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One Total Maximum Daily Load for Bacteria in Gilleland Creek

Segment 1428C

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Executive Summary

This document describes a project to address an impairment of water quality in Gilleland Creek, where concentrations of *Escherichia coli (E. coli)* exceed the criteria used to evaluate the attainment of the contact recreation use. The TCEQ first identified this impairment in the *2004 Texas Water Quality Inventory and 303(d) List*. Gilleland Creek is a freshwater stream approximately 31 miles long with a watershed area of 76 square miles, and is located wholly in eastern Travis County in Texas.

The most probable sources of the impairment are nonpoint source in origin. Using load duration curve analysis, project staff determined that the contact recreation criteria are exceeded during two flow categories: high flow (0-10th percentile flow) and moderate flow (11-50th percentile flow). The percent reductions required to bring the water body into compliance with the contact recreation standard are 92.8 percent at high flow, and 83 percent at moderate flow.

Introduction

Section 303(d) of the federal Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a total maximum daily load (TMDL) for each pollutant that contributes to the impairment of a listed water body. 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 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. TMDLs must also estimate how much the pollutant load must be reduced from current levels in order to achieve water quality standards.

This TMDL addresses impairments to the contact recreation use due to elevated *E. coli* concentrations in Gilleland Creek. 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) in, 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, or fishing) of impaired or threatened water bodies.

Section 303(d) of the Clean Water Act and the implementing regulations of the U.S. Environmental Protection Agency (EPA) (40 Code of Federal Regulations, Part 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 considers eight elements in developing a TMDL; they are described in the following sections:

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

The commission adopted this document on August 8, 2007. Upon EPA approval, the TMDL will become an update to the state's Water Quality Management Plan.

Problem Definition

The TCEQ first identified the impairment to the contact recreation use for Gilleland Creek in the *2004 Texas Water Quality Inventory and 303(d) List* (2004 Inventory and List). Data the TCEQ analyzed from the assessment period of March 1, 1998 through February 28, 2003 (Table 1) showed high concentrations of *E. coli* and fecal coliform bacteria. Most of the data were collected at one site, though data from four other sites were also included; in all, 26 *E. coli* values and 22 fecal coliform values were assessed.

The standards for water quality are defined in the *Texas Water Quality Standards* (Chapter 307 of the Texas Administrative Code). The specific uses assigned to Gilleland Creek are contact recreation, high aquatic life, and fish consumption. The criteria for assessing attainment of the contact recreation use are expressed as the number colony-forming units (cfu) of bacteria per hundred milliliters (100 mL) of water. The number of colony-forming units may not exceed certain concentrations in a single sample, nor as a geometric mean of all samples.

As described in the TCEQ's "2004 Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data" (TCEQ 2004), the TCEQ requires a minimum of 10 samples in order to assess support of the contact recreation use. *E. coli* is now 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. For this project, *E. coli* was used exclusively for data collection and modeling to support development of the TMDL.

Using the *E. coli* criteria, if the minimum sample requirement is met, the contact recreation use is not supported when:

- the geometric mean of all *E. coli* samples exceeds 126 cfu/100 mL; AND/OR
- individual samples exceed 394 cfu/100 mL more than 25 percent of the time.

The TCEQ uses a binomial method to specify the number of exceedances of the single sample criterion required to determine nonsupport of the contact recreation use.

The specific area of Gilleland Creek in which the criteria were exceeded is from the Colorado River upstream to Taylor Lane, as measured at monitoring site 17257 (Figure 1). In that area, both *E. coli* and fecal coliform concentrations exceeded the single sample criteria eight times. The geometric mean for *E. coli* was 240 cfu/100 mL. The geometric mean for fecal coliform for the same five-year period was 365 cfu/100 mL (Table 1).

Table 1. Summary of Criteria and Assessment Data

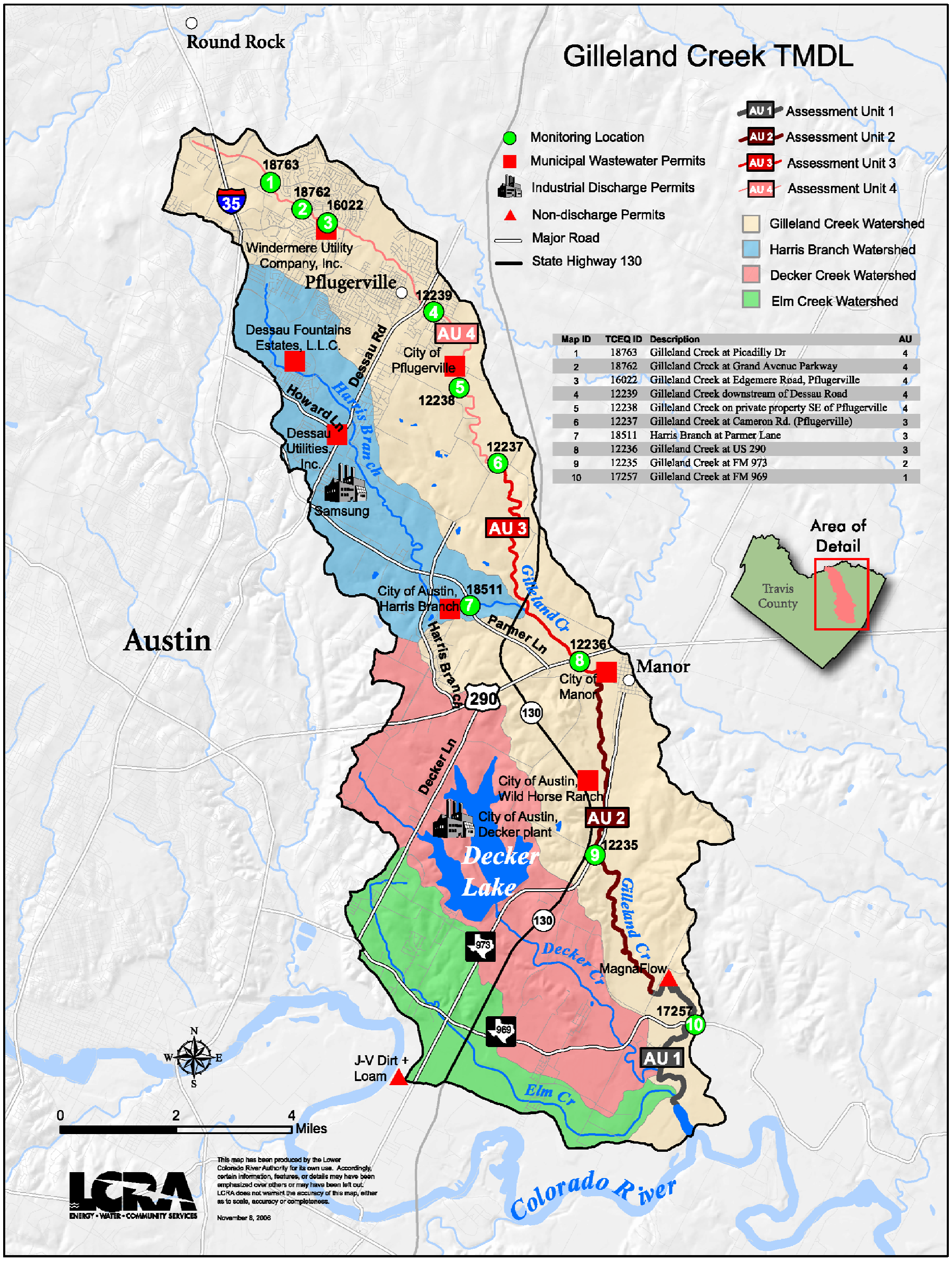
	Water Quality Criteria (cfu/100mL)		**Assessed Concentration, 2004**	
	Geometric Mean	**Individual Sample**	**Geometric Mean**	**Percent Exceedance of Single Sample**
E. coli	126	394*	240	31% exceedance
Fecal coliform	200	400	365	36% exceedance

*assessment methodology allows up to 25 percent of the samples to exceed 394 cfu/100mL.

Watershed Overview

Gilleland Creek is approximately 31 miles long, with a watershed area of 76 square miles (Figure 1). The creek, located in eastern Travis county, winds from its origin at Ward Spring northwest of the city of Pflugerville to upstream of the city of Webberville, where it joins with Segment 1428, the Colorado River Below Town Lake. Elm Creek, Decker Creek, and Harris Branch are the larger tributaries of Gilleland Creek.

The headwaters of Gilleland Creek near the city of Pflugerville in Travis County.



Map ID	TCEQ ID	Description	AU
1	18763	Gilleland Creek at Picadilly Dr	4
2	18762	Gilleland Creek at Grand Avenue Parkway	4
3	16022	Gilleland Creek at Edgemere Road, Pflugerville	4
4	12239	Gilleland Creek downstream of Dessau Road	4
5	12238	Gilleland Creek on private property SE of Pflugerville	4
6	12237	Gilleland Creek at Cameron Rd. (Pflugerville)	3
7	18511	Harris Branch at Parmer Lane	3
8	12236	Gilleland Creek at US 290	3
9	12235	Gilleland Creek at FM 973	2
10	17257	Gilleland Creek at FM 969	1

Figure 1. Gilleland Creek Watershed

The creek is identified as Segment 1428C in the 2004 Inventory and List. It is an unclassified freshwater stream that once was either perennial or intermittent with perennial pools, depending on the area. The creek is now dominated by effluent from facilities permitted to discharge treated wastewater into it.

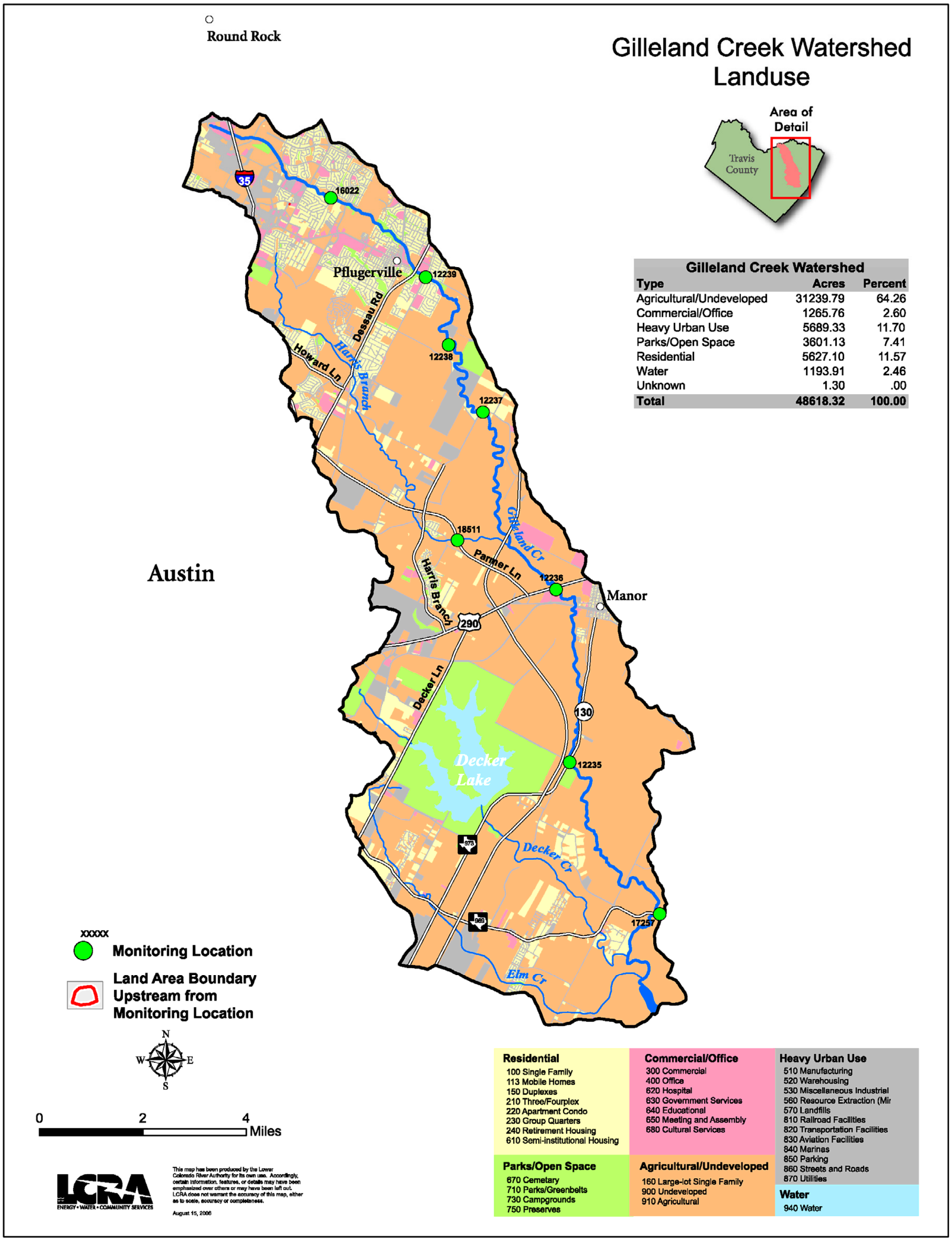


Figure 2. Land Cover in the Gilleland Creek Watershed

The land cover in the watershed is predominantly grassland (Figure 2); however, land use in the watershed is undergoing a rapid transition from primarily agricultural to more urbanized (2003 land use data used). Cultivated lands, low intensity urban development, and woodlands/shrubs are also significant land cover types within the watershed. The majority of the soil types in the watershed are clays: Trinity, Houston Black, Heiden, and Austin silty. The total population for the Gilleland Creek watershed is approximately 44,139 people, with approximately 14,124 households (U.S. Census Bureau 2000).

Results of urbanization are most evident during low flow, when the water in Gilleland Creek consists mostly of wastewater effluent from permitted dischargers in the watershed. At the start of this TMDL project, there were seven domestic wastewater treatment facilities (WWTFs) that discharged to the creek and the two industrial facilities and two solid waste facilities in the watershed that do not discharge to the creek. Shortly after data collection began, the City of Manor's WWTF (11003-001) went permanently offline.

Endpoint Identification

All TMDLs must identify a quantifiable water quality target that indicates the desired water quality condition and provides a measurable goal for the TMDL. The TMDL endpoint also serves to focus the technical work to be accomplished and as a criterion against which to evaluate future conditions. The endpoint for this TMDL is to achieve concentrations of *E. coli* below the criterion for individual samples of 394 cfu/100 mL more than 75 percent of the time, while also being protective of the geometric mean criterion of 126 cfu/100 mL.

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.

Point Sources of Bacteria

Point source dischargers in the Gilleland Creek watershed include six municipal wastewater treatment facilities (WWTFs), two industrial facilities, and two municipal solid waste facilities (non-discharge permits).

WWTFs

Seven municipal WWTFs were permitted to discharge their treated wastewater to the creek (Figure 3) at the start of the project. One of those seven, the City of Manor WWTF (11003-001), went permanently offline shortly after this project was initiated; the City of Austin's Wildhorse Ranch WWTF (10543-013) now processes the waste formerly sent to the City of Manor facility. The remaining six WWTFs are permitted to discharge a maximum of 10 million gallons per day (MGD) into the creek or its tributaries. Ten MGD, if discharged at a constant rate, would result in an average flow of approximately 15.5 cubic feet per second (cfs). This maximum value is not typically experienced under normal circumstances. Normal, average flow from these WWTFs is just less than half of the maximum permitted discharge rate.

During dry weather conditions, a majority of the flow in the creek is effluent from wastewater treatment plants. During dry weather monitoring, the highest flow was measured at Station 12235 (Figure 3), gauged at 9 cfs. By inference, approximately 83 percent of the flow at Station 12235 is composed of WWTF effluent.

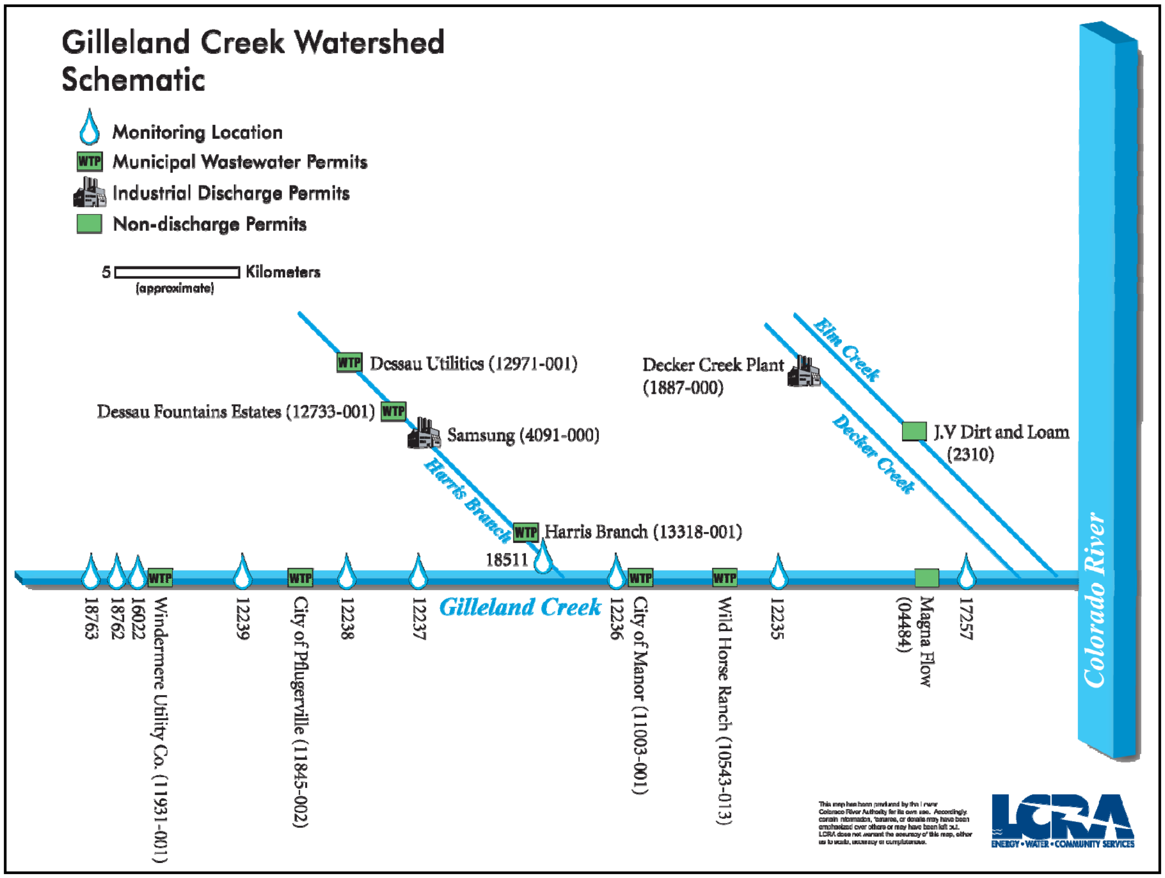


Figure 3. Schematic of Dischargers in the Gilleland Creek Watershed

WWTFs in the Colorado River Watershed must comply with stringent effluent limits mandated in the Colorado River Watershed Protection Rule (October 1986, 30 Texas Administrative Code Chapter 311 Subchapter E). Regarding disinfection, the rule states that sewage treatment facilities must install dual-feed chlorination systems that are capable of automatically changing from one cylinder to another. The rule also sets minimum and maximum chlorination concentrations.

Two facilities are “grandfathered” and therefore do not have to meet the effluent requirements in the rule: Dessau Utilities, and Dessau Fountain Estates. The permit for Dessau Fountain Estates does not require the facility to use the dual-feed chlorination system, while Dessau Utilities is required to use a dual-feed chlorination system.

The Wild Horse Ranch WWTF has obtained TCEQ permission to change from chlorination to ultraviolet disinfection treatment. The TCEQ has the authority to grant permission for the use of alternative disinfection methods on a case-by-case basis.

Industrial Permits

Samsung Austin Semiconductor, L.L.C. has an industrial permit to discharge into a tributary of Harris Branch. This permit (TPDES permit #004091-00), under certain limitations, authorizes the discharge of storm water and reject water treated through reverse osmosis. The City of Austin operates an electric generating station (TPDES permit #001887-000) on Decker Lake, in the Gilleland Creek watershed. The facility is allowed to discharge once-through cooling water into Decker Lake and Creek.

Municipal Solid Waste

Magna-Flow International, Inc. operates Wisian Farm, a facility that applies Class B sewage sludge to land for beneficial uses at a rate not to exceed 12 dry tons/acre/year, and water treatment plant sludge at a rate not to exceed 0.3 dry tons/acre/year (Figure 3). The facility is not authorized to discharge pollutants into surface waters. Sludge is applied on approximately 127 acres within a 283.4-acre tract. Located near Taylor Lane, the facility’s property is adjacent to Gilleland Creek. The facility has operated and continues to operate under a registration. At this time, Magna-Flow International, Inc. has agreed to cease land application of sludge by December 31, 2007. Additionally, Magna-Flow International, Inc. agreed not to apply for a new TCEQ permit for the site and to make its best effort to secure a new site on which to relocate its operations.

J-V Dirt & Loam operates a Type V municipal solid waste composting facility (TCEQ MSW permit #2310). The facility is located within the Elm Creek watershed and is authorized to compost municipal sewage sludge, septage, grease trap waste, and animal manure (Figure 3). The 80-acre facility is located in an excavated sand and gravel pit. The composting facility is not required to have a discharge permit. The actual composting area has a berm to prevent a 100-year flood on the Colorado River from entering the active composting area. The site is underlain by Taylor marl and there is minimal likelihood of groundwater contamination resulting from the composting activity.

Nonpoint Sources of Bacteria

Probable nonpoint sources of pollution in the Gilleland Creek watershed include malfunctioning septic tanks, storm sewer overflows, agriculture practices, pet and wildlife waste, and other natural sources.

On-Site Sewage Facilities

Travis County maintains records on on-site sewage facilities (OSSFs) within the county. Approximately 75 homes within the Gilleland Creek watershed have OSSFs. A review of the location of OSSFs that are recorded for the watershed revealed that with one exception, none of the facilities is located sufficiently close to Gilleland Creek to cause substantial deleterious impacts if they malfunctioned. The exception is an area located between TCEQ monitoring stations 18762 and 16022. In this portion of the watershed, 16 homes with OSSFs border the creek on one side.

Usually, Travis County inspects OSSFs only when they are installed or if governing agencies receive substantial complaints from the public. Many variables affect the potential contribution of these systems to bacteria levels in the creek. Some of these variables include type of system, age of system, soil characteristics, actual operation efficiency of the facility, how well the system is maintained, distance to the creek, and soil moisture conditions.

Sanitary Collection Systems

Overflows from sanitary collection systems are usually infrequent, but when they occur, can be a significant source of bacteria entering a water body. Overflows from these systems often go undetected in remote areas, and are often under-reported or unreported. Between 1992 and 2002, City of Austin staff investigated 19 incidents in the Gilleland Creek watershed. Of these, seven may have influenced bacteria concentrations (Table 2).

Table 2. City of Austin incident investigations

Address	Date	Incident #	Description
700 Pflugerville Loop	7/1/1993	2002	Swimmers have contracted staph infections
108 Parsons St.	4/30/2001	14493	City of Manor discharging raw sewage
1617 Three Points Road	5/16/2001	13538	550 gallons of sewage discharged into drainage ditch
2400 Grand Avenue Parkway	7/2/2001	13678	1,800 gallons of sewage soaked into the ground
15900 Bratton Lane	7/19/2001	13788	Estimated 40,000 gallons of sewage spilled into ditch, 4,000 gallons were recovered
1308 Picadilly Drive	1/9/2002	14596	500 gallons of sewage from Windermere Utility was discharged into ditch, 250 gallons were recovered
14404 Cameron Road	6/25/2002	15690	Discharge of gray water in the creek

Texas Parks and Wildlife Department (TPWD) staff investigated six fish kill events in the watershed between 1982 and 1996. Of the six events, none were attributable to low dissolved oxygen concentrations, which is a common cause. On two occasions when fish were killed, WWTF effluent had been heavily chlorinated in an attempt to oxidize the oxygen-demanding material in poorly treated effluent.

Agriculture

More than half of the watershed—64 percent—is classified as agricultural land. There are no confined animal feeding operations under permit within the Gilleland Creek watershed. Grazing operations are evident along the creek, starting just downstream of Pflugerville and continuing to Gilleland Creek's confluence with the Colorado River. In many instances, livestock have direct access to the stream, increasing the likelihood of direct contribution of bacteria to the creek, as well as through rainfall runoff. Land application of manure is not known to occur within the watershed. Table 3 shows livestock census data for Travis County. The Gilleland Creek watershed comprises seven and a half percent of the area in Travis County.

Table 3. Travis County Livestock Census Data

	Travis County						
Year	**Cattle (all)**	**Beef**	**Goat**	**Sheep**	**Swine**	**Horse**	**Poultry**
2000	34,000	18,000	2,600	na	na	na	na
2001	33,000	20,000	4,000	na	na	na	na
2002	54,000	21,000	3,000	na	888	2,650	1,884
2003	32,000	16,000	4,500	1,500	na	na	na
2004	31,000	16,000	4,300	1,400	na	na	na
2005	28,000	16,000	4,300	1,600	na	na	na
2006	27,000	16,000	4,900	1,700	na	na	na

Data obtained from United States Department of Agriculture National Agriculture Statistics Service.

Pets and Wildlife

Lands classified as residential make up 12 percent of the watershed, and support a growing population of 44,139 people. Fecal material from dogs and cats contains *E. coli* and is usually deposited outdoors in urban areas. On average, there are 0.58 dogs per household and 0.66 cats per household in the United States (American Veterinary Medical Association 2002). Storm runoff from urban areas with pet populations can carry *E. coli* bacteria from pet waste into the nearest water body.

Waste products from deer, feral hogs, raccoons, and other warm-blooded animals also contain bacteria. Wild animals' affinity for living in close proximity to water serves to facilitate waste conveyance to the water body. TPWD census data indicate wildlife populations are average for the size and location of Travis County (TPWD 2006).

Development

The completion of State Highway 130 and the resulting development in the watershed is also expected to have an impact on Gilleland Creek. State Highway 130 crosses Gilleland Creek between stations 12237 and 12236. Due to increased development and impervious cover in the watershed, the creek will be much more prone to events in which storm runoff reaches the receiving water rapidly and the first flush of runoff carries high concentrations of pollutants.

Seasonality

The Lower Colorado River Authority performed a seasonal analysis of the data for this TMDL project to determine if seasonal variability had an effect on the bacterial concentrations in the creek (Table 4). Because there are not four distinct seasons in central Texas in most years, the data were divided into two seasonal periods—summer and winter. The analysis of the summer months includes bacteria data collected March through November, 2005. The winter months included December 2004, and January through February 2005. All bacteria data from these periods, regardless of stream flow conditions, were used for this analysis. Overall, the seasonal analysis did not reveal results that were statistically different from those observed when the data was not divided by season.

Table 4. Seasonality of *E. coli* Concentrations in Gilleland Creek (2005)

Winter (December through February)	***E. Coli***	**Summer (March through November)**	***E. Coli***
Exceedances of Single Sample Criterion	47	Exceedances of Single Sample Criterion	77
Percentage exceed single sample criterion	39.2	Percentage exceed single sample criterion	34.4
Median cfu/dL	280	Median cfu/dL	235

Linkage Between Sources and Receiving Waters

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

Generally, if high bacteria concentrations are measured in a water body at low to median flow in the absence of runoff events, the main contributing source is probably one or more point sources. During ambient flows, these constant inputs to the system will increase pollutant concentrations depending on the magnitude and concentration of the sources. As flows increase in magnitude, the impact of point sources is typically diluted, and would therefore be a smaller part of the overall concentrations.

Bacteria contributions from nonpoint sources are greatest during runoff events. Rainfall runoff, depending upon the severity of the storm, has the capacity to carry bacteria from the land surface into the receiving stream. Generally, this loading follows a pattern of low concentration in the water body just before the rain event, followed by a rapid increase in bacteria concentrations in the water body as the first flush of storm runoff enters the receiving stream. Over time, two factors reduce the concentration. First, the sources of bacteria are attenuated as runoff washes them from the land surface. Secondly, the increasing volume of water in the receiving stream has a diluting effect on instream bacteria concentrations.

In order to determine when bacteria loading occurs in Gilleland Creek, sampling occurred during ambient flows and during runoff events from June 2005 to March 2006. A total of seventeen ambient flow sampling events and six runoff sampling events were conducted. The creek was sampled at a total of nine sample stations along its length, as well as on the major tributaries. Data produced from these sampling events is the data set used for the analysis and development of the TMDL for Gilleland Creek.

In Gilleland Creek, bacteria concentrations in the stream follow a classic rise and fall with rainfall events. On the first day of rainfall events, concentrations rise as flow increases, usually to levels above the contact recreation standard. By the end of the first or second day, both bacteria levels and flow have peaked and begin to decline. By the fourth day after the rainfall event, bacteria levels fall below the contact recreation standard as the creek drops below median flow. This pattern is indicative of nonpoint source pollution.

Project staff compared the graph slopes of load duration curves representing *E. coli* conditions in dry and wet weather to determine whether bacteria concentrations vary in response to runoff events. If the source of bacteria was point source, one would expect to see different slopes for the dry and wet weather events as a result of dilution. However, at all but one site, the slopes of wet and dry weather data were not significantly different, further supporting the case that the bacteria loading to Gilleland Creek is of a nonpoint source origin. The only significant difference was at monitoring site 18762, near the headwaters. This site had elevated concentrations during dry weather monitoring. The site, and the area immediately upstream of the site, was investigated by a foot survey and field fluorometry methods. However, the survey did not give conclusive results that would identify the origin of the elevated bacteria concentrations.

Monitoring associated with storm events showed higher flows and correlated with greater bacteria loads to Gilleland Creek compared to ambient conditions. Although monitoring during dry weather yielded data that exceeded the bacteria criteria, it did not indicate there are significant contributions of bacteria loads to the creek during dry weather.

An attempt was made to create load duration curves based on monthly average stream discharge and geometric means for *E. coli*. However, there were not enough *E. coli* data to calculate geometric means for a useful time period. Additionally, flow data were incomplete and therefore did not produce a well-defined duration curve. In several instances, using a 30-day period, there were not enough data to calculate an average.

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. The margin of safety may be incorporated into the analysis using two methods:

- implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
- explicitly assigning a loading amount for the MOS.

The margin of safety is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning a margin of safety.

The TCEQ incorporated an explicit MOS into this TMDL by setting a more stringent target for bacteria loads that is 5 percent below the geometric mean criterion for *E. coli* samples; that is, the target is 120 cfu/100 mL rather than the criterion of 126 cfu/100 mL. Also, the TMDL is protective of the single sample criterion using a 5 percent margin of safety. The analysis used to choose the target is explained in the following section, "Pollutant Load Allocation." It is worth noting that the water quality standard also provides an implicit margin of safety because the *E. coli* criterion correlates with a low illness rate—less than 1.0 percent.

Pollutant Load Allocation

The TMDL represents the maximum amount of pollutant that the stream can receive in a single day without exceeding the water quality standard. The load allocations for the selected scenarios are calculated using the following equation:

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

Where:

WLA = wasteload allocation (point source contributions);
LA = load allocation (nonpoint source allocation); and
MOS = margin of safety.

Typically, there are several possible allocation strategies that would achieve the TMDL endpoint and water quality standards. Available control options depend on the number, location, and character of pollutant sources.

For bacteria impairments, it is instructive to examine *E. coli* values in the context of loading as well as examining *E. coli* measurements individually or collectively. Expressing results in terms of loading allows us to compare the absolute magnitude of *E. coli* input at each site, and define the reduction in bacteria densities required to meet water quality standards.

A load duration curve is an effective tool for analyzing the effects of bacteria loadings. Load duration curves define the relationship between flow (volume per time) and loadings (mass bacteria per time) using data collected about stream flow and bacteria concentrations. First, project staff generate a curve based on the criterion for the contact recreation use—in this case, the individual sample criterion for *E. coli*. That curve represents the maximum allowable load of bacteria under different flow conditions. Next, staff plot a series of points based on actual bacteria samples expressed as loads. The comparison between the curve and the data points is then used to determine the necessary pollutant reduction.

Load duration curves shed light on the differential between actual conditions and the criterion for support of the use. This differential is called assimilative capacity if it is less than the target line, or an exceedance if it is above the target line. For this TMDL, *E. coli* loads were calculated as:

(flow) x ([*E. coli*]) x (unit conversion factor)

Where:

flow = instantaneous discharge at sampling in cfs,
[*E. coli*] = *E. coli* concentration expressed as the most probable number[1] per deciliter (MPN/dL), as derived from the criterion of 126 cfu/100ml,
Unit conversion factor = 37,854,120

As shown in the load duration curve for Gilleland Creek (Figure 4), there are two flow categories at station 12235 in which reductions in loading are necessary: high flow (0-10 percent) and moderate flow (11-50 percent).

For the Gilleland Creek analysis, only site 12235 had enough flow data to construct a meaningful flow duration curve. This was due the presence of an LCRA maintained flow gage station, which provided historical flows. Table 4 shows the percent reductions required for Gilleland Creek to support the contact recreation standard.

Waste Load Allocation

The waste load allocation for all the WWTFs was calculated using an adjusted criterion: the geometric mean criterion of 126 cfu/100 mL minus 5 percent for MOS.

The maximum permitted flow of the WWTFs is summarized in Table 6. The WLA is derived from the equation:

WLA = adjusted criterion * flow * unit conversion factor (#/day)

Where:

1 The most probable number is a statistical estimate of the actual number of colony-forming units in a water sample.

Adjusted criterion = 120 cfu/100 ml *E. coli* (the standard of 126 cfu/100 ml – 5 percent for MOS = 120 cfu/100ml)
Flow (cfs) = total maximum permitted flow (mgd * 1.54723)
Unit conversion factor = 37,854,120
WLA = 5.55 x 10^{10} cfu/day

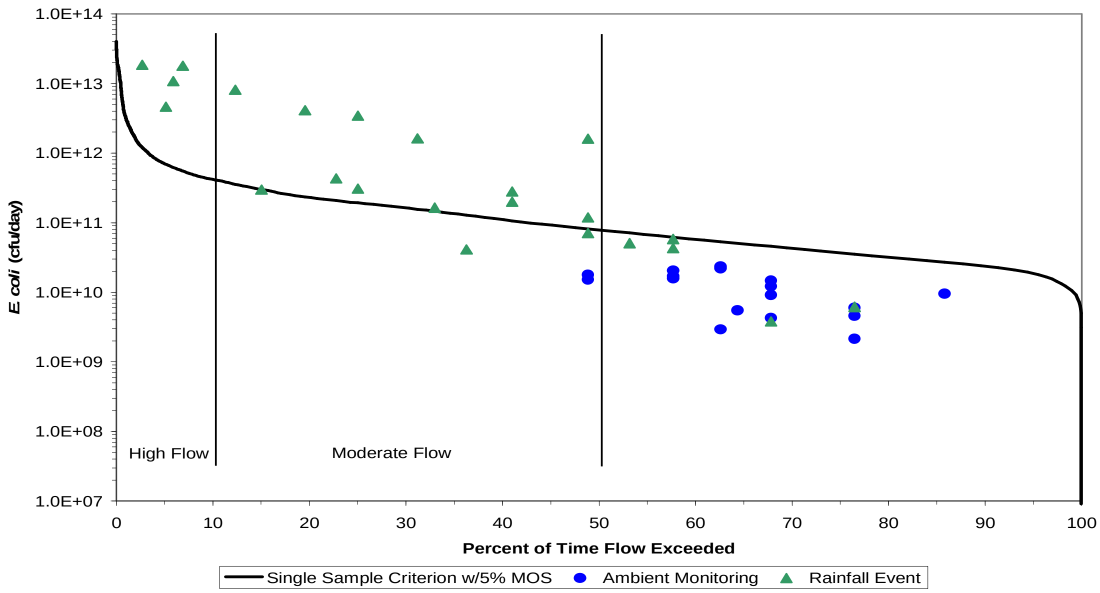


Figure 4. Load Duration Curve at Station 12235

Table 5. Bacteria Reduction Goals by Flow Exceedance Category

Percent Flow Exceedance Category	Estimated Maximum Category Flow (cfs)	Number of Measurements in Category	Mean Percent Reduction
10	45.50	4	92.8
20	25.00	3	82
30	17.75	3	82
40	12.25	3	82
50	8.50	7	0
60	6.25	6	0
70	4.75	9	0
80	3.50	5	0
90	2.50	1	0

Table 6. Maximum Permitted Flow for Each WWTF

Facility Name and Permit Number	Permitted Flow (MGD)	Disinfection Type	Bacteria Effluent Limits
Windermere Utility 11931-001	2.0	Ultraviolet Light	Fecal coliform- 200 daily avg, 400 7d avg, 800 single grab (all units cfu/100 mL)
Pflugerville 11845-002	2.5	Chlorination/dechlorination	No limits or monitoring
Dessau Utilities 12971-001	0.5	Chlorination	No limits or monitoring
Dessau Fountains 12733-001	0.15	Chlorination	No limits or monitoring
Harris Branch 13318-001	2.0	Chlorination/dechlorination	No limits or monitoring
Wild Horse Ranch 10543-013	0.75	Chlorination	No limits or monitoring

Load Allocation

The load allocation is the sum of loading from all nonpoint sources. The load duration curve (Figure 4) shows the water quality criterion is not met during moderate and high flows. Therefore, the load allocation is computed for those conditions. It is calculated as the difference between the TMDL and the total WLA.

LA = TMDL – total WLA

Where:

Total WLA = 5.55×10^{10} cfu/day

At high flow (0-10 percent)

LA = 2.61×10^{13} cfu/day – 5.55×10^{10} cfu/day
LA= 2.60×10^{13} cfu/day

At moderate flow (11-50 percent)

LA = 1.37×10^{13} cfu/day – 5.55×10^{10} cfu/day
LA = 1.36×10^{13} cfu/day

Total Loads

With the explicit MOS incorporated into the WLA, as described previously, total loads were calculated for both high and moderate flows using the equation:

$$TMDL = \sum WLA + LA$$

At high flow (0-10 percent)

TMDL = 5.55×10^{10} cfu/day + 2.60×10^{13} cfu/day

TMDL = 2.61×10^{13} cfu/day

At moderate flow (11-50 percent)

TMDL = 5.55×10^{10} cfu/day + 1.36×10^{13} cfu/day

TMDL = 1.37×10^{13} cfu/day

In order to meet the TMDL at high and moderate flows, reductions of 93 percent and 82 percent, respectively, are required. These reductions will be protective of both the geometric mean and the single sample criterion, with a 5 percent margin of safety. Since it is likely that the bacteria criteria are exceeded due to nonpoint sources, permitted dischargers will be required to maintain compliance with the current disinfection requirements of their permits. The TCEQ does not see a need to modify point source requirements for disinfection at this time. The load reduction will likely come from nonpoint sources.

Public Participation

The public and stakeholder participation process in TMDL development, "Public Participation in TMDL Projects: A Guide for Lead Organizations" is available on the web at <www.state.tx.us/implementation/water/tmdl/tmdlresources.html>.

The Lower Colorado River Authority formed the Gilleland Creek Stakeholder Advisory Group (SAG) at the onset of the project. The first public meeting to form the SAG was held on July 26, 2005, before data collection was initiated, in order to receive public input about the best sites to include in a monitoring plan. SAG members represented affected municipalities, state and county agencies, private landowners, industry, and environmental groups. Public meetings were held at project milestones in order to keep the public informed of progress on the project, as well as to receive input and to gauge the stakeholders' perceptions of the TCEQ's performance on the project. To date, there have been three stakeholder meetings for the project, following the initial meeting in July of 2006 to form the group.

The TCEQ published notices in the *Texas Register* and Pflugerville area newspapers stating the dates of the public comment period on the draft TMDL report, along with the date, time, and place of the public meeting. The public meeting was held in Pflugerville on February 22, 2007 at the Pflugerville Justice Center. Attendees did make comments. Before and after the meeting, project staff participated in an informal question and answer period. Public comment was submitted during the public comment period.

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.

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

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.

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 (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 after 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 best management practices (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.

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