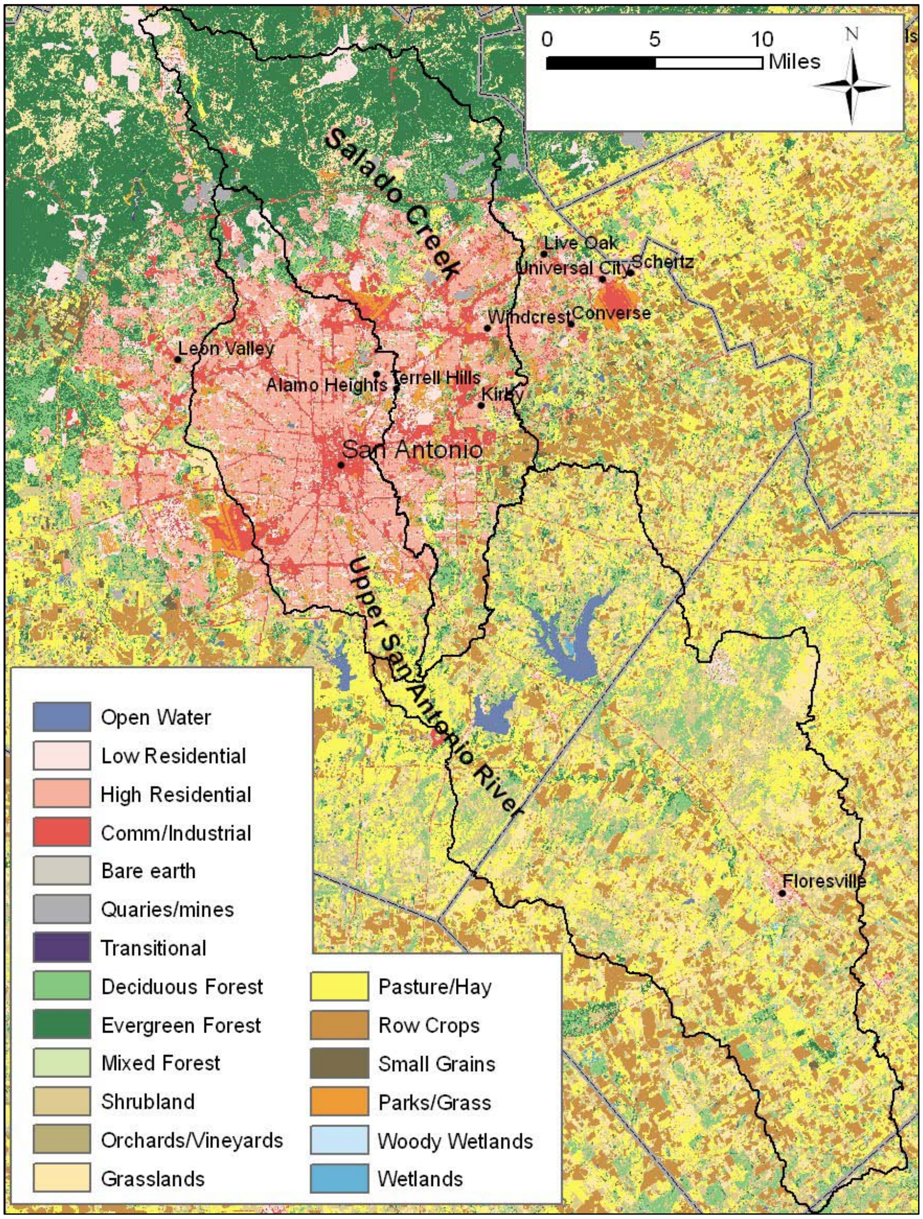

Figure 2: 1992 USGS Land Cover Data for Study Area

Data Used in the Assessment

The data used to assess sources affecting the impaired segments 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 were used in the development of these TMDLs. 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.
- 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 San Antonio River Authority (SARA) is responsible for coordinating the Clean Rivers Program monitoring activities in the San Antonio River Basin for inclusion in the TCEQ's Surface Water Quality Monitoring (SWQM) program database. The TCEQ and the USGS have also conducted water quality monitoring in the basin. Figures 3a and 3b show the locations, names, and numbers for stations at which significant bacteria sampling occurred throughout the period 1997–2004.

Water Quality Data

Review of the available water quality data reinforced earlier assessments, which concluded that the three impaired segments contain elevated levels of bacteria. Tables 1 and 2 summarize the data collected on Salado Creek (including Walzem Creek) and USAR, respectively. The tables include the number of routine samples collected, the number of samples that exceeded the grab sample criterion, and the geometric mean of the sampled concentrations. Figures 4, 5, 6, and 7 show monitoring results for select stations at which more than 10 samples were collected for *E. coli* and fecal coliform. The figures include the geometric mean, the upper quartile (or 75th percentile), and the lower quartile (or 25th percentile) of samples at each station.

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 Salado Creek, continuous streamflow records are available at two monitoring stations. USGS station #08178700 is located at Loop 410 NE at the upper end of the study segment. USGS #08178800 is located at Loop 13 near the lower end. The station at Loop 13 was used for hydraulic calibration of the Salado Creek model.

For the USAR, there were several streamflow-gauging stations available. The key stations selected for determining hydraulic calibration were USGS #08178050 at Mitchell Street,

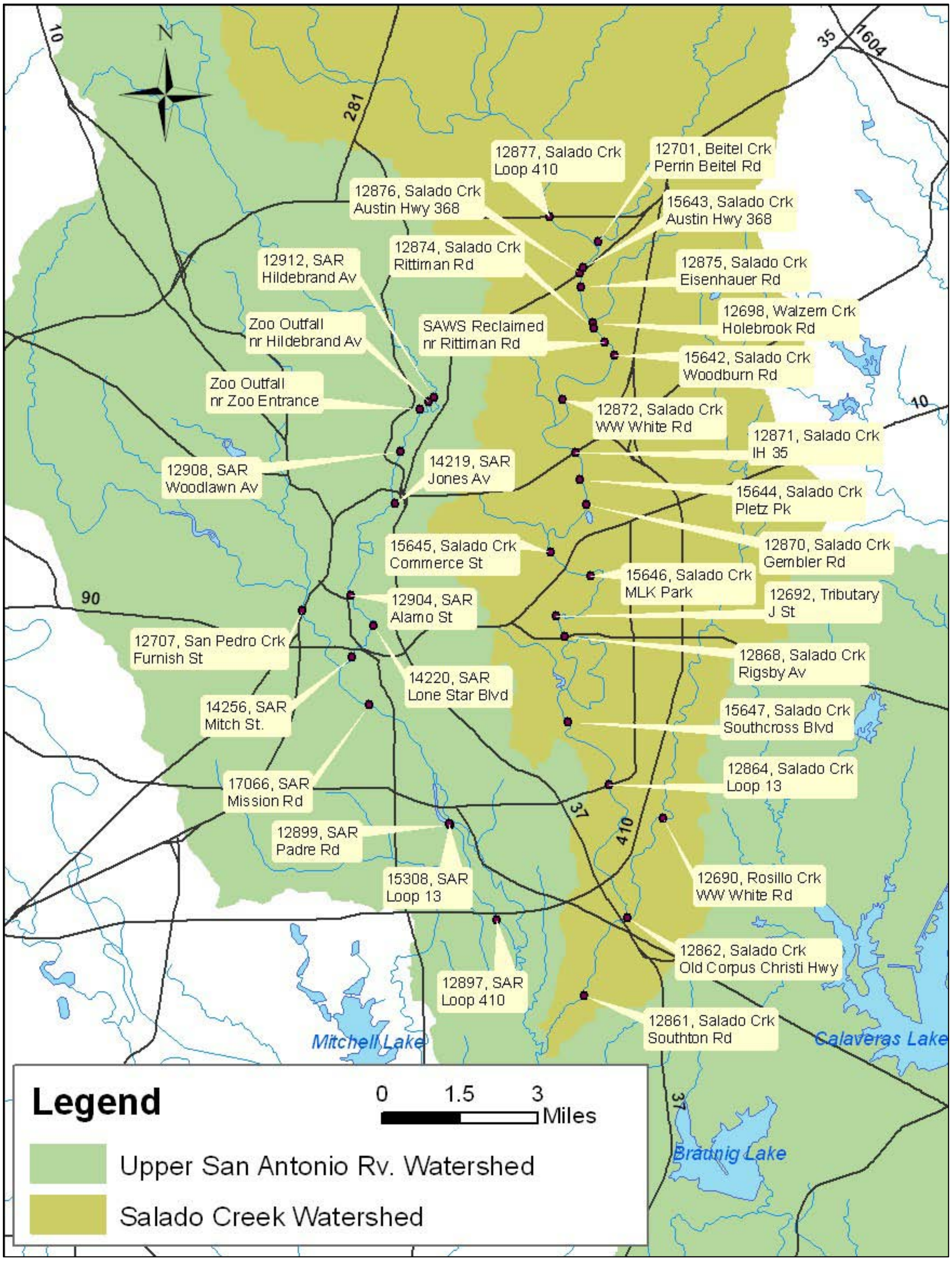

Figure 3a: Sampling Stations – Salado Creek and Northern Portion of USAR

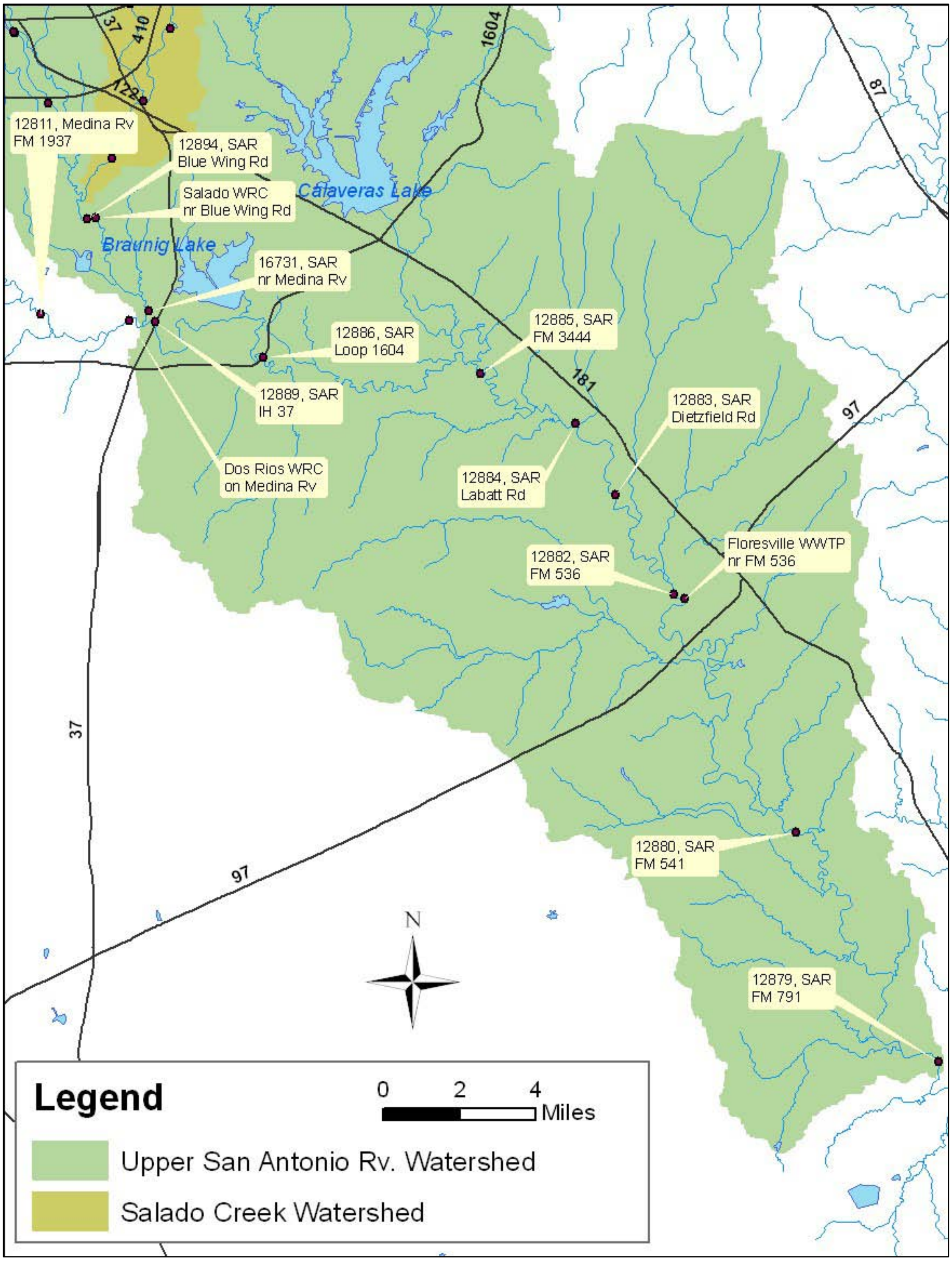

Figure 3b: Sampling Stations, Southern Portion of USAR

USGS #08178565 located at Loop 410 South, and USGS #08183500 located near Falls City. These three stations represent locations just below San Antonio's downtown business district, just below the city's southern limits, and at the downstream end of the segment, respectively.

Precipitation data were available for meteorological stations at the San Antonio International Airport (SAIA), Sea World, and Floresville. The SAIA gage, located inside the Salado Creek watershed, was used in the Salado Creek model. For the northern portion of

Table 1: Bacteria Data Collected on Salado Creek, (1997-2004)

Station	Stream	Location	Fecal Coliform Routine			*E. coli* Routine		
			# Samples	# Exceed	Geo Mean (org/ 100 mL)	# Samples	# Exceed	Geo Mean (org/ 100 mL)
12877	Salado Crk	Loop 410	10	4	249	13	5	105
15643	Salado Crk	Austin Hwy	60	29	439	58	14	225
12876	Salado Crk	Austin Hwy	8	8	3385	10	7	992
12875	Salado Crk	Eisenhauer Rd	66	26	266	64	13	138
12698	Walzem Crk	Holbrook Rd	68	50	815	68	26	263
12874	Salado Crk	Rittiman Rd	20	8	466	20	4	180
15642	Salado Crk	Woodburn Rd	62	30	509	62	16	200
12872	Salado Crk	WW White Rd	78	17	187	73	11	111
12871	Salado Crk	IH 35	62	14	204	62	9	104
15644	Salado Crk	Pletz Pk	60	22	269	59	12	143
12870	Salado Crk	Gembler Rd	40	12	255	40	8	129
15645	Salado Crk	Commerce St	65	31	388	65	11	159
15646	Salado Crk	MLK Pk	104	52	449	99	31	220
12868	Salado Crk	Rigsby Ave	75	33	427	73	24	193
15647	Salado Crk	E Southcross	60	19	311	58	9	159
12864	Salado Crk	Loop 13	80	30	366	79	16	189
12690	Rosillo Crk	WW White Rd	5	4	689	5	4	568
12862	Salado Crk	Old Corpus Rd	144	31	186	139	20	117
12861	Salado Crk	Southton Rd	13	5	258	13	3	153

the USAR, a synthesized precipitation record was developed from the SAIA and Sea World gages. The Floresville gage was used for the southern portion of the USAR model (below the confluence with Salado Creek).

Table 2: Bacteria Data Collected on USAR, (1997-2004)

Station	Stream	Location	Fecal Coliform Routine			*E. coli* Routine		
			# Samples	# Exceed	Geo Mean (org/100 mL)	# Samples	# Exceed	Geo Mean (org/100100 mL)
12912	SAR	Hildebrand Ave	18	8	486	13	4	184
12908	SAR	Woodlawn Ave	28	22	1068	28	18	500
14219	SAR	Jones Rd	3	2	474	5	2	407
12904	SAR	Alamo St	23	13	518	11	2	181
14220	SAR	Lone Star Blvd	4	4	779	-	-	-
14256	SAR	Mitchell St	44	30	577	46	16	329
17066	SAR	Mission Rd	26	15	693	26	7	348
15308	SAR	Loop 13	4	1	297	6	2	234
12899	SAR	Padre Rd	7	3	222	-	-	-
12897	SAR	IH 410	39	12	217	31	7	117
12894	SAR	Blue Wing Rd	29	13	485	23	6	214
16731	SAR	above Medina Rv	37	9	228	37	6	104
12889	SAR	IH 37	27	7	155	23	6	93
12886	SAR	Loop 1604	21	6	237	16	2	126
12885	SAR	FM 3444	7	1	138	-	-	-
12884	SAR	Labatt Rd	15	4	170	8	1	151
12883	SAR	Dietz Rd	29	6	196	24	3	116
12882	SAR	FM 536	19	5	214	12	3	191
12880	SAR	FM 541	22	6	225	17	5	141
12879	SAR	FM 791	91	14	149	84	7	100

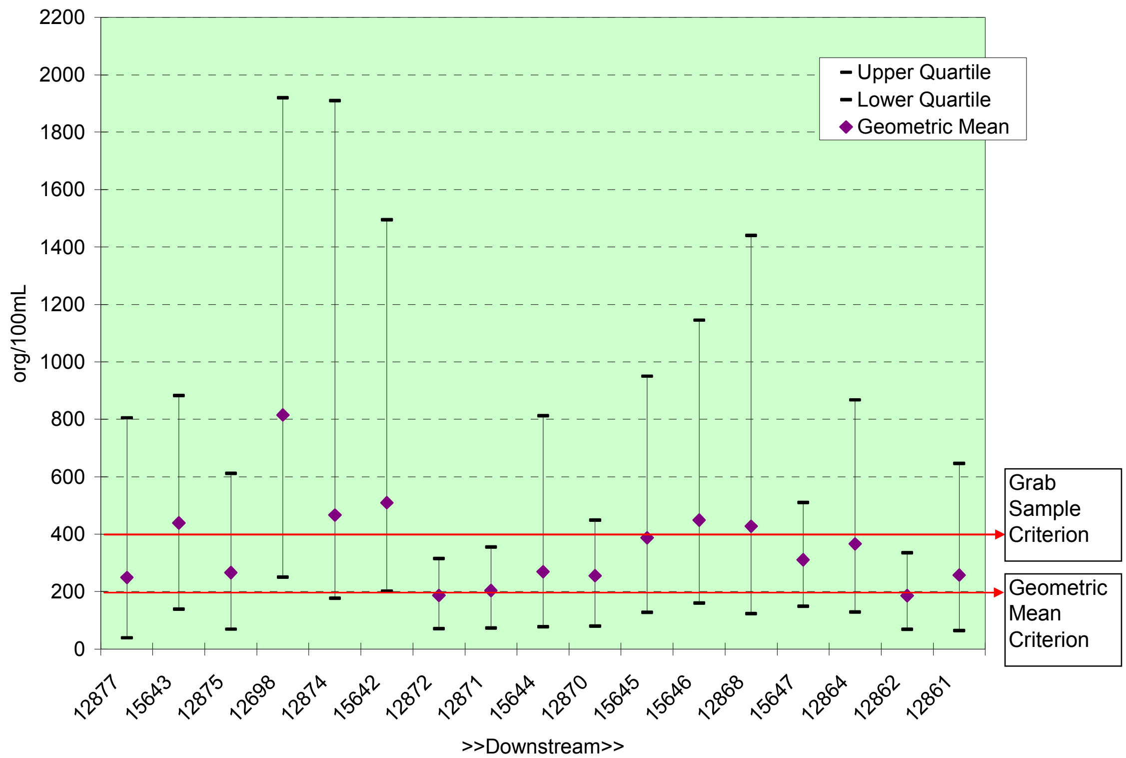

Figure 4: Fecal Coliform Sampling Results, Salado Creek

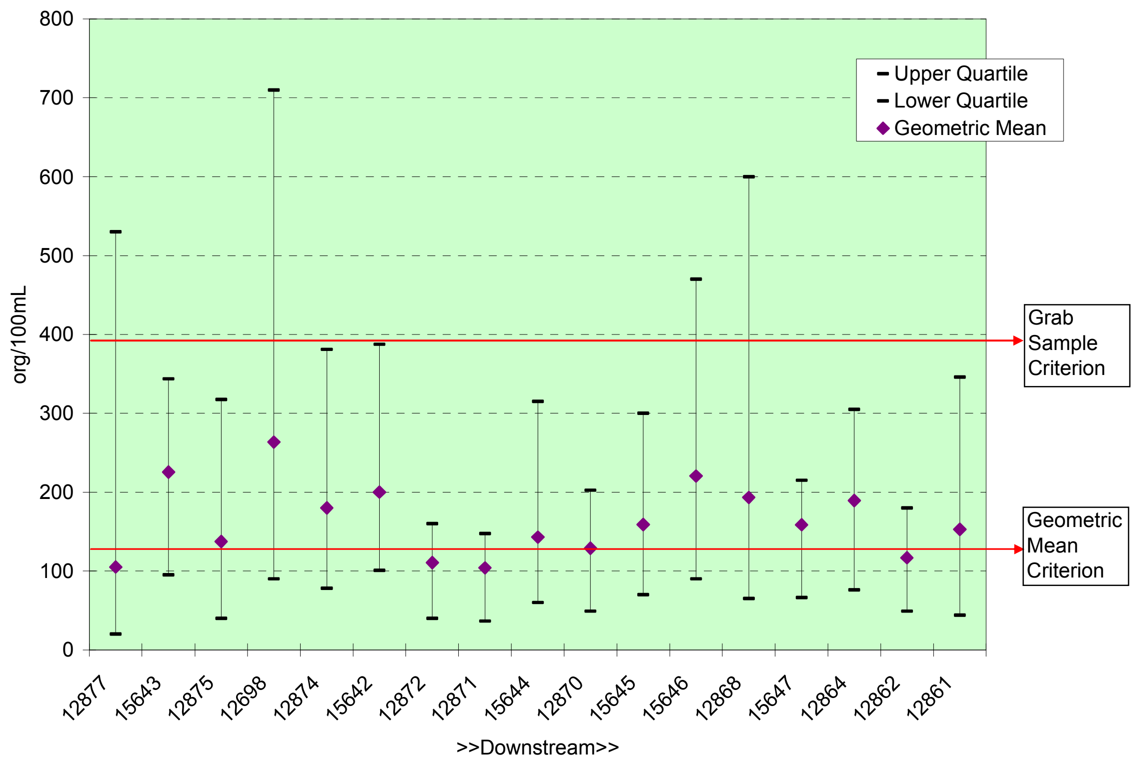

Figure 5: *E. Coli* Sampling Results, Salado Creek

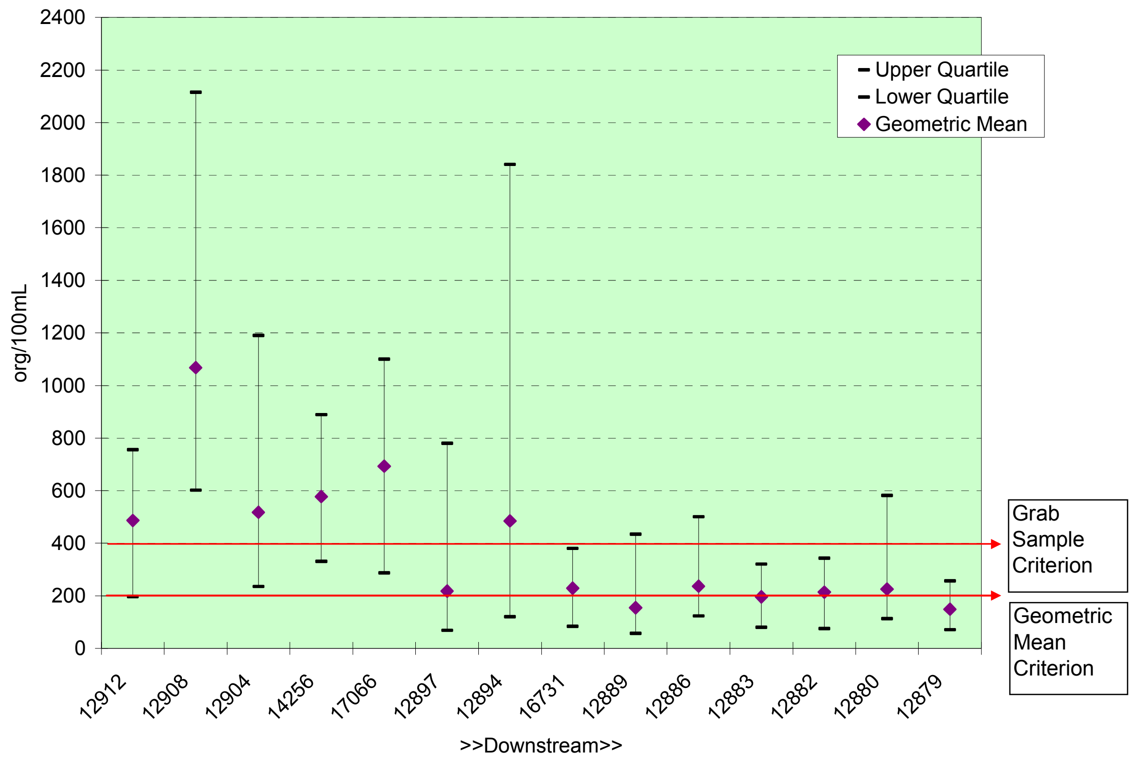

Figure 6: Fecal Coliform Sampling Results, USAR

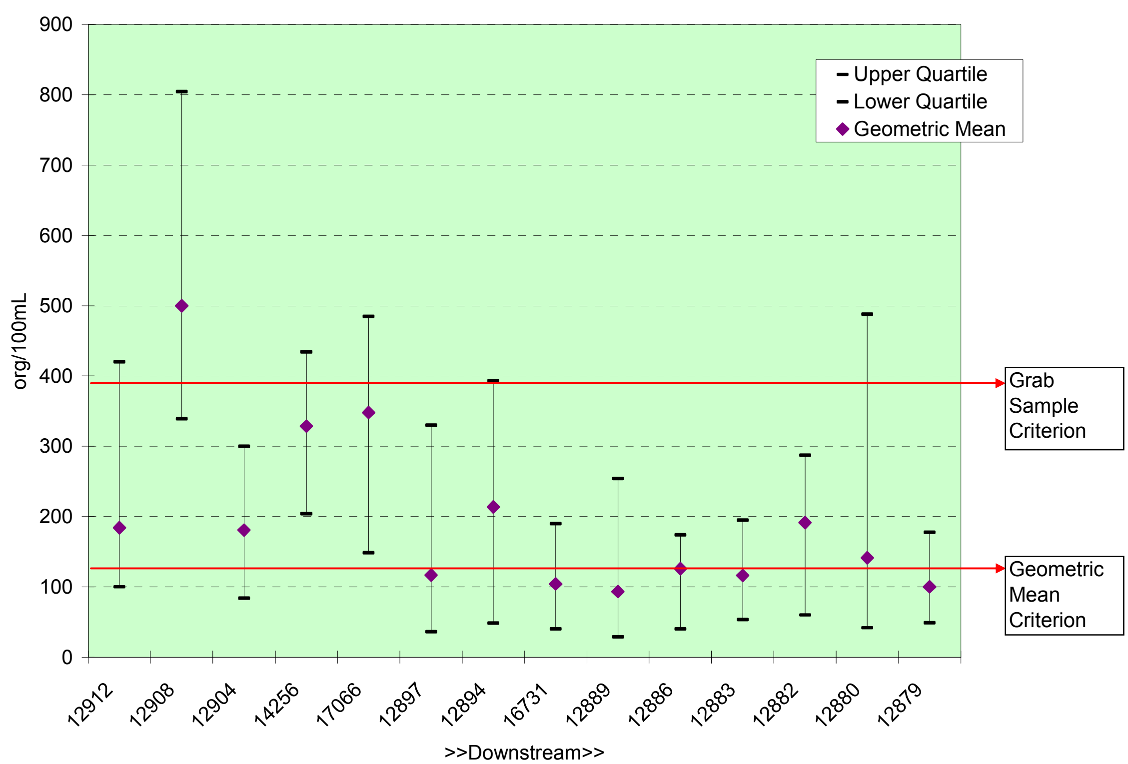

Figure 7: *E. Coli* Sampling Results, USAR

Critical Conditions

Federal law (40 CFR 130.7(c)(1)) requires that TMDLs 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 it is most vulnerable. The critical condition is considered the "worst case scenario" of environmental conditions for a particular study segment. If the TMDL is developed so that the water quality targets are met under critical conditions, then the water quality targets are very likely to be met under all other conditions.

Bacteria data for the impaired segments were analyzed for seasonal and climatic trends. In general, there were no consistent seasonal trends in the watershed. However, bacteria concentrations were found to vary significantly based on climatic conditions and were highest under runoff conditions. Therefore, periods of frequent rainfall correlated 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 they were collected during periods of rising or rapidly receding flow. The results of this analysis are presented in Tables 3 and 4. The analysis was important for calibrating the water quality model, as well as for determining critical conditions. The analysis included fecal coliform samples, and *E. coli* samples that were converted to fecal coliform using standard multipliers.

Table 3: Hydrologic Classification of Historical Data, Salado Creek

Station	Baseflow Data		Runoff Data	
	# of Observed Data	Median of Observed Data (fecal org/100 mL)	# of Observed Data	Median of Observed Data (fecal org/100 mL)
Loop 410 - RCH 49	8	44	17	7500
SH 368 - RCH 52	39	170	21	1310
Walzem Creek - RCH 15	47	500	23	2840
Woodburn - RCH 53	40	248	26	2180
Commerce - RCH 57	42	148	27	1420
Rigsby - RCH 72	43	190	28	1760
Loop 13 - RCH 74	53	176	28	1325

Seasonal Variation

Exceedances occurred throughout the impaired segments regardless of season. Data was collected throughout various seasons. The water quality model accounts for seasonal effects by including temporal variations in climatic patterns, groundwater releases, 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.

Table 4: Hydrologic Classification of Historical Data, USAR

Station	Baseflow Data		Runoff Data	
	# of Observed Data	Median of Observed Data (fecal org/100 mL)	# of Observed Data	Median of Observed Data (fecal org/100 mL)
Woodlawn - RCH 62	11	820	4	4850
Mitchell - RCH 67	32	470	22	8130
Loop 410 - RCH 71	24	93	7	1140
IH 37 - RCH 78	21	90	5	1709
1604 - RCH 25	10	76	4	1010
FM 791 - RCH 28	36	95	6	1025

Source Analysis

Pollutants may come from several sources, both point and nonpoint. Point source pollutants come from a single definable point, such as a pipe, and are regulated by permit under the Texas Pollutant Discharge Elimination System (TPDES). Storm water discharges from industries, construction, and the separate storm sewer systems of cities are considered point sources of pollution. Nonpoint source pollution originates from multiple locations, usually carried to surface waters by rainfall runoff, and is not regulated by permit under the TPDES. The possible sources of bacteria in the impaired segments are discussed in this section.

Point Sources

Bacteria loading in urban storm water originates from nonpoint sources. When storm water flows into a municipal separate storm sewer system (MS4), it is then considered a point source discharge and is subject to a TPDES permit. Collective discharges from the storm sewer systems of large cities are typically considered point sources and are regulated under MS4 permits. The City of San Antonio is required to operate under such a permit, making virtually all urban runoff part of the point source load. Point sources related and unrelated to storm water are discussed in further detail in the following two sections.

Point Sources Other Than Storm Water

Point sources, such as municipal wastewater treatment facilities (WWTFs), can contribute fecal coliform bacteria loads to surface water streams through effluent discharges. These point sources are permitted through the TPDES program managed by the TCEQ. There are several point sources located in the study watersheds that may contribute fecal coliform. These point sources are shown in Table 5, in upstream to downstream order. There may be other permitted discharges in the study area that were not included in the present analysis because of a very low likelihood that they would discharge fecal coliform bacteria. Such sources might include industrial wastewater dischargers, quarries, or facilities that operate with no-discharge permits.

In the Salado Creek watershed, there are no point sources that have a high potential for discharging bacteria. There is one discharger of reclaimed municipal effluent in the upper portion of the study area—the San Antonio Water System (SAWS) Outfall 4 in James Park. SAWS is required to maintain a chlorine disinfectant residual in releases from this distribution system, which results in very minimal bacteria concentrations. TCEQ criteria for Type I Reclaimed water require that fecal coliform concentrations do not exceed:

- 20 cfu/100 mL as a geometric mean
- 75 cfu/100 mL in single grab samples

Compliance with these criteria has been confirmed by historical monitoring data.

Table 5: Point Sources Other Than Storm Water

Point Source Description	Location
Upper San Antonio River	
SAWS Reclaimed Water Outfall #2	Breckenridge Park, near Tuleta Drive
San Antonio Zoo	Breckenridge Park, near Tuleta Drive
SAWS Reclaimed Water Outfall #3	Josephine St, near tunnel entrance
SAWS Salado Water Recycling Center	near Blue Wing Road, below Loop 410
SAWS Dos Rios Water Recycling Center	on Medina River, near confluence with SAR
Floresville WWTF	City of Floresville, near FM 536
Salado Creek	
SAWS Reclaimed Water Outfall #4	James Park, near Rittiman Road

There are several point sources in the USAR watershed. However, most of these point sources are permitted, and are required to achieve disinfection prior to discharge. There are two outfalls of reclaimed municipal effluent located in the upper portion of the watershed. A third potential outfall of reclaimed water is located near the Convention Center on the River Walk, but it has only recently been activated, and is therefore not included in this study.

Near the southern portion of the City of San Antonio, there are two municipal WWTFs—the Dos Rios and Salado facilities operated by SAWS, which have been in operation for a number of years. In the lower portion of the study segment, the Floresville WWTF discharges treated municipal effluent.

There is one facility in the USAR watershed without a permit that discharges substantial concentrations of bacteria. Representing one of the more significant existing loadings to the river, the San Antonio Zoo has an interior waterway, fed by groundwater from the Edwards Aquifer, which passes through numerous animal exhibits. This waterway has one primary and one secondary outfall, both of which discharge directly to the San Antonio River. The discharge flow rate (averaging 1700 gallons per minute) was characterized using data reported annually to the Edwards Aquifer Authority. Bacteria concentrations in the discharge were characterized using available grab sampling data from several sources, including recent sampling provided by SAWS and SARA. The average concentration leaving the Zoo was 23,100 org/100 mL from March through September 2005, and 11,800 org/100 mL from October 2005 through February 2006.

Storm Water

Much of the study area is comprised of the urban landscape of residential, commercial, and industrial areas. Storm water from urban areas is considered a point source and is regulated under TPDES permits. Bacteria from various sources build up on the land's surface and are washed off into a city's storm water system during rainfall events. These bacteria loadings may be derived from urban wildlife, pets, septic system failures, sewer system leaks, discharges of varied nature and composition, and other sources that may be present.

Nonpoint Sources

Nonpoint source (NPS) loadings enter the impaired segments from distributed, non-specific locations and are not typically regulated by permit. Nonpoint sources generally include background loads (birds and wildlife), failing septic systems, animal deposition (pets), and leaking wastewater infrastructure. Each of these sources can contribute pollutants to the stream directly or indirectly. For example, an animal may defecate over the land's surface and the resulting bacteria are available for washoff by storm water; alternatively, the animal may stand in the stream and defecate directly into the receiving water body. Figure 8 illustrates methods of nonpoint source loading.

Failing Septic Systems

Private residential sewage treatment systems (or septic systems) typically consist of one or more septic tanks and a drainage or distribution field. A septic system failure can occur in many ways. For example, drainfield failures, broken pipes, or overloading can result in uncontrolled, direct discharges to streams. Such failures would not be expected to be common in the study watershed, but they could occur in reaches with older homes located near a watercourse or in remote, undetected areas. In addition, effluent can surface from an overloaded drainfield, 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 US 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

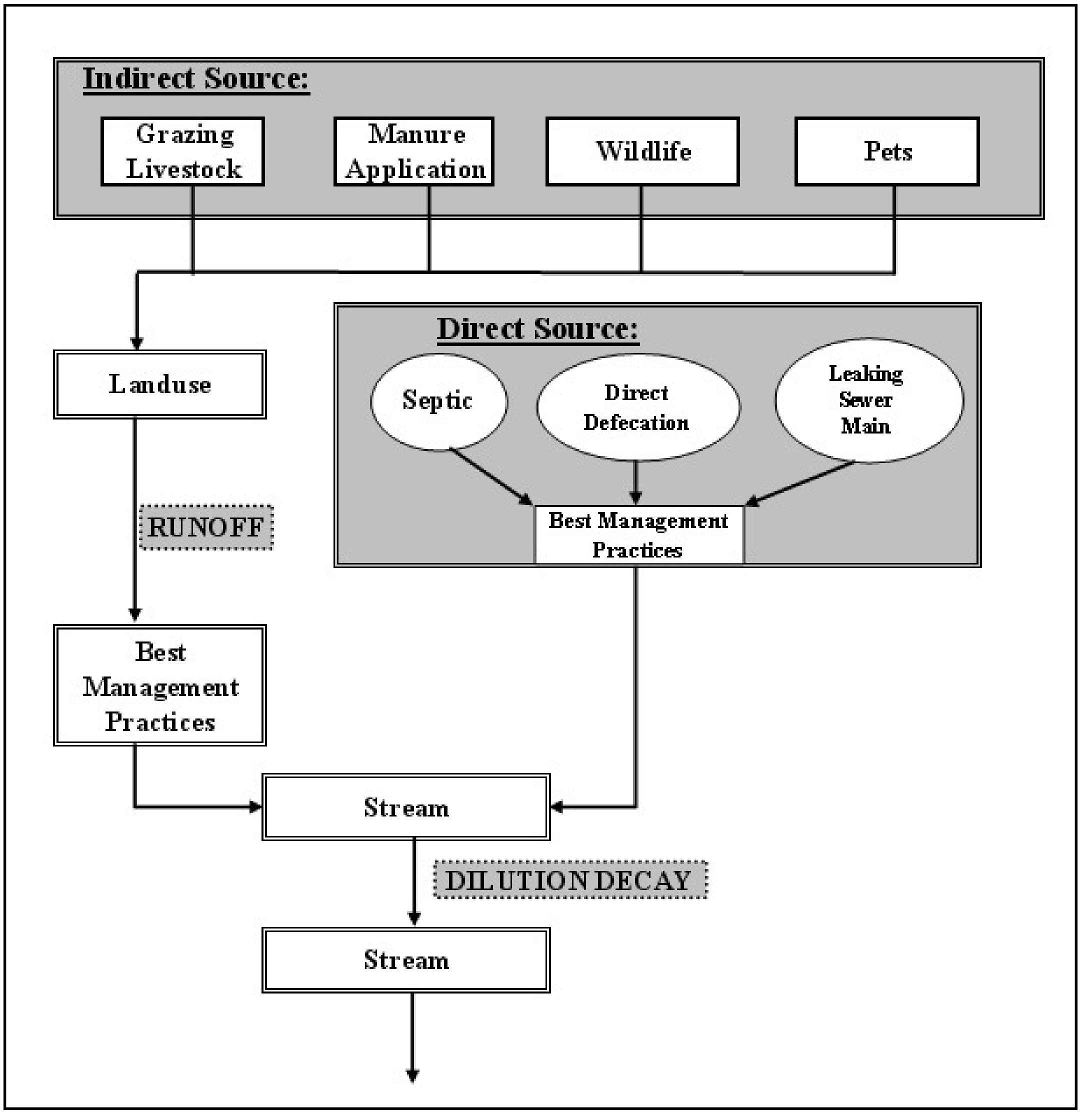

Figure 8: Methods of Nonpoint Source Loading

by intersecting the census tracts with the study area watersheds. Table 6 shows the number of septic systems in the study areas, along with the number of sewer connections and "other" types of disposal. From 1990 to 2000, the population of Bexar County grew by 17 percent and the population of Wilson County grew by 43 percent. Based on these growth rates, the number of septic systems in 2000 has been estimated at 8,910 for the USAR watershed, and 5,960 for the Salado Creek Watershed.

Table 6: Household Sewage Disposal Methods from 1990 US Census

Watershed	Septic	Sewer	Other
Salado Creek	5,094	116,662	197
USAR	7,237	208,228	874

Leaking Wastewater Infrastructure

Leaking wastewater sewer lines are difficult to detect but are potentially significant sources of bacteria, especially in highly urbanized areas where most residences are served by a central 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 are parallel. Also, sewers will typically leak if they become cracked or are improperly installed.

Livestock

Livestock population estimates for Bexar County and Wilson County were based on the 2002 Agricultural Census (USDA 2002). The types of livestock explicitly included in the present analysis included cattle, horses/donkeys, sheep/goats, and hogs. Animal population estimates are presented in Table 7. Other types of livestock had small populations compared to the major livestock species listed above; therefore, the fecal loads from these other animal groups were assumed to be negligible.

Fecal coliform bacteria production rates for livestock in the Salado Creek and Upper San Antonio River watersheds 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 the literature (EPA 2001).

Table 7: Livestock Population Estimates

Region	Cattle	Hogs	Sheep	Horses
Salado Creek	8,214	556	1,746	459
USAR	15,769	697	871	479

Table 8: Fecal Coliform Production Rates for Livestock and Wildlife

Animal	Fecal Coliform (10^9 org/day) (count/animal/day)	Animal	Fecal Coliform (10^9 org/day) (count/animal/day)
Dairy Cow	101	Turkey	0.01
Beef Cow	104	Duck	2.43
Hog	11	Opossums	0.01
Sheep	12	Deer	1
Horse	0.42	Feral Hogs	11
Chicken	0.14	Raccoon	0.13

Wildlife

Representative species of wildlife and non-indigenous pests (like feral hogs) were included in the modeling analysis as potential sources of bacteria. Of course, there are numerous other species of animals that 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. Duck habitat was based on a 300-foot riparian corridor. Habitat for other animals was based on the acreage of undeveloped land. The estimated wildlife inventory is shown in Table 9.

Table 9: Inventory of Wildlife

Region	Ducks	Deer	Raccoons	Opossums	Feral Hogs
Salado Creek	2,220	7,581	5,655	22,622	505
USAR	1,800	2,283	16,226	64,903	7,610

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.

Linkage Analysis

Establishing the relationship between instream water quality targets 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 a TMDL for Salado Creek and the USAR, 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 source 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 instream water quality response in the Salado Creek and USAR watersheds, 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 observed in-stream fecal coliform measurements with the simulated model results. 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. For Salado Creek, these loads are compared graphically in Figure 9. It is apparent that the largest presumed source of fecal coliform bacteria originates in washoff from developed areas, making up about 93.9 percent of the average annual load. This is attributable to the fact that the Salado Creek Basin is highly developed. Typically, developed areas have higher runoff volumes and bacteria concentrations than undeveloped areas. However, runoff conditions are not persistent. Under baseflow, dry-weather conditions, direct nonpoint sources are the most significant load in the watershed. Although direct sources account for only about 2.44 percent of the annual average load, they have a disproportionately large effect on mean stream concentrations because they occur when there is less flow available for load dilution.

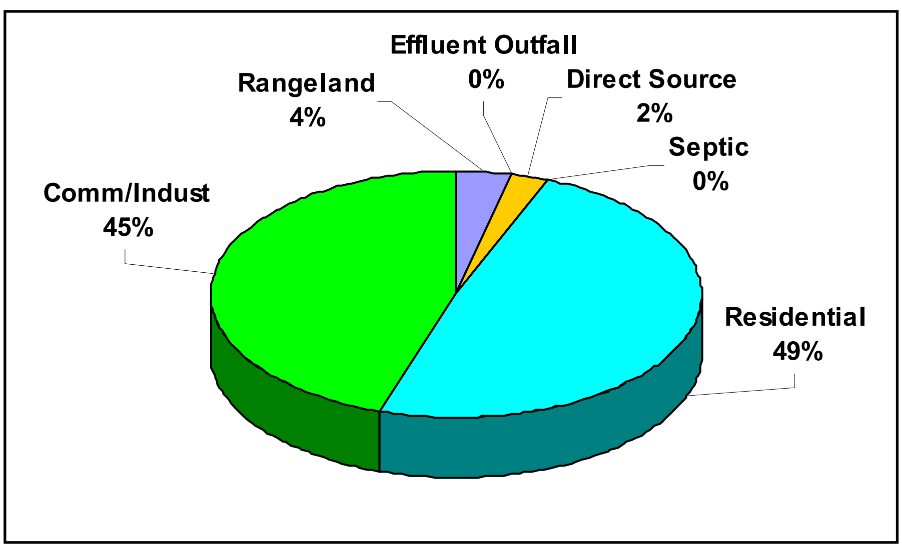

Figure 9: Comparison of Fecal Coliform Sources for Salado Creek

For the USAR, the bacterial loads associated with the model calibration are compared graphically in Figure 10. As with Salado Creek, in the USAR, it is apparent that the largest presumed source of fecal coliform bacteria is runoff from developed urban areas. The combined commercial, industrial, and residential loads account for about 68.1 percent of the average annual load. The second largest bacterial source is the inflow from springs and streams, at about 19.4 percent of the annual load. In reality, springs account for an almost insignificant portion of this load, while loads from Salado Creek and the Medina River dominate this source category. Under baseflow conditions, the primary sources of loading are effluent outfalls at 4.3 percent and direct sources at 2.92 percent. The effluent outfall category is dominated by the load from the City Zoo.

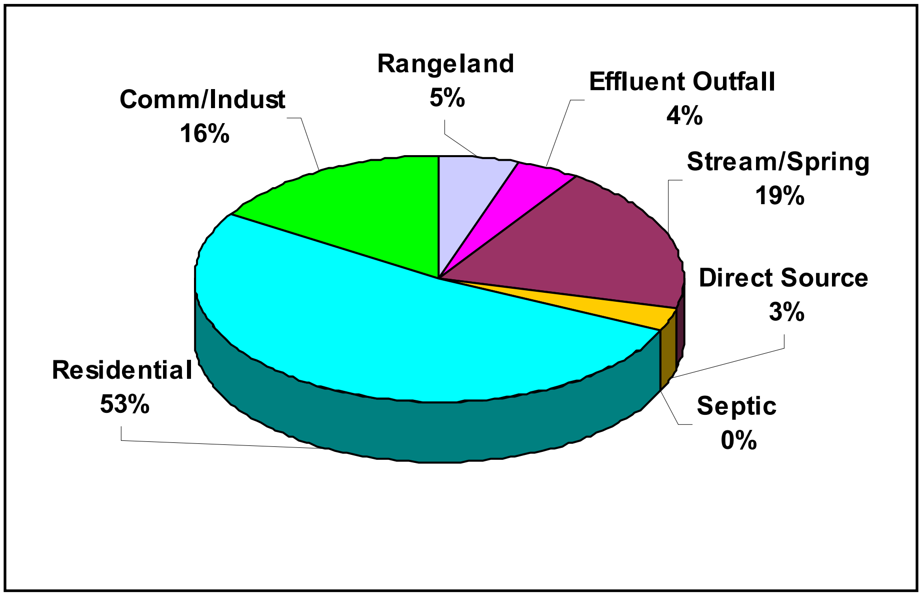

Figure 10: Comparison of Fecal Coliform Sources for the USAR

Margin of Safety

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

- 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.

The TMDL target was established as a fecal coliform geometric mean value of 200 org/100 mL, based on the bacteria criterion specified in the *Texas Surface Water Quality Standards*. An explicit MOS of five percent was employed in the TMDL calculations, or 10 org/100 mL. Application of the model to the TMDL determination was therefore based on achieving an instream geometric mean of 190 org/100 mL. In addition to the explicit MOS, implicit MOS factors were incorporated into the TMDL development process through the use of conservative model assumptions and estimates of source loads.

Pollutant Load Allocation

TMDL Calculation

Total maximum daily loads (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 may be expressed as:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

The TMDL defines the total amount of a pollutant that the receiving water body can assimilate and still support water quality standards. For fecal coliform bacteria, TMDLs are expressed in terms of bacteria counts or resulting concentrations.

The WLA portion of this equation is the total loading assigned to point sources. For the purposes of TMDL development, the WLA includes WWTFs and permitted storm water systems. Inside the City of San Antonio, virtually all storm water runoff is regulated under the City's MS4 permit.

The LA portion of this equation represents the loading assigned to nonpoint sources, which would include storm water runoff not regulated by permit (from areas outside of the City of San Antonio), direct deposition from animals, failing septic systems, and leaking wastewater infrastructure. The MOS is the portion of the loading that is assigned to represent any uncertainty in the data and the modeling process. Therefore, for development of TMDLs in areas that have regulated storm water point sources, the TMDL equation presented above would be modified as follows:

$$TMDL = \Sigma WLA_{\text{non-storm water point sources}} + \Sigma\, WLA_{\text{regulated storm water point sources}} + \Sigma LA_{\text{unregulated storm water and nonpoint sources}} + MOS$$

Allocation Scenario Development

Multiple applications of the HSPF model were performed to develop load reduction scenarios capable of achieving compliance with geometric mean concentration of 190 org/100 mL of fecal coliform (criterion with MOS). Results are presented below for key gauged monitoring stations in the study reaches. Results for several additional locations are presented in the TMDL modeling report (JMA 2006). Minimal exceedances (less than 1 percent of time) of the geometric mean criterion were observed at a few stations in Salado Creek under the allocation scenario. However, based on the overall results, the segment was judged to attain the contact recreation use. In the implementation phase of the TMDL, the required load reductions can be targeted toward specific locations, as determined in the I-Plan.

For Salado and Walzem Creeks, it was determined that a 90 percent reduction in direct nonpoint source loads and a 60 percent reduction in washoff loads would achieve compliance with the criterion. These reductions are prescribed only for the portion of the Salado

Creek watershed below Loop 1604 (including Walzem Creek). Figure 11 shows geometric mean results for the period of simulation at Loop 13, with and without the prescribed loading reductions.

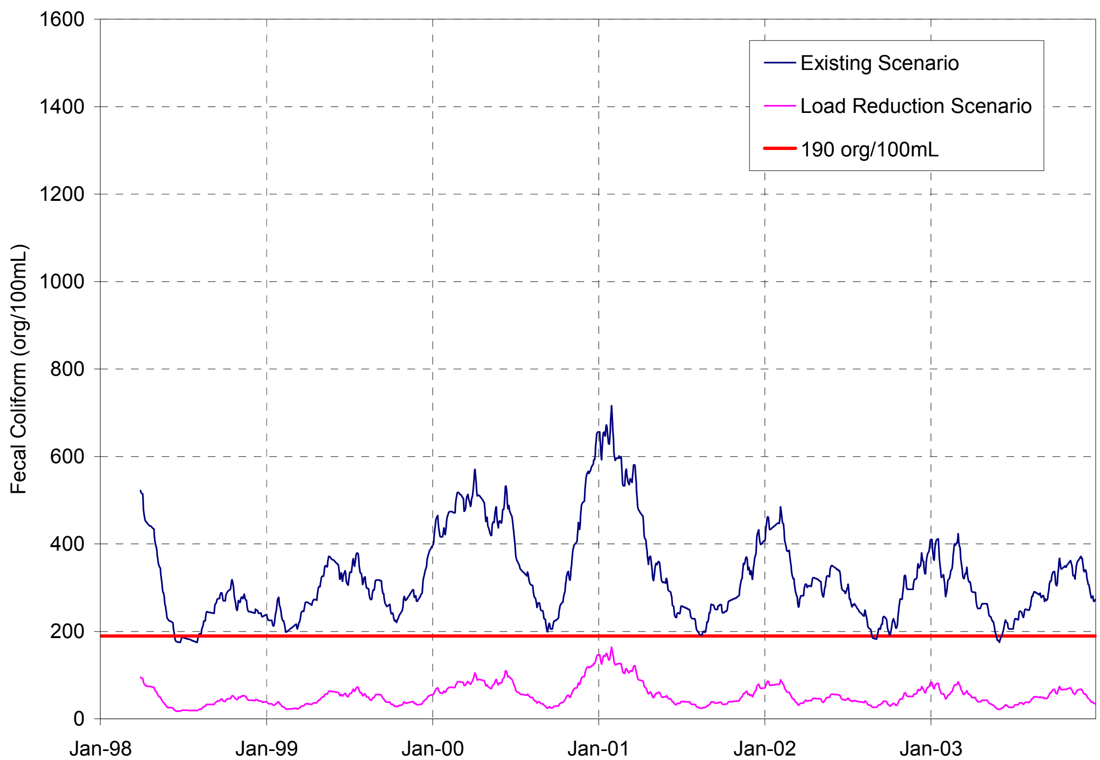

Figure 11: 91-Day Geometric Mean Results for Salado Creek at Loop 13

Multiple applications of the HSPF model were also performed in order to develop load reduction scenarios that would result in attainment of the standards in the USAR. In the final load reduction scenario, a 99.9 percent reduction (complete disinfection) of the Zoo's discharge is prescribed. In addition, a 50 percent reduction in direct nonpoint loads from all reaches and a 30 percent reduction in washoff loads from reaches above the confluence with Salado Creek would be required to meet the criterion. Figures 12 and 13 show the geometric mean results for the period of simulation and illustrate the prescribed loading reductions for the USAR at Mitchell and at FM 541.

Wasteload Allocations

Wasteload allocations are determined for point sources. For the purposes of TMDL development, these point sources include effluent discharges from permitted wastewater treatment facilities, permitted storm water runoff, and other point sources. Wasteload allocations are summarized in Table 10.

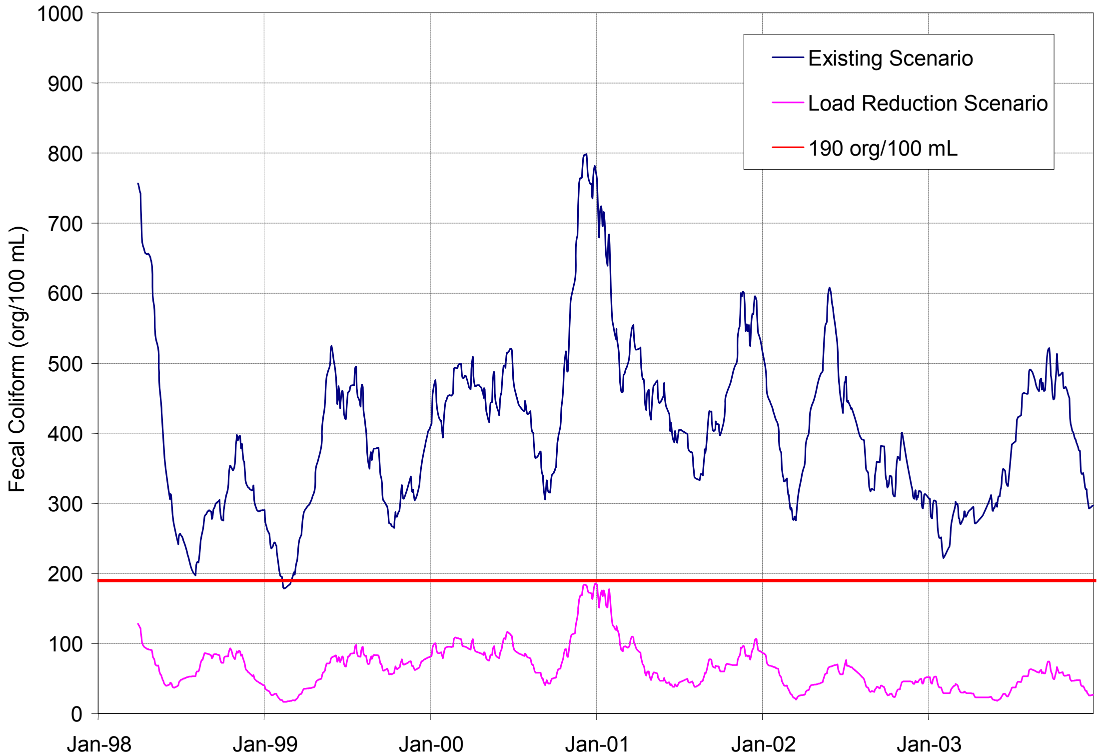

Figure 12: 91-Day Geometric Mean Results for USAR at Mitchell

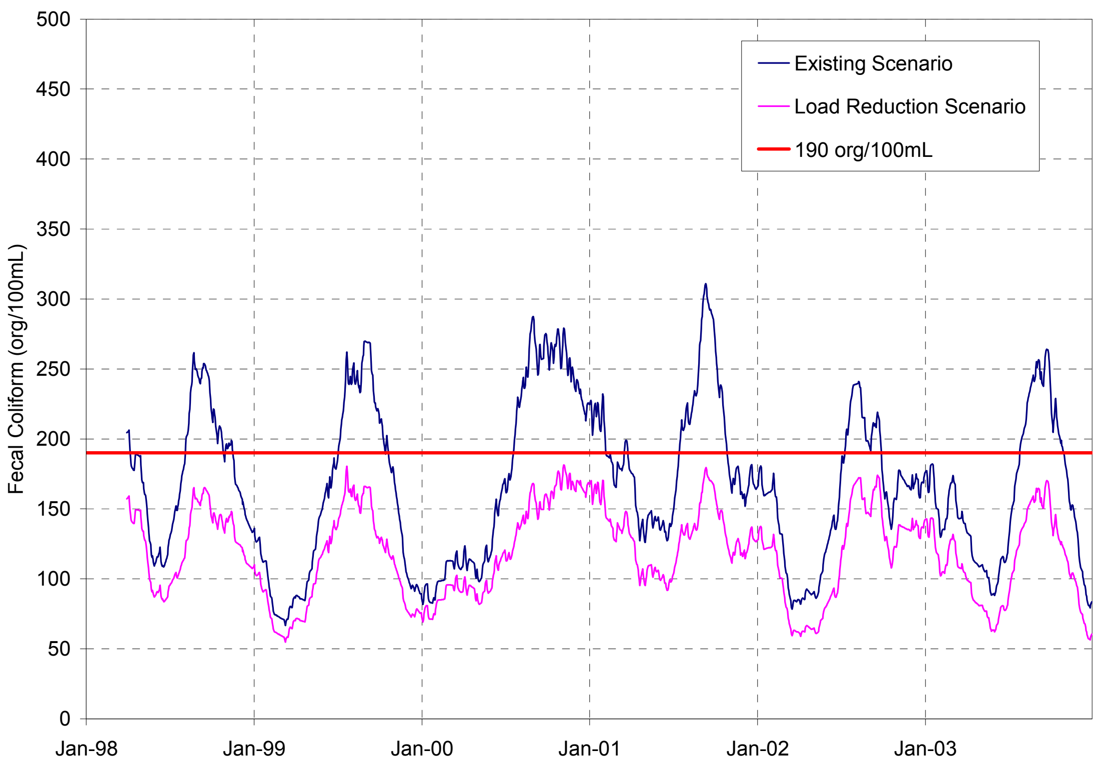

Figure 13: 91-Day Geometric Mean Results for USAR at FM 541

Salado and Walzem Creeks

For Salado and Walzem Creeks, the only significant point sources are the washoff loads from the City of San Antonio's MS4. These runoff-related loads require a 60 percent reduction. In addition, one relatively minor point source, the SAWS reclaimed water outfall #4, is located in James Park just below Rittiman Road. This discharger is required to maintain a disinfectant residual in its effluent. Therefore, the bacteria loading associated with the discharge is expected to be relatively low; this has been confirmed by historical monitoring data. Therefore, no reduction is required at this outfall.

Upper San Antonio River

As with Salado and Walzem Creek, the greatest point sources of bacteria in the USAR segment are the washoff loads from the City of San Antonio's storm sewer system (Central Zone). These runoff-related loads have been prescribed at a 30 percent reduction.

There are several municipal point sources in the watershed. Three of these outfalls are operated by SAWS. Since these outfalls are required to maintain a disinfectant residual, bacterial counts at these discharges would be expected to be relatively low; this was confirmed by available monitoring data. In the lower reaches of the study segment, there is a domestic WWTF operated by the City of Floresville. Assuming that permit effluent meets its disinfection requirements, bacterial loads should be relatively low at this location as well. Therefore, no reductions were required for municipal outfalls.

There is one other major point source in the upper reach of the San Antonio River for which a WLA reduction has been calculated. The San Antonio Zoo continually releases a large volume of water from interior water features that have high bacterial counts. The modeling analysis indicated that this point source discharge had a dramatic affect on bacterial counts in the study area under non-runoff conditions, as shown for station #12908, Woodlawn Avenue (Table 2). As a result, a substantial WLA reduction was prescribed in order to achieve the TMDL target. The calculated WLA for the zoo is based on achieving complete disinfection during baseflow conditions (99.9 percent bacteria removal).

Notably, the SAWS Dos Rios Water Recycling Center (WRC) is not included in Table 10 because it is located on the Medina River, not the USAR. This facility would be considered part of the upstream load from the Medina River, which is included as a Load Allocation. However, because the facility is required to achieve disinfection, bacteria loads are considered minimal.

Load Allocations

Load allocations for nonpoint sources generally include background loads, upstream loads, storm water runoff not subject to permit, septic loads, and other direct nonpoint sources such as direct animal deposition and leaking wastewater infrastructure. A summary of the recommended load allocations is presented in Table 11. In general, greater reductions were required in Salado and Walzem Creeks than in the USAR. This is generally a result of higher base flows in the USAR (from natural springs, zoo flows, and

SAWS reclaimed water outfalls). These higher base flows allow for more dilution of direct loads, and thus provide the USAR with a higher assimilative capacity.

Table 10: WLAs for Point Source Fecal Coliform Loads in Study Areas

Segment	Point Source	Existing Load (10^6 org/day)	Reduction %	WLA (10^6 org/day)
Salado Creek	San Antonio MS4	11,827,718	60%	4,731,088
	SAWS Reclaimed 4	19	0	19
	Subtotal	***11,827,740***		***4,731,107***
Walzem Creek	San Antonio MS4	331,611	60%	132,644
	Subtotal	**331,611**		**132,644**
USAR	San Antonio MS4	24,745,068	30%	17,321,548
	San Antonio Zoo	1,704,110	99.9%	1,704
	SAWS Salado WRC	7,562	0	7,562
	SAWS Reclaimed 2	175	0	175
	SAWS Reclaimed 3	19	0	19
	Floresville WWTF	19	0	19
	Subtotal	***26,456,953***		***17,331,027***

Salado and Walzem Creeks

For Salado Creek and Walzem Creek, a 90 percent reduction in direct nonpoint sources is required to achieve compliance with bacteria criteria, as shown in Table 11. The estimated loads from septic systems are relatively insignificant, as formulated in the modeling analysis, and have not been assigned a load allocation. However, it is possible that septic systems have been under-represented in the analysis and it could be surmised that a portion of the direct source reduction could be directed at septic loads.

The LA for Salado Creek and Walzem Creek is presented in Table 11. It includes only a portion of the bacteria available for washoff that make it to a stream. The TMDL presented in Table 12 is expressed as a gross load; it includes all quantifiable sources available for washoff in the watershed.

Upper San Antonio River

The required load reductions for the USAR are presented in Table 11. A 50 percent reduction in direct nonpoint sources is required for all reaches. No washoff reduction is required outside the Central Zone (MS4 permit area). In addition, a 60 percent reduction has been assigned to the load from Salado Creek. This reduction will be achieved if the loading reductions prescribed for the Salado Creek TMDL are achieved. Loads from the Medina River are also significant, but do not require reduction because these loads are the result of large flow volumes, not high bacteria concentrations, and it has been determined that the Medina River is not impaired by bacteria.

As with Salado Creek, the estimated loads from septic systems are relatively insignificant, and have not been assigned a load reduction. However, it is possible that septic systems have been under-represented in the analysis and it could be surmised that a portion of the direct source reduction could be directed at septic loads.

Table 11: LAs for Nonpoint Source Fecal Coliform Loads in Study Areas

Segment	Nonpoint Source	Existing Load (10^6 org/day)	Reduction %	LA (10^6 org/day)
Salado Creek	Direct Sources	295,614	90%	29,562
	Septic Systems	1,140	0	1,140
	Subtotal	***296,753***		***30,701***
Walzem Creek	Direct Source	3,403	90%	340
	Septic Systems	8	0	8
	Subtotal	***3,411***		***348***
USAR	Washoff (outside MS4)	4,404,425	0%	4,404,425
	Direct Sources	1,162,918	50%	581,460
	Septic Systems	16,732	0	16,732
	Salado Creek	4,218,356	60%	1,705,863
	Medina River	3,501,918	0	3,501,918
	Springs	10,668	0	10,668
	Subtotal	***13,315,019***		***10,221,066***

TMDL Summary

Table 12 summarizes the TMDL fecal coliform loading allocations for Salado Creek, Walzem Creek, and the USAR. Each of these TMDLs was developed with a similar approach. The WLA includes all of the allocated point sources, including permitted urban storm water. The LA is comprised of washoff sources, direct nonpoint sources, septic sources, and various background sources. The MOS is calculated as 5 percent of the TMDL.

The proposed TMDL for fecal coliform is also expected to be protective for Texas water quality criteria related to *E. coli*. The criteria ratio of 0.63 (126/200 = 0.63) was applied to convert fecal coliform to *E. coli*. The actual ratio of observed fecal coliform to *E. coli* concentrations for stations with 10 or more pairs of data in Salado Creek (average of 0.56) and the Upper San Antonio River (average of 0.60) was reasonably close to the assumed *E. coli* to fecal coliform criteria ratio (0.63). Therefore, use of the criteria ratio (0.63) has been applied to all TMDLs. A TMDL to achieve compliance with a fecal coliform concentration of 190 org/100 mL should be protective for an *E. coli* concentration of

120 org/100 mL (190 x 0.63 = 120). This is below the corresponding *E. coli* geometric mean criterion of 126 org/100 mL. Table 13 shows the TMDL summary expressed as *E. coli* loadings.

Table 12: Summary of Fecal Coliform TMDL for Impaired Reach (10^6 org/day)

Segment #	Segment Name	WLA	LA	MOS	TMDL
1910	Salado Creek	4,731,107	30,701	250,622	5,012,430
1910A	Walzem Creek	132,644	348	7,000	139,995
1911	USAR	17,331,027	10,221,066	1,450,110	29,002,203

Table 13: Summary of *E. coli* TMDL for Impaired Reach (10^6 org/day)

Segment #	Segment Name	WLA	LA	MOS	TMDL
1910	Salado Creek	2,980,597	19,342	157,890	3,157,833
1910A	Walzem Creek	83,567	219	4,411	88,195
1911	USAR	10,918,548	6,439,271	913,570	18,271,389

Public Participation

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

In accordance with requirements of law promulgated in 2001 under Texas House Bill 2912, an official steering committee was established and 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 members were formally invited to attend. To ensure that absent members 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 steering committee members at <www.tceq.state.tx.us/implementation/water/tmdl/34-sanantonio_group.html>.

Throughout the term of the project, from 2002 to 2005, four meetings were held in San Antonio. At each meeting the project team received and responded to a number of questions and comments. The objectives of the first meeting in September of 2002 were to:

- Introduce the project team and summarize the public participation process.
- Define what the project was intended to accomplish.
- Provide historical monitoring data, information, issues, and potential sources.

The objectives of the second stakeholders meeting in August of 2003 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Provide information on prior data assessment.
- Provide information on supplemental sampling results.
- Discuss the next phases.

The objectives of the third stakeholders meeting in February of 2005 were to:

- Inform the stakeholders on the status of work being performed on the project.
- Provide information on monitoring results.
- Update stakeholders on preliminary modeling results.
- Discuss the next phase.

The objectives of the fourth stakeholders meeting in August of 2005 were to:

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

Implementation and Reasonable Assurances

The TMDL development process involves the preparation of two documents:

1) **a TMDL**, which determines the maximum amount of pollutant a water body can receive in a single day and still meet applicable water quality standards, and
2) **an implementation plan (I-Plan)**, which is a detailed description and schedule of the regulatory and voluntary management measures necessary to achieve the pollutant reductions identified in the TMDL.

During TMDL development, the TCEQ determines the acceptable pollutant load for impaired water bodies and apportions the load among broad categories of pollutant sources in the watershed. This information is summarized in a TMDL report such as this document.

During TMDL implementation, the TCEQ develops the management strategies needed to restore water quality to an impaired water body. This information is summarized in an implementation plan (I-Plan) which references, but is separate from, the TMDL document. The I-Plan details load reduction and other mitigation measures planned to restore water quality in an impaired water body.

The TCEQ is committed to developing I-Plans for all TMDLs adopted by the commission and to ensuring the plans are implemented. I-Plans are critical to ensure water quality standards are restored and maintained. They are not subject to EPA approval.

The TCEQ works with stakeholders to develop the strategies summarized in the I-Plan. I-Plans may use an adaptive management approach that achieves initial loading allocations from a subset of the source categories. Adaptive management allows for development or refinement of methods to achieve the environmental goal of the plan.

Periodic and repeated evaluations of the effectiveness of implementation methods assure that progress is occurring, and may show that the original distribution of loading among sources should be modified to increase efficiency. This adaptive approach provides reasonable assurance that the necessary regulatory and voluntary activities to achieve the pollutant reductions will be implemented.

As part of the TMDL process, a watershed protection plan (WPP) is being developed to outline actions that will be taken to reduce bacteria loading from the urban portion of the USAR (above Loop 410). The WPP, funded by EPA through the TCEQ, has provided valuable resources and information 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 San Antonio area.
- additional water quality monitoring to determine the magnitude and location of sources of bacteria.
- water quality model enhancements to improve model resolution and to reflect data gathered during the WPP process.

The WPP can be used as the basis for development of the I-Plan for the USAR. Furthermore, some of the best management practices and treatment alternatives investigated for the WPP will also be applicable to Salado and Walzem Creeks.

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.

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 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 additional monitoring and reporting of effluent discharge quality to evaluate and verify loading trends, adjustment of an inspection frequency or a response protocol to public complaints, and escalation of an enforcement remedy to require corrective action of a regulated entity contributing to an impairment.

A TMDL 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. In simple terms, a TMDL is like a budget that determines the amount of a particular pollutant that the water body can receive and still meet a water quality standard. The I-Plan adopted by the commission will direct implementation requirements applicable to certain sources contributing a pollutant load 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 as cost, feasibility, the 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. For these reasons, the I-Plan that is adopted may not approximate the predicted loadings identified category by category in the TMDL and its underlying assessment, but with certain exceptions, the I-Plan must nonetheless meet the overall loading goal established by the commission-adopted and EPA-approved TMDL.

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 (EPA 2006).

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 CFR

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 (EPA 2002). 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.

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