Submitted November 16, 2017

Revised Implementation Plan for One Total Maximum Daily Load for Bacteria in Gilleland Creek

Segment 1428C

Assessment Units 1428C_01, 1428C_02, 1428_03 and 1428C_04

PREPARED BY THE GILLELAND CREEK IMPLEMENTATION PLAN REVISION STAKEHOLDER GROUP
With support from Center For Public Policy Dispute Resolution (University of Texas) and the TMDL Team, Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by the Gilleland Creek Implementation Plan Revision
Stakeholder Group

With support from
University of Texas Center for Public Policy Dispute Resolution

and

TMDL Team, Water Quality Planning Division, Office of Water
Texas Commission on Environmental Quality

Distributed by the
Total Maximum Daily Load Team
Texas Commission on Environmental Quality
MC-203
P.O. Box 13087
Austin, Texas 78711-3087
E-mail: tmdl@tceq.texas.gov

TMDL implementation plans are also available on the TCEQ website at
<www.tceq.texas.gov/waterquality/tmdl/>

Contents

Figures

Tables

Abbreviations

BMP	best management practice
cfu	colony-forming units
CRWN	Colorado River Watch Network
E. coli	*Escherichia coli* (also referred to as fecal bacteria, or fecal contamination)
EII	Environmental Integrity Index
EPA	U.S. Environmental Protection Agency
I-Plan	implementation plan
LCRA	Lower Colorado River Authority
mL	milliliter
MPN	most probable number
MS4	municipal separate storm sewer system
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
SSO	sanitary sewer overflow
SWMP	stormwater management plan
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
TV	closed-circuit television
USDA	United States Department of Agriculture
WWTF	wastewater treatment facility

Revised Implementation Plan for One TMDL for Bacteria in Gilleland Creek

Executive Summary

Gilleland Creek runs through the cities of Pflugerville, Round Rock, Manor and Austin in eastern Travis County. In 2004, the creek was identified as impaired due to concentrations of *Escherichia Coli* (*E. coli*) fecal bacteria that exceeded the Texas Surface Water Quality Standards for contact recreation. On August 8, 2007, the Texas Commission on Environmental Quality (TCEQ) adopted *One Total Maximum Daily Load (TMDL) for Bacteria in Gilleland Creek* (Segment 1428C) to address the bacteriological impairment and the U.S. Environmental Protection Agency (EPA) approved the TMDL on April 21, 2009. Primarily, the TMDL established the maximum amount of bacteria the creek could accept and still meet the state's standards. The second part of the TMDL process is an Implementation Plan (I-Plan) that describes the strategy and activities the TCEQ and watershed stakeholders will implement to improve water quality in the affected watershed.

This revised I-Plan, which updates the original plan developed by the stakeholders and approved by the TCEQ in 2011,[1] is based on the TMDL and its subsequent revisions, which are documented in updates to the state's Water Quality Management Plan. The TMDL identified potential regulated and unregulated sources of *E. coli*. Regulated dischargers in the Gilleland Creek watershed include domestic wastewater treatment facilities (WWTFs), industrial facilities, municipal solid waste facilities, and regulated stormwater dischargers. Potential unregulated *E. coli* sources identified in the TMDL include malfunctioning on-site sewage facilities (OSSFs), agricultural practices, development, and pet, wildlife, and unmanaged animal waste.

The goal of this revised I-Plan is the continued reduction of bacteria concentrations in Gilleland Creek to levels that meet the contact recreation criterion defined in the Texas Surface Water Quality Standards. The stakeholders in the watershed implement the I-Plan through voluntary management measures and/or mandatory, regulatory control actions. This plan documents the stakeholder-developed management measures and control actions that are being employed to mitigate bacteria contributions. The management measures and control actions are being implemented by the

[1] *Implementation Plan for One Total Maximum Daily Load for Bacteria in Gilleland Creek: Segment 1428C*, approved by TCEQ February 9, 2011.

stakeholders under an adaptive management approach that assesses the efficiency and effectiveness of the actions and allows for changing conditions.

Regulated entities in the watershed include the City of Austin, classified as a large (Phase 1) Municipal Separate Storm Sewer System (MS4) and the five entities of the City of Manor, City of Pflugerville, City of Round Rock, Texas Department of Transportation, and Travis County, classified as small (Phase 2) MS4s. The cities of Austin and Pflugerville, as well as the Windermere Utility Company, operate regulated WWTFs within the watershed.

These stakeholder regulated entities are distinguished via their respective permit requirements. Current draft revisions to the Texas Pollutant Discharge Elimination System (TPDES) General Permit for the small MS4 entities will require compulsory implementation of specified best management practices (BMPs) for the pollutant of concern (bacteria). These BMPs are identified in the respective small MS4 permittees' Storm Water Management Plans. For the purposes of this revised I-Plan, the compulsory BMPs for the small MS4s are effectively control actions for the regulated entities.

Included in this revised I-Plan is a summary of the TMDL, details of the plan's implementation and progress, and a summary of the implementation strategy. Management measure and control action discussions provide detailed information on the practices, targets, implementation, sustainability, and measurable progress for each activity. Regulated stakeholders will report their progress each April, to be posted to the TCEQ's website for the I-Plan. Each May, stakeholders will meet to assess progress and adjust implementation strategies to better effect the goal of improving water quality.

Introduction

In November 2016, with five years of implementation under their belts, the stakeholders determined to update their I-Plan, using an adaptive management approach to make revisions based on the state of science, what they know about the effectiveness of current management measures, and best management practices. Stakeholders formed a planning team to help guide the process. The stakeholder group was open to all "individuals or representatives of organizations who are (1) in the Gilleland Creek watershed, (2) who may be affected by or may affect water quality in the watershed, or (3) who can develop or implement actions to reduce water quality problems in the watershed."[2] The group agreed that a smaller subset of those individuals and representatives of entities who would be responsible for implementation of management measures

[2] Meeting Guidelines, Gilleland Creek Implementation Plan Revision Stakeholder Group, approved May 15, 2017.

and control actions would serve as a decision-making group,[3] with the goal of making decisions by consensus.

Stakeholders agreed to work toward the goal of assuring the I-Plan:

- Allows Gilleland Creek to meet contact recreations standards; and
- Manages the entire Gilleland Creek watershed through cooperation among jurisdictions and citizens, and by tailoring solutions to each entity's unique needs.

Participants noted that although the TMDL goal is meeting the water quality standard minus five percent, the I-Plan goal is to actually meet the standard.

The entire stakeholder group met six times, beginning November 2016, to review the most current data about water quality and development in the watershed, to understand the intersection of the stormwater permitting process with the I-Plan process, and to review best management practices. The decision-making entities designated under the group's operational guidelines met via conference call one additional time to coordinate decisions on the final plan draft and process for completion, and coordinated the text and approval of the final plan electronically.

This revised plan reflects the management measures and control actions that the decision-making entities have identified for implementation to meet the goals for the Gilleland Creek I-Plan. One key for holders of Phase 2 MS4 permits was to assure that the revised I-Plan was flexible enough to reflect changes in the actions required under their MS4 permits, but not to impose additional voluntary actions that might then become mandatory under their MS4 permits. Throughout the process, the stakeholders wrestled with the issue of how best to involve the public, both in developing the I-Plan revisions as well as in actions to improve the water quality in Gilleland Creek.

The group agreed to provide annual reporting about the plan's implementation each April, followed by an annual meeting in May to assess progress and make any needed changes in implementation or management measures and control actions.

[3] The following entities are represented on the decision-making group: Cities of Austin, Manor, Pflugerville, and Round Rock; Lower Colorado River Authority; Texas Department of Transportation; Travis County; and Windermere Utility Company.

TMDL Summary

Detailed information about Gilleland Creek (Segment 1428C) and the fecal bacteria impairment can be found in the TMDL (TCEQ 2007) and the initial Gilleland Creek I-Plan (TCEQ 2011). Gilleland Creek is approximately 31 miles long, with a watershed area of 76 square miles located in eastern Travis County (Figure 1). The Gilleland Creek watershed includes portions of the full-purpose jurisdictions of the cities of Austin, Manor, Pflugerville, and Round Rock.

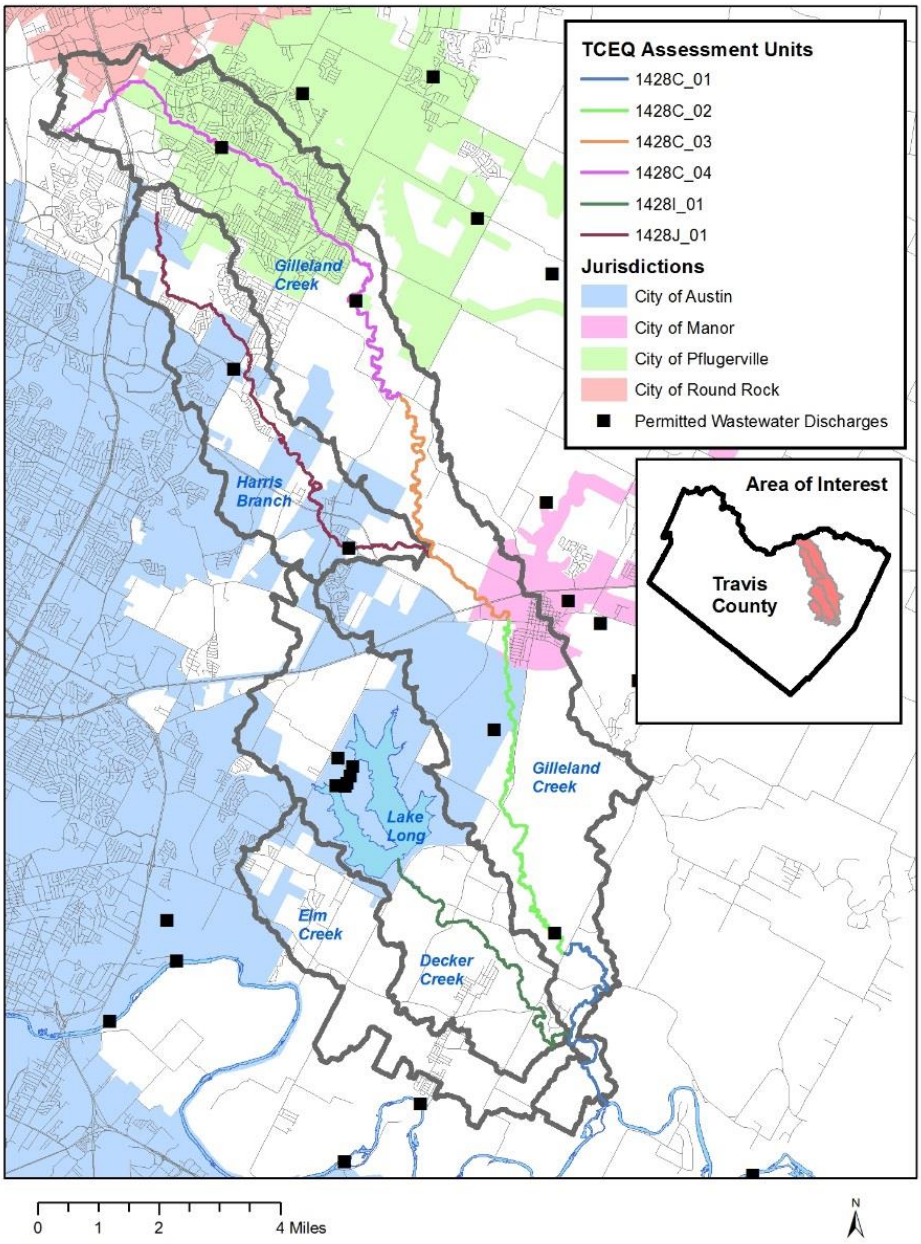

Figure 1. Map of Gilleland Creek within Travis County, Texas

While the majority of the Gilleland Creek watershed remains undeveloped or agricultural (Figure 2), land cover is transitioning to urban uses over time with increasing population. The estimated total population within the watershed was 44,139 people in 2000 (TCEQ 2007) and 77,122 in 2010 (U.S. Census Bureau 2010). Population within the watershed is projected to reach 99,412 in 2025 based on City of Austin estimates. Livestock uses continue to decrease in Travis County with increasing urbanization. Estimated number of cattle in Travis County have declined from 54,000 in 2002 to 20,000 in 2017 (USDA 2017).

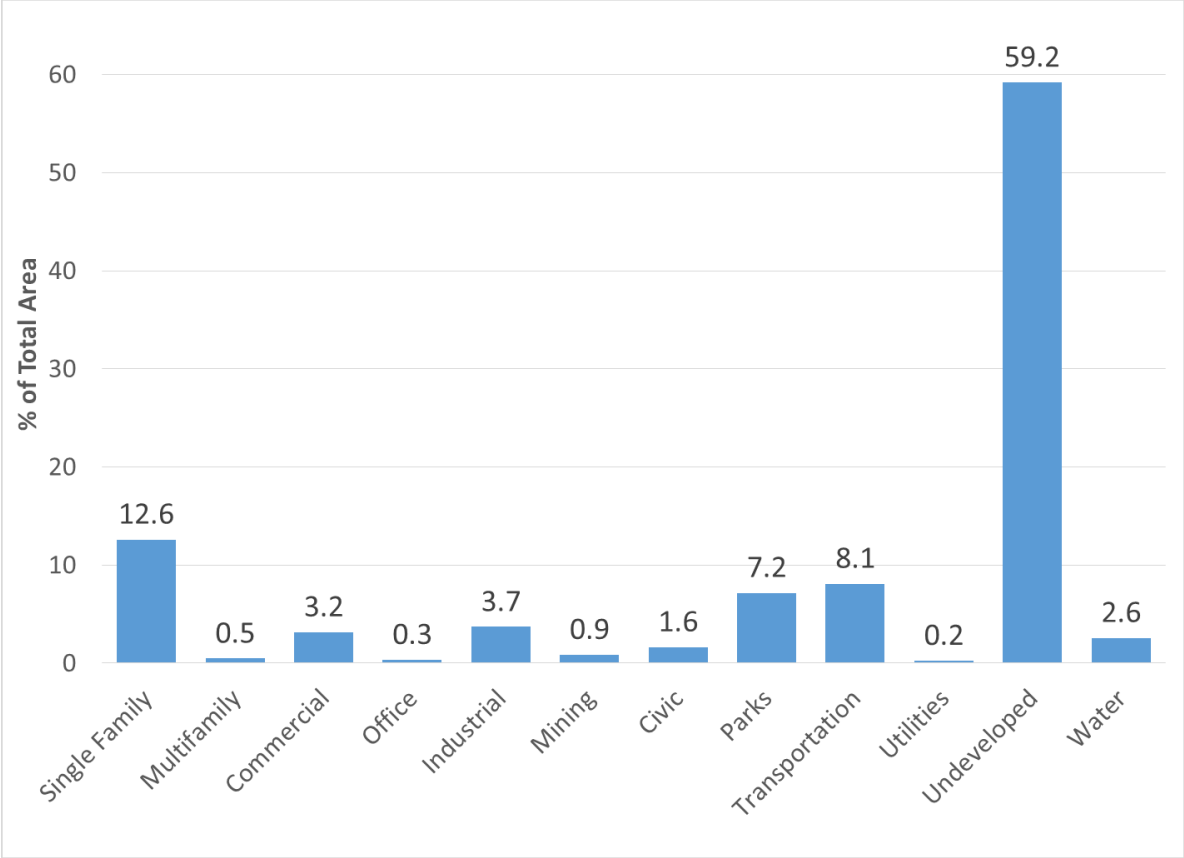

Figure 2. Land use in the Gilleland Creek watershed, based on City of Austin 2006 land use information

Source: City of Austin Geographic Information System

Gilleland Creek was first identified as not supporting the contact recreation criteria in the *2004 Texas Water Quality Inventory and 303(d) List* (https://www.tceq.texas.gov/waterquality/assessment/04twqi/twqi04.html) because the geometric mean *E. coli* bacteria concentration was 240 colony-forming units (cfu) per 100 milliliters (mL) in Assessment Unit 1428C_01, relative to the contact recreation standard of 126 cfu/100 mL. Gilleland Creek *E. coli* concentrations remain elevated above the contact recreation standards of 126 cfu/100 mL as of 2014 (Table 1). More detailed information on spatial and temporal trends in *E. coli* bacteria levels may be found in Appendix 1.

Table 1. Gilleland Creek *E. coli* bacteria geometric means from the *2014 Texas Integrated Report for Clean Water Act Sections 303(d) and 305(b)*

Source: TCEQ 2014

Assessment Unit	Assessment Unit Description	*E. coli* geometric mean (cfu/100 mL)
1428C_01	From the Colorado River upstream to Taylor Lane	126
1428C_02	From Taylor Lane upstream to Old Highway 20	105.3
1428C_03	From Old Highway 20 to Cameron Road	203.96
1428C_04	From Cameron Road to the spring source	327.34

The most probable sources of fecal contamination within the watershed are nonpoint in origin (TCEQ 2007). Nonpoint sources of fecal contamination most likely include wildlife, domestic pets, livestock, leaking centralized wastewater collection infrastructure, and failing OSSFs.

Implementation Progress

The following is a summary of implementation progress under the Gilleland Creek 2011 I-Plan.

Management Measure 1 Progress

Identify, prioritize, inspect, and bring into compliance malfunctioning OSSFs in the Gilleland Creek watershed.

City of Austin Status

- Austin inspected 20 of 42 active OSSFs in the watershed and found 18 to be in good working order. One OSSF was properly abandoned as a result of the inspections. EPA SepticSmart Program door hangers were distributed to OSSF owners and a free homeowner training was conducted on OSSF maintenance. Austin improved its local OSSF ordinance in 2013 (http://www.austintexas.gov/ossf).

Travis County Status

- Travis County inspected 19 out of 59 active OSSFs within the Gilleland watershed and found all 19 to be functional and in good working condition. Outreach materials were sent via certified mail to all identified property owners in the area. The County OSSF regulations were updated by the Commissioners Court in 2014 (https://www.traviscountytx.gov/images/commissioners_court/Doc/county-code/chapter-48.pdf).

Lower Colorado River Authority (LCRA) Status

- LCRA's OSSF Program does not have jurisdiction in the Gilleland Creek watershed and focuses operations within a buffer zone around the Highland Lakes. However, LCRA OSSF staff have served as an information resource by providing educational materials that can be modified for use in educating OSSF owners within the Gilleland Creek watershed on proper maintenance of their systems.

Management Measure 2 Progress

Restore and preserve riparian zones to protect water quality.

City of Austin Status

- Austin adopted new regulations in 2013 to protect floodplains and riparian areas from unsustainable development practices. Stream protective buffers were expanded to now begin at 64 acres of cumulative drainage area, adding protection for more than 400 miles of streams in Austin that were not previously protected (http://www.austintexas.gov/department/watershed-protection-ordinance).
- Austin published 30 scientific publications relating to riparian zone management during the 2011-2015 plan timeframe. These and other reports are available online at http://www.austintexas.gov/watershed_protection/publications/default.cfm, and via the City of Austin riparian blog at http://www.austintexas.gov/creekside.

Texas State Soil and Water Conservation Board Status

- The Texas State Soil and Water Conservation Board (TSSWCB) has partnered with the Texas Water Resources Institute, Texas Riparian Association, Texas A&M Forest Service, Texas Parks and Wildlife Department, U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) and many other partners to provide and deliver educational programs about the nature and function of riparian zones and vegetation, their benefits, local technical resources, and BMPs for protecting them.
- On April 18, 2017, a Riparian and Stream Ecosystem workshop was held in the watershed, reaching 48 people. The training, including a field tour of local riparian areas, focused on water quality issues relating to Gilleland Creek, including riparian vegetation ratings, how to photo monitor, and local resources for landowners.

Travis County Status

- Travis County adopted code regulations in 2012 that created buffer zones to protect waterways from unsustainable development practices. Stream protection buffers zones begin at 64 acres of drainage area and vary in length from 100 to 300 feet. Drainage areas are calculated as cumulative. To date, Travis County has protected over 4,000 feet of development from occurring near Gilleland Creek.
- In addition, Travis County Parks Department has acquired 1,667 acres of riparian lands within the watershed that will serve as open spaces for the general public and be protected from future development.

LCRA Status

- Over the past five years, the LCRA Creekside Conservation Program has continued to offer technical and financial assistance to private landowners implementing BMPs within the Gilleland Creek watershed. Through a unique partnership with the TSSWCB and the NRCS, the Creekside program prioritizes conservation projects within impaired water bodies in hopes of reducing soil erosion and nonpoint source pollution.
- Education and outreach within the impaired watersheds is a strong focus of the grant-funded program. On May 5, 2016, 59 participants attended an educational event hosted by LCRA in Pflugerville, Texas to promote the program and explain the benefits of BMPs.
- Although no landowners within the Gilleland Creek watershed have utilized the program yet; the LCRA plans to continue to offer and prioritize the program within the watershed.

Management Measure 3 Progress

Determine the effectiveness of retrofitting existing stormwater detention basins to perform as water quality facilities to reduce bacteria concentrations.

Center for Research in Water Resources and City of Pflugerville Status

- The final report titled *Retrofit of an Existing Flood Control Facility to Improve Pollutant Removal* (Gilpin & Barrett 2014) determined that the retrofitted stormwater detention basin to a water quality facility showed no significant reduction in *E. coli* or total phosphorus concentrations between the inlet and outlet of the test basin. However, the water quality facility proved effective in reducing other present stormwater pollutants such as Total Kjeldahl Nitrogen, nitrate+nitrite, and total suspended solids. The City of Pflugerville opted not to continue with funding the ongoing operational costs of the retrofit since it was not an effective solution in reducing bacteria concentrations to a level that would meet the contact recreational criterion defined in the Texas Surface Water Quality Standards.

Management Measure 4 Progress

Partners coordinate to develop a general campaign to raise public awareness of unregulated contributions of bacteria pollution, specifically pet waste.

City of Austin status

- Austin continues the Scoop the Poop education campaign, a robust regional pet waste management public outreach effort. In 2016, the City of Austin estimates that more than 3,126,000 pounds/annually of pet waste have potentially been diverted from streams and lakes in Austin as a result of the Scoop the Poop program: http://www.austintexas.gov/department/scoop-the-poop.

Travis County Status

- Travis County has successfully handed out over 7,500 pet waste disposal bags as part of its public outreach effort to educate the public on the proper disposal of pet waste. The bags are provided along the walking trails within the County's Northeast Metropolitan Park, which is located along the banks of Gilleland creek in the City of Pflugerville.

City of Pflugerville Status

- The City of Pflugerville continues to make efforts to reduce the amount of pet waste present in stormwater runoff. Educational brochures and pet waste bag dispensers are regularly handed out at community events and distributed at various departments throughout the city. Outreach is also conducted multiple times a year through social media. Furthermore, as more parks and trail land are acquired or built, the City continues to do its best to install and provide maintenance of signage/ pet waste collection bag dispensers.

City of Round Rock Status

- The City of Round Rock installed 68 pet waste stations throughout city parks and conducted public education through utility bill newsletters, social media, and its webpage.

Management Measure 5 Progress

Develop and adopt equivalent water-quality ordinances between government jurisdictions.

City of Austin/Travis County Status

- In 2014, Travis County Commissioners approved amendments to Title 30 of the City of Austin Land Development Code relating to Joint Travis County/City of Austin Subdivision Regulations to implement the City of Austin Watershed Protection Ordinance (see Management Measure 2 Progress). One of the principal effects of these amendments was to expand setbacks for new development around waterways to protect riparian areas, including those within the Gilleland Creek watershed.

City of Pflugerville Status

- Due to some funding issues and development concerns, the City of Pflugerville has chosen not to adopt any water quality ordinances at this time. However, the City does not prohibit any proposed water quality efforts initiated by developers and continues to maintain compliance with its regulatory obligations outlined in the TPDES Phase II MS4 permit. As the City continues to grow, it will evaluate the feasibility of future water quality initiatives. Just recently, for example, the City Council adopted the Strategic Plan for 2016-2017, directing City staff members to introduce concepts of a Drainage Master Plan and possible funding mechanisms including a Drainage Utility Fee. A Drainage Master Plan and associated fee could potentially create new funding for further watershed analysis and research that could enable the City to better understand potential repercussions of implementing water quality ordinances. However, any such ordinances will likely better serve the Wilbarger Creek and Cottonwood Creek watersheds, as the areas within the Gilleland Creek watershed are mostly developed at this point.

City of Round Rock Status

- City of Round Rock has limited jurisdictional area within the Gilleland watershed and an even smaller area abutting or adjacent to any waterways. Almost all of Round Rock's Gilleland watershed is already in a developed condition. The remaining undeveloped tract setbacks will be regulated though floodplain and zoning regulations that consider the fully-developed 100-year floodplain. To facilitate these efforts, the City of Round Rock hired the Federal Emergency Management Agency contractor to create fully-developed 100-year floodplains along Gilleland Creek during the recent Federal Emergency Management Agency map revisions.

Management Measure 6 Progress

Conduct annual visual inspection of wastewater collection systems within 100 feet from the centerline of Gilleland Creek and its tributaries.

City of Austin Status

- Austin inspected approximately 6.64 miles of wastewater collection system components within 100 feet of Gilleland Creek and its tributaries, and no failures were identified.

Windermere Utility Company Status

- Windermere Utility conducts an annual inspection of the wastewater collection systems within 100 feet of Gilleland Creek and its tributaries. During 2015 one failure was identified and repaired. No other failures have been identified.

City of Pflugerville Status

- The City of Pflugerville continues to conduct yearly visual inspections of the wastewater collection system within 100 feet of Gilleland Creek and its tributaries via smoke testing and running cameras. The City makes repairs as needed and reinforces the lines and manholes as technology changes.

City of Round Rock Status

- The City of Round Rock inspected all of its wastewater lines in the Gilleland Creek watershed. One point repair was completed in 2017 to a small area of damage made during potholing by another utility company. No other problems or defects were found.

Control Action 1 Progress

Monitor and report E. coli concentrations from WWTF effluent.

City of Austin Status

- As of 2017, the City of Austin operates four WWTFs discharging within the Gilleland Creek watershed. Operational improvements were made during the 2011-2016 I-Plan period as a result of fecal bacteria effluent monitoring results. The Harris Branch WWTF (WQ0013318-001) flows were diverted to the Wild Horse Ranch WWTF (WQ0010543-013) on June 26, 2017. The Whisper Valley WWTF, also known as the Taylor Lane WWTF (WQ0010543-014), is under construction, and construction is anticipated to be completed in fall 2017.

Windermere Utility Company Status

- Windermere Utility currently operates one WWTF that discharges directly into Gilleland Creek. The fecal bacteria in these WWTF flows are monitored and reported according to the TPDES permit requirements.

City of Pflugerville Status

- The Upper Gilleland Creek WWTF remains in operation and compliance with the TPDES Multi-Sector General Permit (MSGP) (TXR05BN19), and Wastewater permit (WQ0011845002). The facility discharges up to 5.3 million gallons per day directly into Gilleland Creek. It uses chlorination/dechlorination as its primary disinfection method. The City is currently in the planning process of making major improvements to the facility in order to increase capacity and implement more modern technologies for wastewater treatment.

Implementation Strategy Summary

This revised I-Plan documents 12 management measures and two control actions to reduce bacteria loads. Management measures are voluntary activities, such as restoring and improving riparian buffer zones. Management measures were selected by the entities taking responsibility for their implementation. Control actions are regulatory activities, such as monitoring *E. coli* bacterial concentrations in WWTF effluent. The control actions in the plan fall into two regulatory groups: (1) those activities of small MS4 entities under a TPDES general permit; and (2) wastewater treatment facility monitoring and reporting under individual TPDES permits.

Adaptive Implementation

This revised I-Plan will be implemented using adaptive management, wherein measures are periodically assessed for efficiency and effectiveness. The iterative process to evaluate and adjust the management measures and control actions in the I-Plan will ensure continuing progress toward achieving water quality goals, and shows a commitment to improving water quality. Existing management measures may be adjusted or eliminated by the entities responsible for their implementation after assessment of progress using a schedule of implementation, interim milestones, water quality data, and changed circumstances. Control actions will be adjusted based on changes in the regulatory actions that form their basis, including additional or reduced actions needed to comply with permitting.

Management Measures

1.0: Riparian Zone Restoration and Protection

- *1.1 Grow Zones*
- *1.2 Protect Riparian Areas from New Development*
- *1.3 Creekside Conservation Program*

2.0: Wastewater Infrastructure Maintenance

- *2.1 OSSF Regulation*
- *2.2 Inspect and Repair Sewer Lines*
- *2.3 Sanitary Sewer Overflow Response*
- *2.4 Private Lateral Inspection*

3.0: Domestic Pet Waste

3.1 Citywide Scoop the Poop Campaign

3.2 Pet Waste Signage at Parks

4.0: Stormwater Treatment

4.1 New Stormwater Controls on Public Lands

4.2 Inspect Existing City-Owned and Commercial Stormwater Controls

4.3 Perform Dry Weather Screening

Control Actions

1: Small MS4 Compliance with Stormwater Management Plan (SWMP) Requirements

2: Monitor and Report E. coli Concentrations from WWTF Effluent

Management Measures and Control Actions in the Revised I-Plan

Management Measure 1.0: Riparian Zone Restoration and Protection

As a result of an expanding and increasingly urbanized metropolitan area, the riparian vegetation communities of Austin-area streams continue to transform further from their natural state (Duncan et al. 2011). Riparian systems provide a suite of ecosystem services including stabilized stream banks, diverse animal assemblages, and groundwater recharge (Richardson et al. 2007) in addition to providing a range of water quality benefits to streams (Mayer et al. 2005, Meyer et al. 2007), including reduction of bacteria concentrations through stormwater filtration, dilution, and reduction of suspended sediments (Casteel et al. 2005, Lee et al. 2003, Meals 2001, Young et al. 1980).

Through decades of urban development with limited protective setbacks from riparian areas and inappropriate maintenance practices, riparian buffers on public and private lands have been severely degraded throughout the entire region. In Austin, increased urbanization represented by the percent impervious cover within the watershed is related to changes in hydrology resulting in shifts in vegetation composition (Sung et al. 2011), and impervious cover within riparian zones has been directly related to bacteria concentrations in streams (Porras et al. 2013).

The more degraded an ecosystem, the more fundamentally altered the basic services will become (Hobbs and Cramer 2008). The reduction or elimination of activities causing the degradation or prevention of natural recovery may be all that is necessary to restore riparian function and improve water quality (Kauffman et al. 1997, Richardson et al. 2007), although more active restoration efforts may be necessary to restore ecological function when environmental disturbance is extreme (Hobbs and Prach 2008).

Natural riparian buffer areas have been shown to reduce instream *E. coli* bacteria concentrations when stormwater runoff is diverted through buffers prior to discharge into the receiving water (Casteel et al. 2005). Vegetative filter strips have been demonstrated to reduce fecal coliform bacteria by 69 percent in feedlot runoff (Young et al. 1980). Stream bank restoration, livestock exclusion, and riparian restoration were demonstrated to reduce *E. coli* bacteria concentrations in Missiquoi River tributaries in Vermont by 49 to 52 percent between treatment and control watersheds (Meals 2001). The restoration and enhancement of functional riparian buffers along Austin area streams is a primary strategy the City of Austin Watershed Protection Department is implementing through a combination of targeted restoration and regulatory actions to reduce *E. coli* bacteria concentrations citywide.

1.1 Grow Zones

There are 11 City of Austin parks within the Gilleland Creek watershed. As part of this revised I-Plan, the City of Austin will evaluate the feasibility of increasing the number of parks in the Gilleland Creek watershed with "Grow Zones" riparian restoration projects. The purpose of the Grow Zone program is to restore riparian zone function along stream corridors in parks that have historically been degraded due to maintenance practices, like mowing, and overuse by park users (www.austintexas.gov/blog/grow-zones).

For Grow Zone project areas, the City of Austin has established buffer areas along both banks of a creek, for which passive plant growth is allowed without regular mowing. Grow Zones are typically 25 feet in width to allow for compatibility with other park uses in a limited space, although fully functional riparian zones may need to be 300 feet in width or wider (Duncan et al. 2012). Change over time is monitored by City of Austin staff (Richter and Duncan 2012), and adaptive management is applied when necessary, including coordination of periodic trash removal, invasive vegetation management, or native vegetative planting. Educational signage is installed to demarcate efforts and inform the public that the initial growth stages are intentional modifications in park land management by the City of Austin.

This management measure will be implemented by the City of Austin Watershed Protection Department in collaboration with the City of Austin Parks and Recreation Department. Through this strategy, the City of Austin will evaluate adding new Grow Zones in parks within the Gilleland Creek watershed over the

five-year time frame of this revised I-Plan. The primary action this strategy uses to reduce fecal bacteria loads to streams is to enhance the density, diversity, and health of riparian vegetation and soil by reducing destructive maintenance, managing vegetation succession, and enhancing soil carbon and nutrient dynamics (Duncan et al. 2011; Duncan 2012; Richter and Duncan 2012; Wagner 2013; Williams et al. 2013).

This effort is primarily managed by the City of Austin, but also utilizes a range of local and regional stakeholders including neighborhood associations, adopt-a-park groups, adopt-a-creek groups, the Austin Parks Foundation, Keep Austin Beautiful, Tree Folks, and others. These groups assist with tree planting, invasive species control, litter pick-up, and educational efforts, which are all critical to both water quality improvement and public acceptance of the change in maintenance practices. The Grow Zone program has the ability to reduce any source of fecal bacteria in park areas including fecal bacteria from pet waste, wastewater, human waste, and wildlife, as long as stormwater is directed through the vegetated buffer areas. The Grow Zone program approach is very efficient as it is primarily a passive, managed succession strategy that requires little maintenance or inputs, and reduces mowing and staff time relative to historic active maintenance practices.

Table 2. Management Measure 1.1 – Grow Zones

(1) Management Measure	Implement Grow Zones in parks where feasible.
(2) Best Management Practice	Enhance riparian area plant abundance and diversity to improve stormwater infiltration and removal of fecal contamination.
(3) Area of Emphasis	Eleven City of Austin parks within the affected watershed and its tributaries.
(4) Education Target	Individual neighborhood groups, park users, and residents in proximity to new Grow Zone initiative parks may receive direct outreach. In addition, citywide educational efforts including website and pamphlet distribution at area garden stores on benefits and appropriate management of riparian zones will be maintained.
(5) Schedule of Implementation	Evaluate feasibility and develop schedule of implementation (if feasible) in Year 1. Implement Grow Zones in Years 2-5 as feasible.
(6) Interim, Measurable Milestones	Percent of feasible Grow Zones implemented.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed. Increased riparian zone plant abundance and diversity to improve stormwater infiltration and removal of fecal contamination.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin Watershed Protection Department staff will perform annual inspections of Grow Zone areas. City of Austin Parks and Recreation Department staff will report problems to Watershed Protection during regular maintenance visits.
(9) Responsible Organizations	City of Austin Watershed Protection Department and City of Austin Parks and Recreation Department.

1.2 Protect Riparian Areas from New Development

The City of Austin is a home-rule city that derives its land use control and development authority from the Texas Constitution as articulated in the City of Austin Charter. The City of Austin protects water quality through the Land Development Code which governs zoning, subdivision, and the construction process. City of Austin water quality ordinances have evolved over time (http://www.austintexas.gov/page/watershed-protection-ordinance).

In 2013, the City of Austin adopted phase 1 of a new watershed protection ordinance that will improve creek and floodplain protection, including critical headwater areas, to protect water quality and reduce erosion, flooding, and long-range infrastructure maintenance costs (http://www.austintexas.gov/department/watershed-protection-ordinance). The new watershed protection ordinance seeks not only to encourage land development patterns that provide improved preservation of floodplains and creeks, but also simplifies development regulations where possible to minimize the impact of changes on the ability to develop private land.

The Watershed Protection Ordinance now protects stream buffers in smaller headwater streams. Under previous city code, a 320-acre minimum drainage area was required before protections were in place. The current code protects drainage areas of 64 acres or more. The 2013 ordinance effectively protects riparian buffer areas along streams from modification by future development, reducing an increase in future fecal bacteria loading. In Austin, commercial and residential areas have higher measured stormwater runoff concentrations of *E. coli* (with 24,111 most probable number (MPN)/100 mL for commercial; 38,592 MPN/100mL for residential) than undeveloped land (with 9,291 MPN/100 mL).[4] Functional riparian buffers are assumed to have a 49 percent removal efficiency for *E. coli* bacteria from stormwater runoff (Meals 2001). The 2013 ordinance primarily affects new subdivision development. As part of this revised I-Plan, the City of Austin will continue to implement phase 1 of the Watershed Protection Ordinance and the amount of riparian buffer protected from new development will be tracked and reported annually as a measurable milestone of this revised I-Plan.

[4] MPN is a method used to estimate the concentration of viable microorganisms in a sample.

Table 3. Management Measure 1.2 - Protect Riparian Areas from New Development

(1) Management Measure	Protect riparian areas from new development.
(2) Best Management Practice	Protect existing riparian area plant abundance and diversity from new development by establishing buffers to maintain existing stormwater infiltration and removal of fecal contamination.
(3) Area of Emphasis	Subdivision and commercial development near riparian areas within the City of Austin full purpose and extra-territorial jurisdiction.
(4) Education Target	Continue citywide education about benefits of functional riparian zone.
(5) Schedule of Implementation	Implemented through the City of Austin site development permit application review process as new development occurs.
(6) Interim, Measurable Milestones	Linear feet of protected riparian zone buffer
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed. Maintenance of existing riparian zone plant abundance and diversity to improve stormwater infiltration and removal of fecal contamination.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin site development permit records will be tracked through existing processes.
(9) Responsible Organizations	City of Austin Watershed Protection Department and City of Austin Development Services Department.

1.3 Creekside Conservation Program

Since 1990, the LCRA's Creekside Conservation Program has promoted the reduction of soil erosion and nonpoint source pollution by offering a cost sharing incentive to private landowners within the lower Colorado River watershed. The program offers both technical and financial assistance to implement BMPs and place private property under conservation management plans.

Conservation plans are developed by the NRCS in collaboration with local soil and water conservation districts and encompass the entire land unit to address soil and water conservation concerns. All BMPs implemented through the conservation plans are subject to NRCS technical standards and include, but are not limited to, cross fencing, slope stabilization, vegetative buffers, range seeding, alternative water source development, and rotational grazing of livestock. Participants may be reimbursed up to 50 percent of their pre-approved project cost, and are eligible to receive a maximum cost-share amount up to $20,000. While not required for participation in the Creekside Program, landowners are encouraged to obtain a Water Quality Management Plan certified by the TSSWCB.

The Creekside Conservation Program is currently supported by a federal Clean Water Act Section 319(h) nonpoint source grant through the TSSWCB. Since 2004, a series of grants has provided funding for LCRA to offer this assistance throughout LCRA's statutory district. Through the program, the LCRA prioritizes areas along or within the watershed of impaired water bodies, including a specific priority area for Gilleland Creek.

Table 4. Management Measure 1.3 - LCRA Creekside Conservation Program

(1) Management Measure	Implementation of the LCRA Creekside Conservation Program.
(2) Best Management Practice	BMPs implemented through the program include, but are not limited to cross fencing, brush management, range seeding, alternative water source development, and rotational grazing of livestock. Participants may be reimbursed up to 50 percent of their pre-approved project cost, and are eligible to receive a maximum cost-share amount up to $20,000. All BMPs are subject to NRCS technical standards and guidelines.
(3) Area of Emphasis	The 11 county project region of the Lower Colorado River Basin, to specifically include the priority area of the Gilleland Creek watershed.
(4) Education Target	Private property owners within the Creekside Conservation Program's project region, including landowners within the Gilleland Creek watershed.
(5) Schedule of Implementation	Interested landowners contact the Creekside program's project coordinator or the local NRCS office to develop a conservation plan. LCRA, NRCS, and the relevant soil and water conservation districts evaluate the project and select landowners eligible for cost sharing assistance. The Conservation Plan is approved and implemented on the participating landowners' property in accordance with NRCS standards and guidelines. Once the project is completed, the landowner is reimbursed accordingly.
(6) Interim, Measurable Milestones	Tracking the number of landowner conservation plans developed; tracking the amount of cost-share assistance used to implement specific BMPs; measuring the amount of acres placed under conservation plans; calculating NPS pollutant load reduction based on completion of BMPs; and recording the number of people participating in Field Day(s).
(7) Progress Indicators	Landowners participating in the program; successful implementation of BMPs within the Gilleland Creek watershed; landowners attending educational field days; and reduction in *E. coli* concentrations in the affected watershed.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ).
(9) Responsible Organizations	The LCRA Creekside Conservation Program's project coordinator, TSSWCB, NRCS, soil and water conservation districts, and participating landowners.

Management Measure 2.0: Wastewater Infrastructure Maintenance

2.1 OSSF Regulation

The City of Austin regulates OSSFs generating less than 5,000 gallons of wastewater per day. The City of Austin is an Authorized Agent of the TCEQ and Austin Water is a Designated Representative to administer the program. The program falls primarily under the authority of the TCEQ rules contained within Texas Administrative Code (TAC), Title 30, Chapter 285 (On-Site Sewage Facilities) (30 TAC 285). Additional regulatory authority is derived from Texas Health and Safety Code, Chapter 341 (Minimum Standards of Sanitation and Health Protection Measures) and Chapter 366 (On-Site Sewage Disposal Systems). The Austin City Ordinance No. 990211-E and the Austin City Code, Chapter15-5, adopt the current 30 TAC 285 as its local rule.

OSSF effluent may contain human pathogenic bacteria or viruses (Hagedorn 1984, Corapcioglu et al. 1997). According to EPA, properly designed, sited, and maintained OSSFs are not likely to be sources of fecal contamination to surface water and are a cost-effective long-term option for waste disposal that meet public health and water quality goals (EPA 1997). Failing or improperly managed OSSFs may pose a threat to water quality and public safety as nonpoint sources of pollution (Alhajjar et al. 1990, EPA 2005). Fecal contamination from OSSFs is of additional concern as the typical treatment mechanisms may result in inherent selection for environmental persistence of fecal bacteria (Gordon et al. 2002). Case studies in Florida have documented chronic fecal indicator bacteria levels exceeding contact recreation standards in waters impacted by failing OSSFs (Propst et al. 2011).

As part of this revised I-Plan, and consistent with current City of Austin regulations, any property owner that has a failing or substantially modified OSSF will have to properly abandon the OSSF and connect their property to a centralized wastewater collection line when one is available within 100 feet of the property. The number of cutovers to centralized wastewater collection within the Gilleland Creek watershed will be reported annually. Austin Water will continue to support Austin City Council policies, waiving wastewater capital recovery fees (approximately $2,000 per connection) after full purpose annexation as an incentive to abandon existing OSSFs and connect to the City of Austin-owned centralized wastewater collection system as new wastewater mains become available in recently annexed areas. The City of Austin will continue to promote the 3-1-1 call system and the 512-974-2550 Environmental Hotline for reporting potential wastewater problems, so that failing OSSFs may be identified.

Table 5. Management Measure 2.1 - OSSF Regulation

(1) Management Measure	Continue to require failing OSSFs located within 100 feet of City of Austin centralized wastewater collection lines to cut over and properly abandon the OSSF. Continue to support the existing policy waiving wastewater capital recovery fees for a two-year period after annexation as an incentive to abandon existing OSSFs and connect to the Austin wastewater collection system as new wastewater mains become available in recently annexed areas.
(2) Best Management Practice	Reduce fecal contamination from failing OSSFs through regulation.
(3) Area of Emphasis	OSSFs within the affected watershed and within the City of Austin full purpose jurisdiction or limited purpose jurisdiction for health and safety.
(4) Education Target	Continue to promote cutover for functioning systems to Austin wastewater collection system. Continue to promote 3-1-1 and the Environmental Hotline to report potential wastewater issues. Continue OSSF education efforts as needed.
(5) Schedule of Implementation	Implemented when opportunities arise as full purpose annexation occurs, or when an OSSF fails or does not meet Austin capacity requirements and Austin wastewater collection mains are located within 100 feet of the property.
(6) Interim, Measurable Milestones	Number of OSSFs cutovers to Austin wastewater collection system per year.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed; removal of failing or aging OSSFs.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin – Austin Water OSSF permit records will be tracked through existing processes.
(9) Responsible Organization	City of Austin - Austin Water.

2.2 Inspect and Repair Sewer Lines

Austin Water maintains centralized wastewater collection lines and wastewater treatment plants for the City of Austin. Damage due to root penetration, corrosion, exposure of wastewater lines in creek channels from bank erosion, and aging may lead to release of raw sewage from the collection system. Leaking sanitary sewer lines may be a source of fecal contamination to receiving waters, resulting in instream bacteria concentrations in excess of contact recreation standards during non-storm conditions (Propst et al. 2011). Defective wastewater infrastructure also allows for infiltration of rainwater into the collection system, potentially compromising treatment plant operations or leading to sanitary sewer overflows (Metcalf and Eddy, Inc. 1979).

Austin Water personnel and private contractors perform closed-circuit television (TV) inspection and cleaning of the wastewater collection system piping. The inspection is part of a preventative maintenance program to minimize sanitary sewer overflows by repairing or replacing defective piping that may impact water quality or wastewater system reliability. Defects that are observed in the wastewater piping are recorded in a database and prioritized for repair.

Inspection is conducted on approximately 2.5 million feet of wastewater lines per year citywide, representing approximately 12.5 percent of the total system length. Rehabilitation projects are conducted on approximately 40,000 to 50,000 feet of wastewater lines per year citywide to prevent sanitary sewer overflows and infiltration and inflow of rainwater. Rehabilitation projects are prioritized based on overall condition and criticality of the line.

As part of this revised I-Plan, Austin Water will identify the length of wastewater lines inspected within the affected watershed, the number of problems identified and corrected with spot repairs, and the length of wastewater lines replaced or upgraded annually. This strategy will reduce the frequency of sanitary sewer overflows and reduce the probability of sewage leaking from the collection system. Infrastructure inspection not only identifies active failures resulting in loss of raw sewage to the environment, but also proactively identifies failures that have not yet occurred but are likely to occur in the future. The rate of occurrence and size of active and potential failures is highly variable over time and space, and is dependent on the age of infrastructure, pipe material, and surrounding conditions. Both active and potential infrastructure failures will be addressed by this measure. Because of the high concentration of *E. coli* in raw wastewater, with examples ranging from 0.006 billion MPN/100 mL (Sobsey et al. 1998) to 0.028 billion MPN/100 mL (Olańczuk-Neyman et al. 2001), raw wastewater can have substantial impacts on receiving water fecal bacteria concentrations.

Table 6. Management Measure 2.2 - Inspect and Repair Sewer Lines

(1) Management Measure	Inspect wastewater infrastructure in the affected watershed and prioritize repairs as problems are encountered based on overall condition and criticality.
(2) Best Management Practice	Reduce fecal contamination from failing wastewater infrastructure and prevent fecal contamination by proactively maintaining wastewater infrastructure.
(3) Area of Emphasis	City of Austin wastewater service area within the affected watershed.
(4) Education Target	Continue citywide public education efforts to reduce potential for sanitary sewer overflows with campaigns like "Ban the Blob." Continue promotion of Austin environmental hotline and 3-1-1 for citizens to report wastewater overflows.
(5) Schedule of Implementation	Consistent with existing citywide wastewater system maintenance schedule.
(6) Interim, Measurable Milestones	Number of feet of wastewater lines inspected. Number of problems encountered and repaired (spot repairs). Number of feet of wastewater mains replaced/upgraded in affected watershed.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed; repairs of failing wastewater infrastructure made.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin – Austin Water system maintenance tracked through existing processes.
(9) Responsible Organization	City of Austin – Austin Water.

2.3 Sanitary Sewer Overflow Response

Sanitary sewer overflows (SSOs) occur when equipment failures, blockages, breaking, or inflow and infiltration of rainwater or groundwater that overwhelms the capacity of wastewater lines cause a release of sewage from the wastewater collection system (EPA 2004). Fecal contamination of receiving waters from SSOs may contribute to fecal bacteria levels in excess of contact recreation standards (EPA 2004).

The City of Austin responds to SSOs. Austin Water personnel are on duty or on call 24 hours a day, 7 days a week, to respond to SSOs. The objective of the Austin Water response program is to arrive at the source of the wastewater emergency within one hour of receiving the call and to control the overflow as soon as possible by starting wastewater bypass pumping systems, locating and eliminating the cause of the interrupted wastewater service, and recovering or disinfecting spilled wastewater as soon as possible. Austin Water personnel have equipment and staff to control most wastewater emergencies, but may also utilize private contractors for pumping and hauling wastewater as needed.

The City of Austin Watershed Protection Department receives notification from Austin Water of all SSO events. Watershed Protection Department personnel investigate any SSO greater than 50 gallons, as well as any SSO that may affect a storm sewer or water body, to ensure impacts to receiving waters are minimized. Watershed Protection Department personnel also directly investigate citizen complaints of polluting discharges, and report to Austin Water if illicit sanitary sewer connections to the storm drain system are detected or if SSOs are observed. The City of Austin will remediate if the SSO is from a privately owned system and the private entity cannot or will not remediate. The City of Austin, through various departments, will require repairs of private wastewater infrastructure if failures are clearly documented.

As part of this revised I-Plan, the City of Austin will continue to promote the use of the 3-1-1 call system and the 24-hour 512-974-2550 environmental hotline to provide for citizen reporting of SSOs. The City of Austin will continue public education efforts to reduce the likelihood of SSOs with educational campaigns like the Ban the Blob initiative (http://www.austintexas.gov/greaseblob) to reduce disposal of grease into the sanitary sewers.

As part of this revised I-Plan, the City of Austin will track the number of SSOs that occur within the Gilleland Creek watershed and the volume of sewage recovered from SSOs annually. By recovering wastewater from SSOs, the City of Austin will reduce the fecal bacteria load to the affected watershed from SSOs.

Table 7. Management Measure 2.3 - Sanitary Sewer Overflow Response

(1) Management Measure	Respond to SSOs in affected watershed and remove sewage from creeks during overflow events when feasible.
(2) Best Management Practice	Reduce fecal contamination from failing wastewater infrastructure.
(3) Area of Emphasis	City of Austin wastewater service area within the affected watershed.
(4) Education Target	Continue citywide public education efforts to reduce potential for sanitary sewer overflows with campaigns like "Ban the Blob." Continue promotion of Austin environmental hotline and 3-1-1 for citizens to report wastewater overflows.
(5) Schedule of Implementation	City of Austin Water will investigate and remediate SSOs in the affected watershed as they are discovered.
(6) Interim, Measurable Milestones	Volume of wastewater recovered after SSO events in the affected watershed.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed; removal of sewage from SSOs.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin – Austin Water responses will be tracked through existing processes.
(9) Responsible Organization	City of Austin – Austin Water.

2.4 Private Lateral Inspection

A private lateral is the wastewater line that connects a building to the City of Austin centralized wastewater collection system. Private laterals are not owned by the City of Austin. Failures in private sewer infrastructure are known sources of fecal contamination, and may not be directly observed by routine inspection of publicly-owned infrastructure (Propst et al. 2011).

Austin Water performs investigations of private laterals for City of Austin retail wastewater customers when there is a wastewater overflow on private property or when there is a problem with the City of Austin wastewater system that could affect a private lateral (www.austintexas.gov/department/private-lateral-program).

The City of Austin private lateral program exists to ensure defective private wastewater lines are repaired to reduce the chance of wastewater overflows and so that inflow and infiltration of rainwater into the centralized wastewater collection system are reduced. This subsequently decreases wastewater overflow incidents and reduces fecal contamination of area water bodies. Austin Water personnel respond to wastewater trouble calls from citizens who experience or witness wastewater overflows, backups, or stoppages. As part of the response, Austin Water crews perform an assessment of the city-owned portion of the collection system as well as the private sewer lateral inside the customer's property. In addition to identifying and repairing defects in the city-owned sewer service line or sewer main, Austin Water communicates with the property owner if the private sewer lateral needs to be repaired.

Under the City of Austin Private Lateral Ordinance, enforcement action may be taken to encourage the property owner to repair the defective private lateral. An Austin Water grant program is available to fund repairs for qualified property owners with incomes equal to or less than 80 percent of the Austin median family income amount. The City of Austin Watershed Protection Department receives notification from Austin Water of all sewage spills from private lateral failures, and investigates any incident resulting in more than 50 gallons of sewage being spilled or any sewage spill which may affect a storm sewer or water body. Watershed Protection Department personnel also directly investigate citizen complaints of polluting discharges, and report to Austin Water if illicit sanitary sewer connections to the storm drain system are detected or if failing private lateral wastewater lines are suspected.

As part of this revised I-Plan, the City of Austin will continue to jet clean and conduct televised inspections of private laterals initiated by private lateral backups, stoppage, or overflows at no additional charge to the affected customers. The City of Austin will continue to repair city wastewater infrastructure. When problems are identified in private lateral lines, the City of Austin will continue to enforce legal requirements on property owners to ensure the proper repair of the private lateral. The City of Austin will initiate a

program to place liens on properties in which a private lateral failure has been identified and verified when, after municipal court action, the private lateral repair has not been completed. The City of Austin will contract for the repairs to such private laterals and place a lien on the properties for the actual cost of repair plus administrative and interest-related expenses. The City of Austin will annually report the number of private lateral failures identified and the number of liens placed on private properties in the affected watershed.

Table 8. Management Measure 2.4 - Private Lateral Inspection

(1) Management Measure	Continue to jet clean and conduct TV inspections of private laterals initiated by private lateral backups, stoppage, or overflows at no additional charge to the affected customers. Continue to repair city infrastructure before customers are required to fix their private lateral. Continue to enforce legal requirements on property owners with verified private lateral failures to ensure the proper repair of the private lateral.
(2) Best Management Practice	Reduce fecal contamination from failing wastewater infrastructure.
(3) Area of Emphasis	City of Austin wastewater service area within the affected watershed.
(4) Education Target	Continue citywide public education efforts to reduce potential for sanitary sewer overflows with campaigns like "Ban the Blob." Continue promotion of Austin environmental hotline and 3-1-1 for citizens to report wastewater overflows.
(5) Schedule of Implementation	The jet cleaning and TV inspection of private laterals will continue as problems are reported.
(6) Interim, Measurable Milestones	City of Austin – Austin Water will track the number of private lateral failures identified per year in the affected watershed.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin - Austin Water responses will be tracked through existing processes.
(9) Responsible Organization	City of Austin – Austin Water.

Management Measure 3.0: Domestic Pet Waste

Domestic pets like dogs and cats can be a source of fecal pathogen contamination to natural waters (EPA 2001; TCEQ 2010). Genetic analysis of urban runoff to a reservoir in New York estimated that 95 percent of fecal coliform bacteria found in urban stormwater was of non-human origin (Alderiso et al. 1996). TMDL analyses in Maryland found domestic pet contributions to fecal bacteria loads ranged from 12 to 33 percent, while wildlife contributions ranged from 4 to 52 percent (Dalmasy et al. 2007). A bacteria source tracking study for an urban watershed in Seattle estimated that 20 percent of fecal bacteria in runoff originated from dogs (Samadpour and Checkowitz 1998). As much as 22 percent of the fecal load from contributing watersheds to the Peconic Estuary was derived from dogs (Cameron Engineering & Associates 2012). A dog off-leash area immediately adjacent to Bull Creek in Austin likely contributed to elevated levels of fecal bacteria in a popular swimming area (City of Austin 2011). Cats may have contributed to fecal contamination of a Florida creek (PBS&J 2010).

One gram of dog waste contains an estimated 23 million fecal coliform bacteria (van der Wel 1995), and on average domestic dogs excrete 340 grams of feces daily (USDA 2005). The number of domestic animals in Austin may be estimated by combining human and animal census estimates (Herrington et al. 2010). Based on national averages, it may be assumed that 37.2 percent of households have dogs and 32.4 percent of households have cats (AVMA 2007). The 2010 U.S. Census estimates that there are 354,241 housing units in Austin. Households with dogs were assumed to have 1.7 dogs, and households with cats were assumed to have 2.2 cats (AVMA 2007). Based on these assumptions in combination with U.S. Census results from Austin, there are approximately 224,000 dogs in Austin generating 76,000 kilograms of fecal waste or 1.75 x 1015 cfu of *E. coli* daily. This estimated fecal loading rate is consistent with the 4 billion cfu *E. coli* per dog per day derived from a study of the Peconic Estuary (Cameron Engineering & Associates 2012).

By Austin City Code 3-4-6, it is a Class C misdemeanor punishable by a fine up to $500 for not promptly and sanitarily disposing of dog or cat feces on private or public property other than property owned by the handler or owner of the dog. A Chesapeake Bay study found that 41 percent of dog walkers did not pick up dog waste (Swann 1999). Public education is an effective tool at reducing the fecal bacteria contamination from domestic pets. There was a 31 percent increase in the number of respondents who believed that uncollected dog waste was a potential water quality problem after a public education campaign at a metropolitan park in Austin, with 60 percent of respondents claiming to pick up dog waste more frequently than before the education campaign (City of Austin 2011).

3.1 Citywide "Scoop the Poop" Campaign

As part of this revised I-Plan, the City of Austin will continue public education efforts to reduce fecal contamination from domestic dogs. Public education is an effective tool to reduce fecal contamination from domestic animals (City of Austin 2011). The City of Austin will continue "Scoop the Poop" citywide education efforts annually (http://www.austintexas.gov/department/scoop-the-poop).

Previous education activities conducted for "Scoop the Poop" include radio and television public service announcements, social media outreach, giveaways at public events, public art, print media ads, brochures, partnerships with animal-focused non-profit organizations, and a wide variety of signage. Citywide campaign efforts will be summarized and reported annually as an interim milestone of this revised I-Plan.

Table 9. Management Measure 3.1 - Citywide "Scoop the Poop" Campaign

(1) Management Measure	Continue citywide domestic pet waste collection public education efforts.
(2) Best Management Practice	Reduce fecal contamination from domestic pet waste through education.
(3) Area of Emphasis	Austin metropolitan area.
(4) Education Target	Dog and cat owners.
(5) Schedule of Implementation	Ongoing citywide public education efforts will continue through the implementation period.
(6) Interim, Measurable Milestones	Summary of citywide outreach campaign activities per year.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin Watershed Protection Department will track outreach campaign activities.
(9) Responsible Organization	City of Austin Watershed Protection Department.

3.2 Domestic Waste Signage and Pet Waste Collection Bags at Parks

The City of Austin Watershed Protection Department has purchased and cooperated with the City of Austin Parks and Recreation Department to install 850 dispensers of pet waste collection bags in Austin parks citywide. The dispensers are maintained by Parks and Recreation Department staff during routine park maintenance visits. The Watershed Protection Department purchases more than 1,500,000 disposable bags annually for use in the dispensers at no charge to park users. Making disposable bags available to park users at no charge is intended to be an incentive for the proper collection and disposal of dog waste in city parks.

As part of this revised I-Plan, the City of Austin will continue to make pet waste collection bags available at no charge in Austin parks. The City of Austin will identify which, if any, of the 11 parks in the Gilleland Creek watersheds do not currently have pet waste disposal signage and pet waste bag dispensers. There is currently no centralized inventory of where pet waste bag dispensers have been installed to date. Over the five-year time frame of this revised I-Plan, the City of Austin will install and maintain pet waste bag dispensers in parks in the Gilleland Creek watershed where appropriate. The number of parks with signs and dispensers installed will be tracked and reported annually as a measurable milestone of this revised I-Plan.

Table 10. Management Measure 3.2 – Domestic Waste Signage and Pet Waste Collection Bags at Parks

(1) Management Measure	The City of Austin will identify which, if any, of the 11 parks in the Gilleland Creek watershed do not currently have pet waste disposal signage and pet waste bag dispensers and add dispensers and signage where appropriate.
(2) Best Management Practice	Reduce fecal contamination from domestic pet waste through signage at city parks.
(3) Area of Emphasis	Eleven City of Austin parks within the affected watershed.
(4) Education Target	Park users with domestic pets.
(5) Schedule of Implementation	Feasibility in the 11 parks will be evaluated and an implementation schedule developed in Year 1. Signage and dispensers will be added where appropriate in Years 2-5.
(6) Interim, Measurable Milestones	Number of parks with signage and dispensers added per year.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin Watershed Protection Department will track signage installation.
(9) Responsible Organization	City of Austin Watershed Protection Department.

Management Measure 4.0: Stormwater Treatment

Stormwater runoff is the dominant mechanism by which nonpoint source fecal loads are transported to receiving waters. Management of stormwater to reduce bacteria can be achieved with non-structural BMPs like riparian zone enhancement or preservation (see Management Measure 1.0), or with structural control measures like sedimentation/filtration basins. Fecal bacteria are strongly associated with stream sediment (Byappanahalli and Ishii 2011), and removal of sediment from stormwater runoff may reduce bacteria loads. Stormwater structural control BMP effectiveness for bacteria removal is variable depending in part on retention time and mechanism of treatment.

4.1 New Stormwater Controls on Public Lands

The City of Austin Watershed Protection Department is a fee-funded municipal drainage utility. Approximately $2 million in departmental Capital Improvement Project funds are appropriated annually for water quality protection projects, including structural stormwater treatment facilities. The Watershed Protection Department regularly identifies opportunities for retrofitting existing stormwater control measures to enhance performance or construct new stormwater control measures on public lands. Common stormwater structural control measures in Austin include sedimentation/filtration basins, wet ponds, and retention/irrigation systems, although newer innovative methods including infiltration and biofiltration methods are constructed with increasing frequency.

As prescribed in the Watershed Protection Department Master Plan (http://www.austintexas.gov/department/watershed-protection-master-plan), the Watershed Protection Department initially identifies and prioritizes areas in which to evaluate structural control measure retrofits or additions based on need determined by field sampling data collected under the Environmental Integrity Index (EII) program (http://www.austintexas.gov/department/environmental-integrity-index). The EII includes biennial sampling of 122 reaches across 49 watersheds in Austin for a range of water quality, sediment quality, physical integrity, and biological metrics. For problem areas, further evaluation considers feasibility and cost-benefit in determining which sites will be targeted for structural control measure retrofit or additional activities by the City of Austin. The typical life cycle for watershed protection stormwater capital improvement projects, once a location has been identified, consists of a preliminary engineering review with hydraulic analyses, design, permitting, construction, and maintenance.

As part of this revised I-Plan, the City of Austin will investigate additional opportunities on public lands within the Gilleland Creek watershed for retrofitting any existing stormwater control measures to enhance bacteria

removal, or constructing new stormwater control measures to serve a previously untreated drainage area. Identified opportunities will follow the existing citywide prioritization process for stormwater projects. If an opportunity is found and prioritized, the new or retrofit stormwater control measure will follow the typical project life cycle of preliminary engineering review, design, construction, and maintenance with completion of each phase being the measurable milestone reported annually.

Table 11. Management Measure 4.1 - New Stormwater Controls on Public Lands

(1) Management Measure	The City of Austin will identify and implement stormwater quality structural control retrofits or new installations on public lands within the affected watershed using capital improvement project funds based on citywide prioritization.
(2) Best Management Practice	Reduce fecal contamination from nonpoint pollution sources utilizing structural control measures to treat stormwater runoff.
(3) Area of Emphasis	City of Austin full purpose jurisdiction within the affected watershed.
(4) Education Target	Continue citywide education efforts about good housekeeping measures to reduce bacteria loads in stormwater runoff.
(5) Schedule of Implementation	Water quality problem areas will be assessed and prioritized based on problem severity on a citywide basis annually. If the affected watershed ranks high in problem severity, opportunities for stormwater structural control installations or retrofits will be investigated. If opportunities exist, an implementation schedule will be developed based on cost and available funding.
(6) Interim, Measurable Milestones	Annual water quality problem severity for stormwater structural control additions of the affected watershed.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed; number of project opportunities identified.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin Watershed Protection Department will track problem severity and project opportunities.
(9) Responsible Organization	City of Austin Watershed Protection Department.

4.2 Inspect City-Owned and Commercial Stormwater Controls

Consistent with the City of Austin TPDES MS4 stormwater discharge permit, the City of Austin Watershed Protection Department routinely inspects structural stormwater control measures within its full-purpose jurisdiction and extra-territorial jurisdiction to reduce stormwater pollutant loads. Stormwater structural controls may reduce bacteria concentrations in stormwater runoff.

Routine inspection and maintenance to correct problems are necessary to maintain structural control effectiveness over time. Watershed Protection Department field inspections of stormwater control measures include checks for sediment build-up, structural integrity, erosion, blockage of the inlet, blockage of the outlet, functioning riser pipe, trash rack, presence of excessive trash, and excessive vegetation growth impairing function.

Problems observed for City of Austin owned facilities are addressed by City of Austin field operations staff. If maintenance issues are identified for residential or commercial facilities not owned by the City of Austin, a notice of violation is issued to the responsible party by City of Austin field operations staff and corrective action is taken to ensure continued functionality and compliance with city code. Commercial facilities are inspected once every 3 years. Residential and city-owned facilities are inspected annually.

Complaints are received by City of Austin through the 3-1-1 call system. Complaint calls about structural control measures are investigated by field staff within several days of receiving notification, and appropriate corrective action is taken as needed.

As part of this revised I-Plan, the number of structural control measures inspected within the Gilleland Creek watershed will be reported annually.

Table 12. Management Measure 4.2 - Inspect City-Owned and Commercial Stormwater Controls

(1) Management Measure	The City of Austin will inspect existing City-owned and commercial stormwater quality controls in the affected watershed and repair problems or require repairs on a periodic basis.
(2) Best Management Practice	Reduce fecal contamination from nonpoint pollution sources utilizing structural control measures to treat stormwater runoff.
(3) Area of Emphasis	City of Austin full purpose jurisdiction within the affected watershed.
(4) Education Target	Continue citywide education efforts about good housekeeping measures to reduce bacteria loads in stormwater runoff.
(5) Schedule of Implementation	Stormwater controls are inspected on a periodic basis based on a citywide schedule, or as problems are reported.
(6) Interim, Measurable Milestones	Number of stormwater structural controls inspected within the affected watershed.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed; number of problems identified and repaired.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin Watershed Protection Department will track inspections.
(9) Responsible Organization	City of Austin Watershed Protection Department.

4.3 Perform Dry Weather Screening

The City of Austin Watershed Protection Department conducts dry weather screening of storm drain outfalls greater than or equal to 36 inches in diameter (or equivalent cross-sectional area for non-circular outfall structures). This activity is consistent with TPDES MS4 permit requirements related to illicit discharge detection and elimination, and is conducted following established protocols (Brown et al. 2004).

Dry weather screening consists of physical inspection of storm drain outfalls during periods without antecedent rainfall to identify outfalls discharging water when no stormwater runoff is expected. Dry weather screening is a means to identify and remediate illicit connections, potentially including sanitary sewer cross-connections, to the storm drain system and thereby reduce fecal contamination of waterways (Sercu et al. 2009).

When dry weather flow is found during inspection, the City of Austin Watershed Protection Department samples the flow for parameters to aid in source identification. If the source is determined to be non-natural, additional investigations are conducted to identify the source and appropriate corrective action is taken.

An individual outfall is typically inspected at least once every five years. To identify and reduce illicit cross-connections of sanitary sewers to the storm drain system, the City of Austin will inspect each storm drain outfall 36 inches in diameter or equivalent cross sectional area within the affected watershed at least once during the five-year period. The number of outfalls inspected within the affected watershed will be reported annually.

Table 13. Management Measure 4.3 - Perform Dry Weather Screening

(1) Management Measure	The City of Austin will perform dry weather screening of storm drain outfalls greater than 36 inches in the affected watershed on a periodic basis.
(2) Best Management Practice	Reduce fecal contamination from nonpoint pollution sources by identifying illicit connections to the storm drain system.
(3) Area of Emphasis	City of Austin full purpose jurisdiction within the affected watershed.
(4) Education Target	Continue citywide education efforts about good housekeeping measures to reduce bacteria loads in stormwater runoff.
(5) Schedule of Implementation	Storm drain outfalls in the affected watershed greater than 36 inches are inspected once every five years.
(6) Interim, Measurable Milestones	Number of outfalls inspected within the affected watershed.
(7) Progress Indicators	Reduction in *E. coli* concentrations in the affected watershed; number of outfalls with dry weather flows identified.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program (Austin, LCRA, TCEQ). City of Austin Watershed Protection Department will track inspections.
(9) Responsible Organization	City of Austin Watershed Protection Department.

Control Action 1: Small MS4 Compliance with SWMP Requirements

History

In *One TMDL for Bacteria in Gilleland Creek, Segment 1428C*, under the Implementation and Reasonable Assurances section, the TMDL states:

> *"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 document further states that the I-Plan shall identify voluntary and regulatory actions which may include *"required modification to a Stormwater Management Program (SWMP)."*

After the EPA approved the TMDL, the stakeholder group developed the I-Plan for Gilleland Creek. The I-Plan defined six management measures (voluntary activities) and one control action (regulatory activity). The only control action was for WWTFs that, at the time, were the only regulated entities with permit requirements regarding the bacteria impairment.

Amid the I-Plan creation, the small MS4 entities were regulated by TPDES General Permit TXR040000, which spanned from August 2007 until December 2013. Stormwater discharges from MS4 jurisdictions are considered permitted or regulated nonpoint sources. The small MS4 SWMPs were already submitted and in progress. The original TPDES Small MS4 General Permit did not have prescriptive requirements regarding existing impairments or TMDLs; the only requirement was for the SWMPs to comply with existing TMDLs or I-Plans.

The original I-Plan addressed this overlapping period by including the following language:

> "*To the extent that the MS4 permittees are implementing their respective storm water management plans (SWMPs), their permits are considered consistent with the Gilleland Creek Bacteria TMDL and this I-Plan…Each permittee will implement its SWMP, as necessary, to target reductions in the waste load of bacteria from those portions of their MS4s that are located within the Gilleland Creek watershed."*

Evolution to Control Actions

In December 2013, the TPDES Small MS4 General Permit was updated pursuant to EPA guidance to include specific language regarding impaired water bodies and TMDL requirements. The update required permittees with approved TMDLs to include information in their SWMPs and annual reports on implementing any targeted controls required to reduce the pollutant of concern. Specifically, the SWMP and annual report must address (1) Targeted Controls, (2) Measurable Goals, (3) Identification of Benchmarks, and (4) Annual Reports.

The updated MS4 permit also specified a list of BMPs required if the pollutant of concern is bacteria. All small MS4 entities that received coverage under the TPDES Small MS4 General Permit submit and report annually on a SWMP that addresses the following.

"The BMPs shall, as appropriate, address the following:

a. Sanitary Sewer Systems

(i) Make improvements to sanitary sewers to reduce overflows;

(ii) Address lift station inadequacies;

(iii) Improve reporting of overflows; and

(iv) Strengthen sanitary sewer use requirements to reduce blockage from fats, oils, and grease.

b. On-site Sewage Facilities (for entities with appropriate jurisdiction)

(i) Identify and address failing systems; and

(ii) Address inadequate maintenance of On-Site Sewage Facilities (OSSFs).

c. Illicit Discharges and Dumping

Place additional effort to reduce waste sources of bacteria; for example, from septic systems, grease traps, and grit traps.

d. Animal Sources

Expand existing management programs to identify and target animal sources such as zoos, pet waste, and horse stables.

e. Residential Education

Increase focus to educate residents on:

(i) Bacteria discharging from a residential site either during runoff events or directly;

(ii) Fats, oils, and grease clogging sanitary sewer lines and resulting overflows;

(iii) Decorative ponds; and

(iv) Pet waste."

The above BMP list addresses focus areas coincident to those covered by the original I-Plan Management Measures; however, those actions were voluntary for all MS4s. The updated TPDES Small MS4 General Permit made the above list of actions mandatory and thus has shifted what once were voluntary management measures to regulatory control actions by mandating those BMPs for all small MS4 permittees with impairments for bacteria.

The following MS4s are regulated by the TCEQ and have approved SWMPs that address the required list of BMPs.

Table 14. MS4s with approved SWMPs that address the required list of BMPs

MS4 Entity	TPDES Permit #	Entity Type
City of Manor	TXR040467	City
City of Pflugerville	TXR040078	City
City of Round Rock	TXR040253	City
Travis County	TXR040327	County
Texas Department of Transportation (statewide permit)	WQ0005011000	State Agency

Monitoring, Reporting, and Adaptive Management

Additionally, permittees are required to *"monitor or assess progress in achieving benchmarks and determine the effectiveness of BMPs"* through an evaluation of program implementation measures or assessment improvements in water quality. Small MS4 entities will report annually on their targeted BMPs and progress. An I-Plan annual report will include the detailed information provided by the MS4 entities.

The schedules for revising the I-Plan, the TPDES Small MS4 General Permit, and related SWMPs do not coincide. For example, TCEQ is drafting a revised TPDES Small MS4 General Permit, which will be submitted to the EPA in late 2017 for review and approval. Small MS4 entities will then update their respective SWMPs as required by new permit language and/or adaptive management requirements in that revised permit. Thus, it is best to refer to each permittee's SWMP rather than list specifically in this revised I-Plan the tasks each entity is performing.

The EPA's "anti-backsliding" rules for water quality-based permits (e.g., the TPDES Small MS4 General Permit) ensures that these new additional requirements (and/or their equivalents) remain the baseline for small MS4s and the basis for all future SWMPs. By including the requirements in the TPDES Small MS4 General Permit, there is a stronger commitment on behalf of the MS4 entities, a prescribed oversight and enforcement mechanism by TCEQ, and a built-in adaptive management process as the SWMPs are reviewed, updated, and renewed.

Table 15. Control Action 1 - Small MS4 Compliance and SWMP Requirements

(1) Control Action	**Small MS4 Compliance and SWMP Requirements** *BMPs per the 2013-2018 TPDES Small MS4 permit. Control Action and SWMPs will update with permit renewal*				
(2) Best Management Practice	Sanitary Sewer Systems	On-site Sewage Facilities	Illicit Discharges and Dumping	Animal Sources	Residential Education
(3) Area of Emphasis	Reduce sanitary sewer overflows	Identify/address failing systems	Reduce waste sources of bacteria (e.g. septic systems, grease and grit traps)	Identify and target animal sources (e.g. zoos, pet waste, and horse stables)	Bacteria discharges from residential sites
	Address lift station inadequacies	Address inadequate maintenance OSSFs			Fats, oils and grease clogs in lines and overflows
	Improve reporting of overflows				Decorative Ponds
	Reduce fats, oils and grease blockages				Pet waste
(4) Education Target	Operations and maintenance staff and policy makers	OSSF owners and regulators	Operations and maintenance staff, stormwater staff, system owners, etc.	Code enforcement and zoning staff, policy	Residents and potentially visitors
(5) Schedule of Implementation	Initiated in 2013. Primary activities complete 2018.	Initiated in 2013. Primary activities complete 2018.	Initiated in 2013. Primary activities complete 2018.	Initiated in 2013. Primary activities complete 2018.	Initiated in 2013. Primary activities complete 2018.
(6) Interim, Measurable Milestones	Annual reporting required on subgoals and progress toward full implementation.	Annual reporting required on subgoals and progress toward full implementation.	Annual reporting required on subgoals and progress toward full implementation.	Annual reporting required on subgoals and progress toward full implementation.	Annual reporting required on subgoals and progress toward full implementation.
(7) Progress Indicators	Accomplishment of subgoals and targeted reductions.	Accomplishment of subgoals and targeted reductions.	Accomplishment of subgoals and targeted reductions.	Accomplishment of subgoals and targeted reductions.	Accomplishment of subgoals and targeted reductions.
(8) Monitoring Component	LCRA, City of Austin, and TCEQ provide water quality monitoring data through a Clean Rivers Program Quality Assurance Project Plan for assessment by TCEQ. Other entities, including Colorado River Watch Network (CRWN), perform water quality monitoring, although that data is not assessed by TCEQ.				
(9) Responsible Organizations	TPDES Small MS4s (as applicable) via submitted SWMP				

Control Action 2: Monitor and Report *E. coli* Concentrations from WWTF Effluent

In November 2009, TCEQ's Commission approved Rule Project No. 2009-005-309-PR. The rulemaking adds bacteria limits for *E. coli* for fresh water discharges to TPDES domestic permits in 30 TAC Chapter 309 and sets the frequency of testing for bacteria in 30 TAC Chapter 319.

As of 2017, domestic WWTFs discharging within the watershed are operated by City of Austin, City of Pflugerville, and SWWC Utilities, Inc. (Windermere Utility Company).

Table 16. WWTF Permits for Control Action 2

Permittee	Facility	Permit #
City of Austin	Decker Creek	WQ001887000
City of Austin	Dessau	WQ0012971001
City of Austin	Harris Branch	WQ0013318001
City of Austin	Taylor Lane	WQ0010543014
City of Austin	Wild Horse Ranch	WQ0010543013
City of Pflugerville	Pflugerville	WQ0011845002
SWWC Utilities, Inc.	Windermere	WQ0011931001

All new and existing WWTFs in the watershed will monitor fecal bacteria (*E. coli*) according to their individual permit provisions. Monitoring and reporting through Discharge Monitoring Reports will continue as required by the individual permits. TCEQ is responsible for the enforcement of compliance with concentrations less than the limits stated in each facility's permit. If monitoring results indicate concentrations approaching or exceeding the limit set in the facility's permit, then the facility will make necessary operational changes to reduce the bacteria concentrations as required by the facility's permit.

Table 17. Control Action 2 - Monitor and report effluent *E. coli* at existing and new WWTFs

(1) Control Action	Monitor and report effluent *E. coli* at existing and new WWTFs.
(2) Best Management Practice	Proper operation of WWTFs.
(3) Area of Emphasis	Identify/address failing WWTF systems.
(4) Education Target	Status updates provided through TCEQ-hosted annual stakeholder meeting.
(5) Schedule of Implementation	Initiated in 2009; ongoing as specified in individual WWTF permits.
(6) Interim, Measurable Milestones	Continue monitoring and reporting *E. coli*. Make operational adjustments, and summarize and present data to stakeholders.
(7) Progress Indicators	All wastewater treatment facilities have *E. coli* concentrations less than permit limits. Reduction in *E. coli* concentrations in the affected watershed.
(8) Monitoring Component	Monitoring data self-reported from WWTFs.
(9) Responsible Organizations	City of Austin, City of Pflugerville, Windermere Utility Company.

Implementation Tracking, Sustainability, and Milestones

Implementation tracking provides information that can be used to determine if progress is being made toward meeting the goals of the TMDL. Tracking also allows stakeholders to evaluate the actions taken, identify those actions which may not be working, and make any changes that may be necessary to get the I-Plan back on target. Implementation milestones are measures of activities associated with control actions or management measures undertaken to improve water quality. Schedules and milestones for this revised I-Plan are included in the descriptions of each management measure and control action.

Water Quality Indicators

Water quality indicators are a measure of water quality conditions for comparison to pre-existing conditions or water quality standards. Routine *E. coli* bacteria monitoring will occur within each of the identified impaired assessment units included in this revised I-Plan to track the success of management measures and control actions over time.

Multiple governmental entities will collect *E. coli* bacteria samples from established monitoring sites (Figure 1) under a TCEQ-approved Quality Assurance Project Plan following TCEQ Surface Water Quality Monitoring Procedures Manual guidelines (https://www.tceq.texas.gov/waterquality/monitoring/swqm_guides.html#procedure). Results will be submitted to TCEQ for inclusion in future assessments through the Texas Clean Rivers Program (https://www.tceq.texas.gov/waterquality/clean-rivers). Conventional water quality parameters including nutrients and physiochemical parameters may also be collected to assist with continued fecal contamination source identification.

A current list of Texas Clean Rivers Program sample sites with site location maps, sampling frequency and monitoring parameters may be found on the LCRA Coordinated Monitoring Schedule webpage (https://cms.lcra.org). Texas Clean Rivers Program data for Gilleland Creek (Segment 1428C) may be downloaded from the TCEQ webpage (https://www80.tceq.texas.gov/SwqmisWeb/public/crpweb.faces) or map viewer (https://www80.tceq.texas.gov/SwqmisWeb/public/crpmap.html).

Additional monitoring will be performed by volunteers coordinated through the LCRA's CRWN program. CRWN supports community-based environmental stewardship by providing volunteers with the information, resources, and training necessary to monitor and protect the waterways of the lower Colorado

River watershed. Monitoring locations and sample data are available via the CRWN webpage (https://crwn.lcra.org/).

Table 18. Gilleland Creek water quality indicator monitoring summary for fiscal year 2018

Segment	TCEQ Station Location ID	Site Name	Monitoring Entity
1428C_01	17257	Gilleland Creek downstream of Webberville Road/FM 967	LCRA
1428C_02	12235	Gilleland Creek at FM 973 south of Manor	City of Austin
1428C_03	12236	Gilleland Creek at US 290 north of Manor	City of Austin
1428C_04	20474	Gilleland Creek in Northeast Metropolitan Park southeast of Pflugerville	TCEQ

Communications Strategy

Communication is necessary to ensure that stakeholders understand the revised I-Plan and its progress in improving water quality. The TCEQ and responsible entities will disseminate information about progress to interested parties.

The TCEQ and responsible entities will periodically assess the results of implemented activities and other sources of information to evaluate this I-Plan revision. Several factors may be evaluated, such as the pace of implementing planned activities, effectiveness of best management practices, load reductions, and progress toward meeting water quality standards. Evaluations will be in the form of annual progress reports each April, followed by annual meetings each May. If the responsible parties find through periodic assessments that insufficient progress has been made in improving water quality, the implementation strategy may be adjusted, consistent with the principles of adaptive management.

Summary and Discussion of Data Used

Multiple entities monitor Gilleland Creek water quality at different sites, using different analytical methods and at different sample frequencies. Some monitoring is done under the Texas Clean Rivers Program (https://www.tceq.texas.gov/waterquality/clean-rivers), and thus generates *E. coli* data of consistent quality utilized in water quality assessments by TCEQ (see Water Quality Indicators). Other entities sample water quality for different objectives and with different levels of quality control, and generate data that is not assessed by TCEQ.

In an effort to more completely understand the patterns of fecal contamination within the Gilleland Creek watershed, as part of the development of this Implementation Plan, all available *E. coli* routine monitoring data from Gilleland Creek was compiled from publicly-accessible Internet resources and reviewed (Table 19). This includes data collected by paid professionals, as well as data collected by trained volunteers through the CRWN.

Table 19. Sources of *E. coli* data included in the review of this Implementation Plan

Collecting Entity	Data Source
City of Austin Watershed Protection Department	https://data.austintexas.gov/Environmental/Water-Quality-Sampling-Data/5tye-7ray/data
Colorado River Watch Network	https://crwn.lcra.org/
Lower Colorado River Authority	http://waterquality.lcra.org/
Texas Commission on Environmental Quality	http://www80.tceq.texas.gov/SwqmisWeb/public/crpweb.faces

Nineteen Gilleland Creek sites with *E. coli* data were identified, with data ranging from 1994 to 2017. For presentation purposes, sites are nicknamed based on a combination of subwatershed prefix (Gilleland=G, West Gilleland=W, Harris Branch=H, Decker=D) and downstream-to-upstream order (most downstream site = 1, second most downstream site = 2, etc.) (Figure 3). There were insufficient *E. coli* data from Elm Creek for analysis.

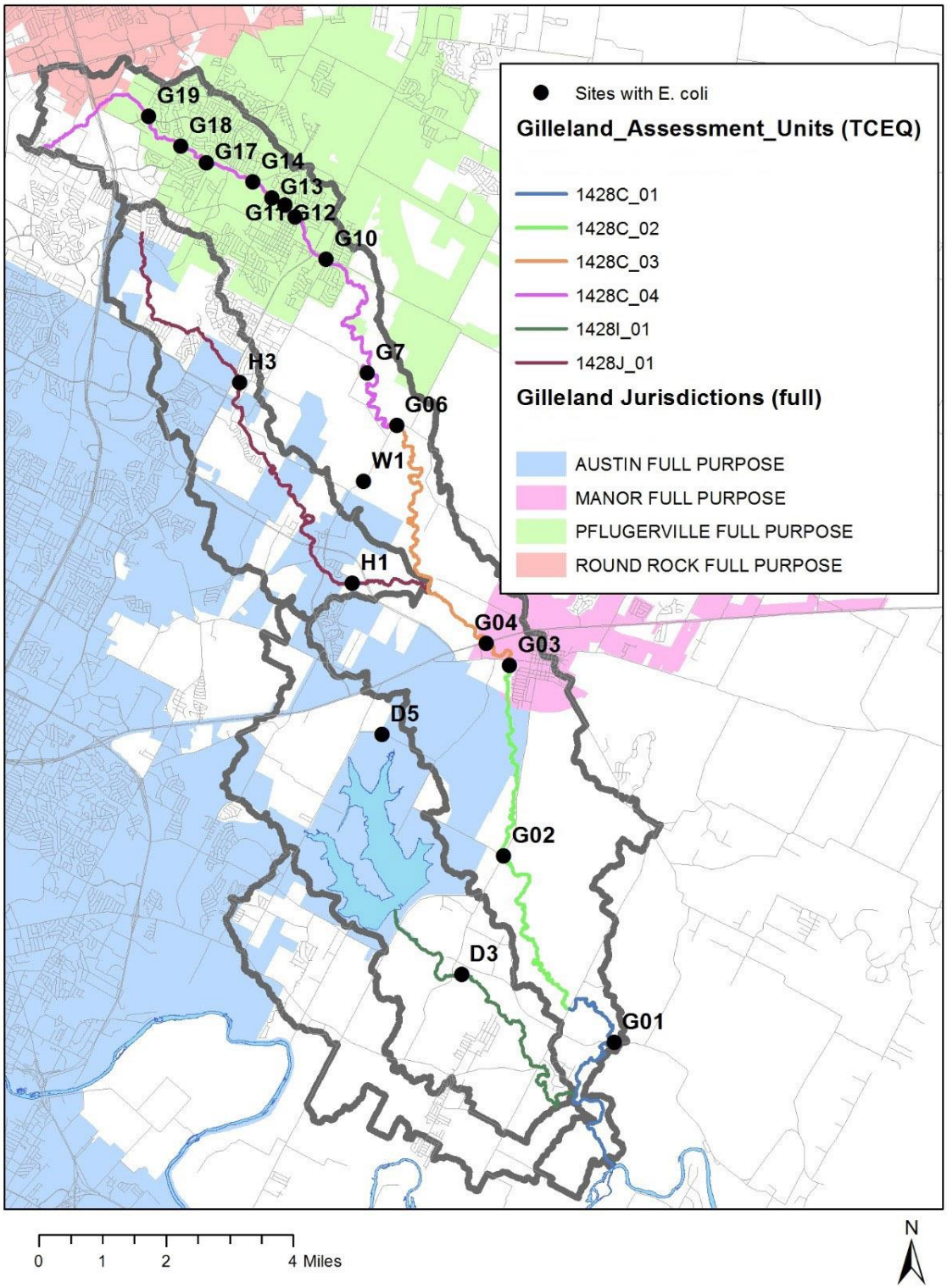

Figure 3. Gilleland Creek sites with *E. coli* data included in this analysis

G=Gilleland, W=West Gilleland, H=Harris Branch, D=Decker Creek

Using data from 2009 to 2017, the geometric mean *E. coli* concentrations exceed the primary contact recreation criteria of 126 cfu/100 mL at 14 of 19 sites (Table 20). This table shows the number of samples (#), year of first sample (First), year of last sample (Last), minimum *E. coli* measurement (Min), maximum *E. coli* measurement, geometric mean *E. coli* using all data (Geomean all), geometric mean *E. coli* using all data since 2009 (Geomean since 2009), and geometric mean *E. coli* excluding Colorado River Watch Network volunteer monitoring data since 2009 (Geomean since 2009 no CRWN).

Table 20. Summary of *E. coli* data used in this analysis

E. coli in MPN/100 mL. Highlighted cells exceed the 126 *E. coli* cfu/100 mL primary contact recreation criteria. #N/A indicates only Colorado River Watch Network volunteer monitoring data available.

Site	#	First	Last	Min	Max	Geomean (all)	Geomean (since 2009)	Geomean (since 2009 no CRWN)
G19	70	2008	2016	10	5200	153	157	#N/A
G18	94	2008	2016	1	12710	151	153	#N/A
G17	55	2009	2016	1	1049	117	117	#N/A
G14	58	2009	2017	1	2100	99	99	#N/A
G13	23	2006	2017	100	4111	291	265	#N/A
G12	25	2012	2017	67	1200	245	245	#N/A
G11	117	2005	2017	17	882	179	188	277
G10	45	2008	2017	1	733	110	106	#N/A
G07	31	2009	2017	36	3500	349	349	384
G06	25	2005	2017	48	435	184	207	207
W1	14	2005	2017	19	1011	116	131	131
H3	21	2005	2017	70	3000	519	394	394
H1	23	2005	2017	7	2420	158	224	224
G04	18	2009	2012	46	490	211	211	211
G03	24	2005	2017	23	500	130	139	139
G02	61	2004	2017	12	5800	100	100	100
G01	149	1994	2017	22	24000	175	195	195
D5	14	2005	2017	4	2420	156	216	216
D3	24	2005	2017	3	649	23	35	35

Exceedances of the primary contact recreation criteria occur throughout the watershed (Figure 4). Higher geometric mean values are observed in the upper portion of the watershed.

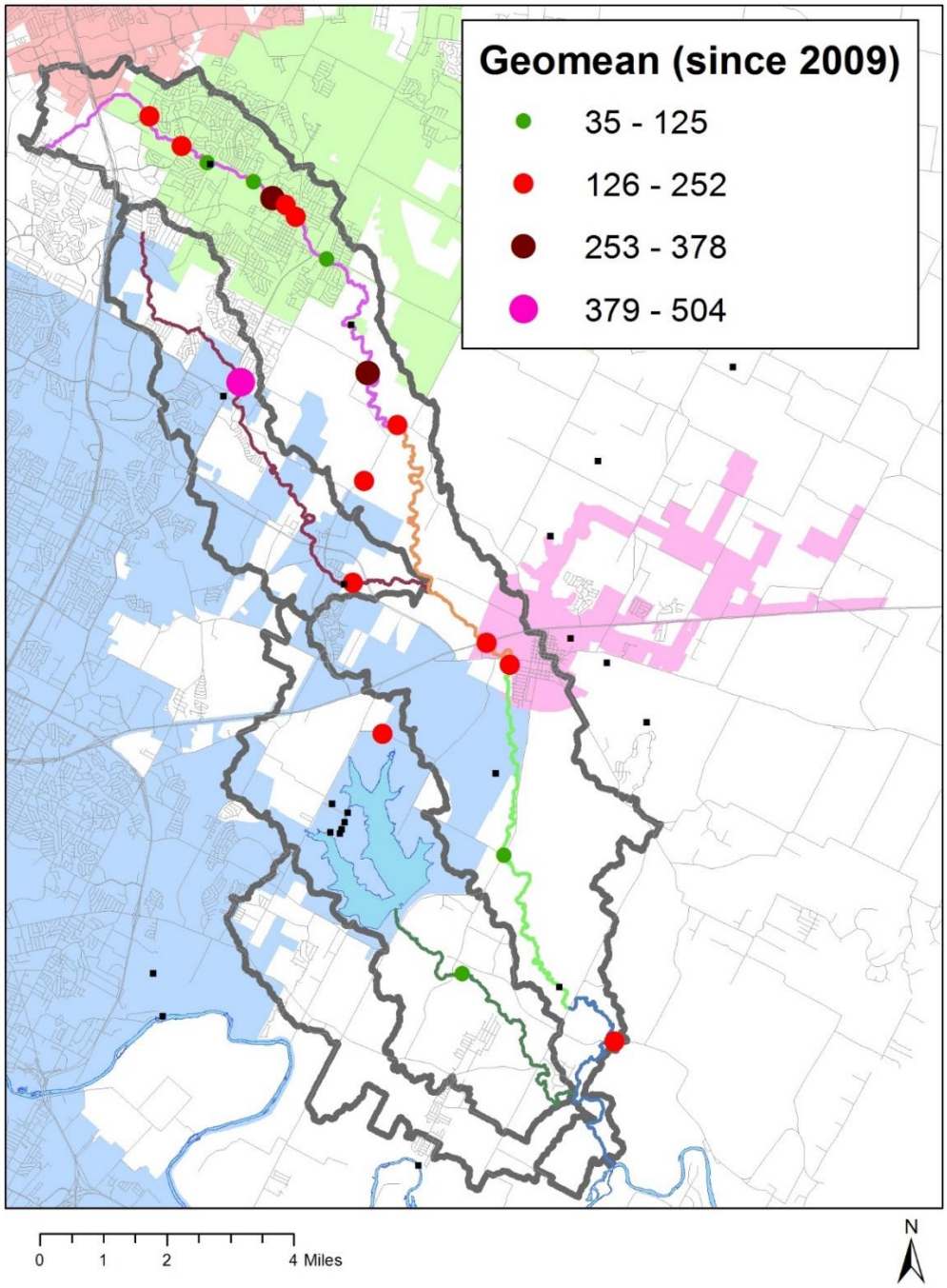

Figure 4. *E. coli* geometric means in MPN/100 mL

Black squares represent permitted discharges of treated wastewater effluent. Only green circles represent sites with geometric mean *E. coli* values less than the primary contact recreation criteria of 126 cfu/100 mL.

Because sampling frequencies and sampling dates between entities vary, individual samples collected during non-storm influenced conditions (no rainfall for at least 3 days prior to sampling) at multiple sites on the same day were qualitatively assessed for longitudinal patterns in an attempt to limit frequency and timing confounding factors (Table 21). Dates were selected to provide as many sites for comparison as possible. No obvious or consistent spatial patterns are evident.

Table 21. *E. coli* (MPN/100 mL) samples at multiple sites on the same day during non-storm influenced conditions

Highlighted cells exceed the 126 *E. coli* cfu/100 mL primary contact recreation criteria.

Site	30-Mar-05	16-Dec-09	15-Apr-15	10-Jan-17
G11	17	127	272	222
G06	310	66	154	361
H3	138	27	133	19
H2	205	70	166	91
H1	205	167	387	63
G03	500	36	236	102
G02	310	135	115	23
G01	250	22	313	44
D5	130	71	59	548
D3	28	133	96	5
E3	120	10	29	10

Temporal trends were assessed using running 20-sample geometric mean values for sites on the main stem of Gilleland Creek. Only main stem Gilleland Creek sites were assessed because these sites had the highest sampling frequency (Figure 5). Geometric means may be increasing over time at upstream sites (G14, G17, G18, G19), all located within the City of Pflugerville jurisdiction. Geometric means may also be increasing (degrading) even more dramatically over time at the mouth (G01), within unincorporated Travis County. Geometric means may be decreasing (improving) at G02, G07, G10 and G11. Sites G10 and G11 are located in the downstream portion of the City of Pflugerville jurisdiction.

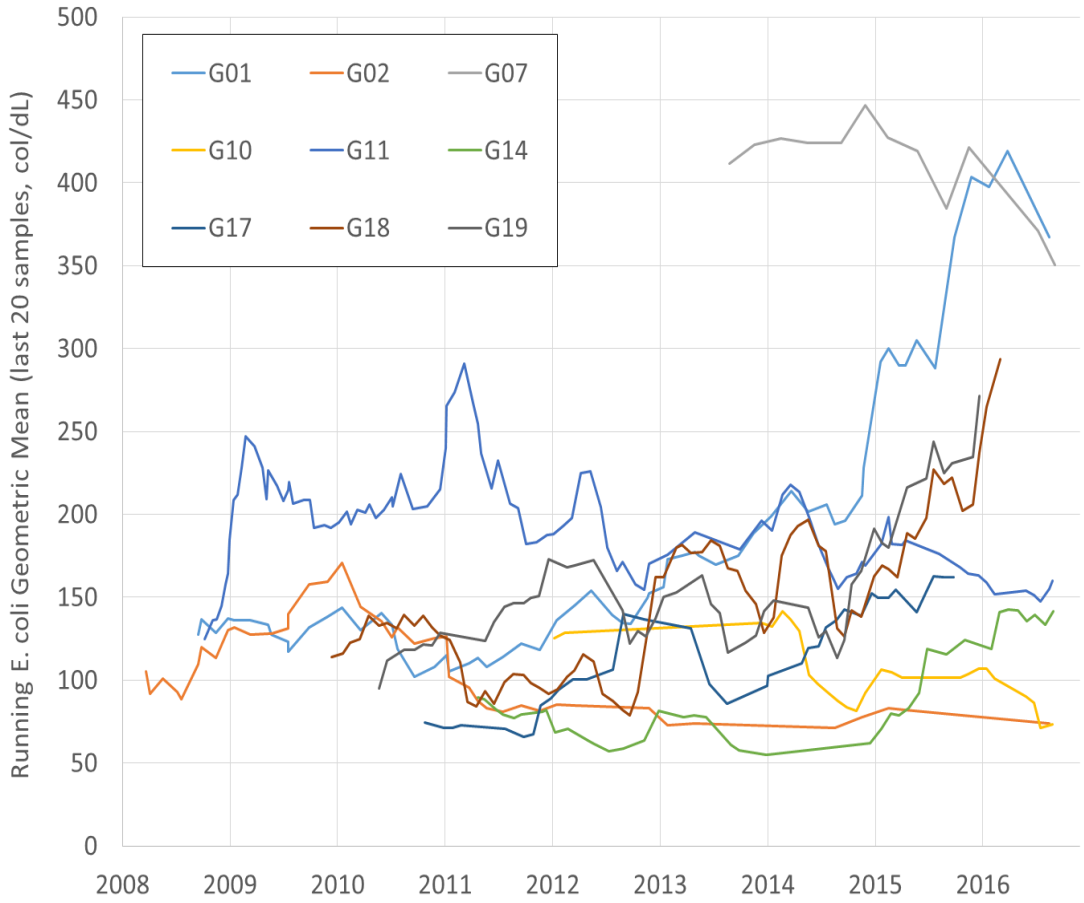

Figure 5. Running *E. coli* (MPN/100 mL) geometric means by site over time calculated using the prior 20 samples

The City of Austin EII is a multi-metric index assessing overall water quality conditions at a wide range of sites in the greater Austin area (https://austintexas.gov/department/environmental-integrity-index). While fecal bacteria are elevated in Gilleland Creek from nonpoint sources as noted in this revised Implementation Plan, and nutrients are elevated from permitted point source discharges of treated wastewater effluent, other indicators of water quality are generally good. Aquatic habitat, aquatic life (benthic macroinvertebrates and diatom), and aesthetic condition index scores are good and sediment toxicity is low based on EII assessments. Gilleland Creek EII scores are generally stable over time from 1999 to 2015, and Gilleland Creek ranks better than 26 out of the 49 watersheds assessed in recent assessments.

References

Alderisio, K. A., Wait, D. A., and M. D. Sobsey. 1996. Detection and Characterization of Male Specific RNA Coliphages in a New York City Reservoir. In Watershed Restoration Management New York City Water Supply Studies (ed. J. J. McDonnell, D. L. Leopold, J. B. Stribling & L. R. Neville), pp. 133–142. American Water Resources Association, Herndon, Virginia.

Alhajjar, B.J. and G. Chesters, J.M. Harkin. 1990. Indicators of Chemical Pollution from Septic Systems. Ground Water. 28(4): 559-568.

American Veterinary Medical Association (AVMA). 2007. U.S. Pet Ownership and Demographics Sourcebook, 2007 Edition.

Brown, E., and D. Caraco, R. Pitt. 2004. Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments. U.S. Environmental Protection Agency Cooperative Agreement X-82907801-0. Prepared by the Center for Watershed Protection and University of Alabama.

Byappanahalli, M. N., and S. Ishii. 2011. Environmental Sources of Fecal Bacteria. The Fecal Bacteria, edited by M.J. Sadowsky and R.L. Whiman, ASM Press.

Cameron Engineering & Associates, LLP. 2012. Pathogen Load Assessment for the Peconic Estuary Program. Prepared for the Suffolk County Department of Health Services. http://peconicestuary.org/wp-content/uploads/2017/06/PathogenLoadAssessmentforthePec.pdf.

Casteel, M. J., Bartow, G., Taylor, S. R., and Sweetland, P. 2005. Removal of Bacterial Indicators of Fecal Contamination in Urban Stormwater Using a Natural Riparian Buffer. 10th International Conference on Urban Drainage, Copenhagen/Denmark.

City of Austin. 2011. Lower Bull Creek District Park Contact Recreation Use Assessment Update, January 2011. City of Austin Watershed Protection Department and Austin/Travis County Health an.d Human Services Department. SR-11-07.

Corapcioglu, Y. and C. Munster, S. Pillai. 1997 Transport, Survival of Viruses in Ground Water Systems Studied. Ground Water Monitoring and Remediation 17:41.

Dalmasy, D., and L. Currey, A. Soehl. 2007. Fecal Pollution, What is Your Contribution? eMDE, quarterly newsletter of the Maryland Department of the Environment. II (7).

Duncan, A. 2012. A functional approach to riparian restoration. City of Austin Watershed Protection Department. SR-12-05. http://www.austintexas.gov/watershed_protection/publications/document.cfm?id=196455.

Duncan, A., and S. Wagner, M. Scoggins, A. Richter. 2011. Riparian Reference Condition: Using Regional Plant Composition to Guide Functional Improvements in the City of Austin. City of Austin Watershed Protection Department. SR-11-13.

Duncan, A., M. Scoggins, S. Wagner. 2012. City of Austin Riparian Zone Restoration Site Prioritization. City of Austin Watershed Protection Department. SR-12-13.

Environmental Protection Agency (EPA). 1997. Response to Congress on Use of Decentralized Wastewater Treatment Systems. U.S. Environmental Protection Agency, Office of Water.

Environmental Protection Agency (EPA). 2001. Source Water Protection Practices Bulletin: Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. EPA 916-F- 01-027.

Environmental Protection Agency (EPA). 2004. Report to Congress: Impacts and Control of CSOs and SSO. United States Environmental Protection Agency, Office of Water. EPA 833- R-04-001.

Environmental Protection Agency (EPA). 2005. A Homeowners Guide to Septic Systems. EPA- 832-B-02-005.

Gilpin, C. A., Barrett, M., 2014. Retrofit of an Existing Flood Control Facility to Improve Pollutant Removal. The University of Texas at Austin.

Gordon, D.M., and S. Bauer, J.R. Johnson. 2002. The Genetic Structure of Escherichia coli Populations in Primary and Secondary Habitats. Microbiology 148(5): 1513-1522.

Hagedorn, C. 1984. Microbiological Aspects of Groundwater Pollution Due to Septic Tanks. In Groundwater Pollution Microbiology, edited by G. Bitton and C.P. Gerba. John Wiley and Sons, New York.

Herrington, C., and M. Westbrook, M. Menchaca. 2010. Wastewater Disposal Practices and Change in Development in the Barton Springs Zone. City of Austin Watershed Protection Department. SR-11-01.

Hobbs, R. J., and Cramer, V. A. 2008. Restoration Ecology: Interventionist Approaches for Restoration and Maintaining Ecosystem Function in the

Face of Rapid Environmental Change. Annu. Rev. Environ. Resourc., 33: 39-61.

Hobbs, R. J., and Prach, K. 2008. Spontaneous Succession versus Technical Reclamation in the Restoration of Disturbed Sites. Restoration Ecology, Vol. 16, no. 3, pp. 363-366.

Kauffman, J. B., Beschta, R. L., Otting N., and Lytjen, D. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries vol. 22 No. 6.

Lee, K.H., T.M. Isenhart, and R.C. Schultz. 2003. Sediment and Nutrient Removal in an Established Multi-Species Riparian Buffer. Journal of Soil and Water Conservation Jan-Feb 2003 v58 i1 pS1 (8).

Mayer, P. M., Reynolds Jr., S. K., and Canfield, T. J. 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. EPA/600/R05/118.

Meals, D. W. 2001. Water Quality Response to Riparian Restoration in an Agricultural Watershed in Vermont, USA. Water Science and Technology Vol 43 No 5 pp 175–182.

Metcalf and Eddy, Inc. 1979. Wastewater Engineering: Treatment, Disposal, Reuse. McGrawHill, Boston.

Meyer, J. L., Strayer, D. L., Wallace, B. L., Eggert, S. L., Helfman, G. S., and Leonard, N. E. 2007. The Contribution of Headwater Streams to Biodiversity in River Networks. Journal of the American Water Resources Association. Vol 43 No 1.

Olańczuk-Neyman, K., and H. Stosik-Fleszar, S. Mikołajski. 2001. Evaluation of Indicator Bacteria Removal in Wastewater Treatment Processes. Polish Journal of Environmental Studies 10(6): 457-461.

PBS&J. 2010. Miller Creek Technical Report (WBID 2287). Prepared for the Department of Environmental Protection, Tallahassee, FL.

Porras, A., and A. Richter, C. Herrington. 2013. Relationship of Fecal Indicator Bacteria to Demographic Patterns and Land Use in Austin, Texas. City of Austin Watershed Protection Department. SR-13-10.

Propst, C.W., and V.J. Harwood, G. Morrison. 2011. Case Studies of Urban and Suburban Watersheds in Microbial Source Tracking: Methods, Applications, and Case Studies. Edited by C. Hagedorn, A.R. Blanch, V.J. Harwood. Springer, New York.

Richardson, M. D., Holmes, P. M., Esler, K. J., Galatowitsch, S. M., Stromberg, J. C., Kirkman, S. P., Pysek, P., and Hobbs, R. J. 2007. Riparian Vegetation: Degradation, Alien Plant Invasion, and Restoration Prospects. Diversity and Distributions, 13: 126-139.

Richter, A., and A. Duncan. 2012. Riparian Functional Assessment: Choosing Metrics that Quantify Restoration Success in Austin, Texas. City of Austin Watershed Protection Department. SR-12-12.

Samadpour, M., and N. Checkowitz. 1998. Little Soos Creek Microbial Source Tracking. Resource. University of Washington Urban Water Resources Center.

Sercu, B., and L. C. Van De Werfhorst, J. Murray, P. A. Holden. 2009. Storm Drains Are Sources of Human Fecal Pollution during Dry Weather in Three Urban Southern California Watersheds. Environmental Science and Technology 43(2): 293-298.

Sobsey, M.D., and M.J. Casteel, H. Chung, G. Lovelace, O. D. Simmons III, J. S. Meschke. 1998. Innovative technologies for Wastewater Disinfection and Pathogen Detection. In Proceedings of Disinfection '98, The Latest Trends in Wastewater Disinfection: Chlorination versus UV Disinfection, Water Environment Federation Technical Exhibit and Conference, Baltimore, MD, April 19-22, pp. 483-493.

Sung, C. Y., Ming-Han, L., Rogers, G. O., Volder, A., and Wang, Z. 2011. Investigating Alien Plant Invasion in Urban Riparian Forests in a Hot and Semi-Arid Region. Landscape and Urban Planning 100: 278–286.

Swann, C. 1999. A Survey of Residential Nutrient Behaviors in the Chesapeake Bay. Widener Burrows, Inc. Chesapeake Research Consortium. Center for Watershed Protection. Ellicott City, MD. 112 pp.

TCEQ. 2007. One Total Maximum Daily Load for Bacteria in Gilleland Creek (Segment 1428C). https://www.tceq.texas.gov/assets/public/waterquality/tmdl/69gilleland/69-gillelandbacteria-adopted.pdf.

TCEQ. 2010. Four Total Maximum Daily Loads for Indicator Bacteria in Halls Bayou and Tributaries. Adopted by the TCEQ September 15, 2010.

TCEQ. 2011. Implementation Plan for One Total Maximum Daily Load for Bacteria in Gilleland Creek Segment 1428C. https://www.tceq.texas.gov/assets/public/waterquality/tmdl/69gilleland/69-gillelandiplan.pdf.

TCEQ. 2014. 2014 Texas Integrated Report for Clean Water Act Sections 303(d) and 305(b) (TCEQ 2014). https://www.tceq.texas.gov/waterquality/assessment/14twqi/14txir.

U.S. Census Bureau. 2010. Decennial Census 2010. https://www.census.gov/.

U.S. Department of Agriculture (USDA). 2017. National Agricultural Statistics Service. https://www.nass.usda.gov/index.php.

U.S. Department of Agriculture (USDA), Natural Resources Conservation Service. 2005. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_035763.pdf

van der Wel, B. 1995. Dog Pollution. The Magazine of the Hydrological Society of South Australia 2(1).

Wagner, S. 2013. Upper Boggy Creek Willowbrook Reach Riparian Restoration. City of Austin Watershed Protection Department. SR-13-04.

Williams, L., and M. Scoggins, A. Richter. 2013. Using Leaf-Litter to Determine Ecological Function of Urban Riparian and Stream Systems in Austin, Texas. City of Austin Watershed Protection Department. SR-13-09.

Young, R. A., Huntrods, T., and Anderson, W. 1980. Effectiveness of Vegetated Buffer Strips in Controlling Pollution from Feedlot Runoff. J. Environ. Qual., Vol. 9, no. 3.