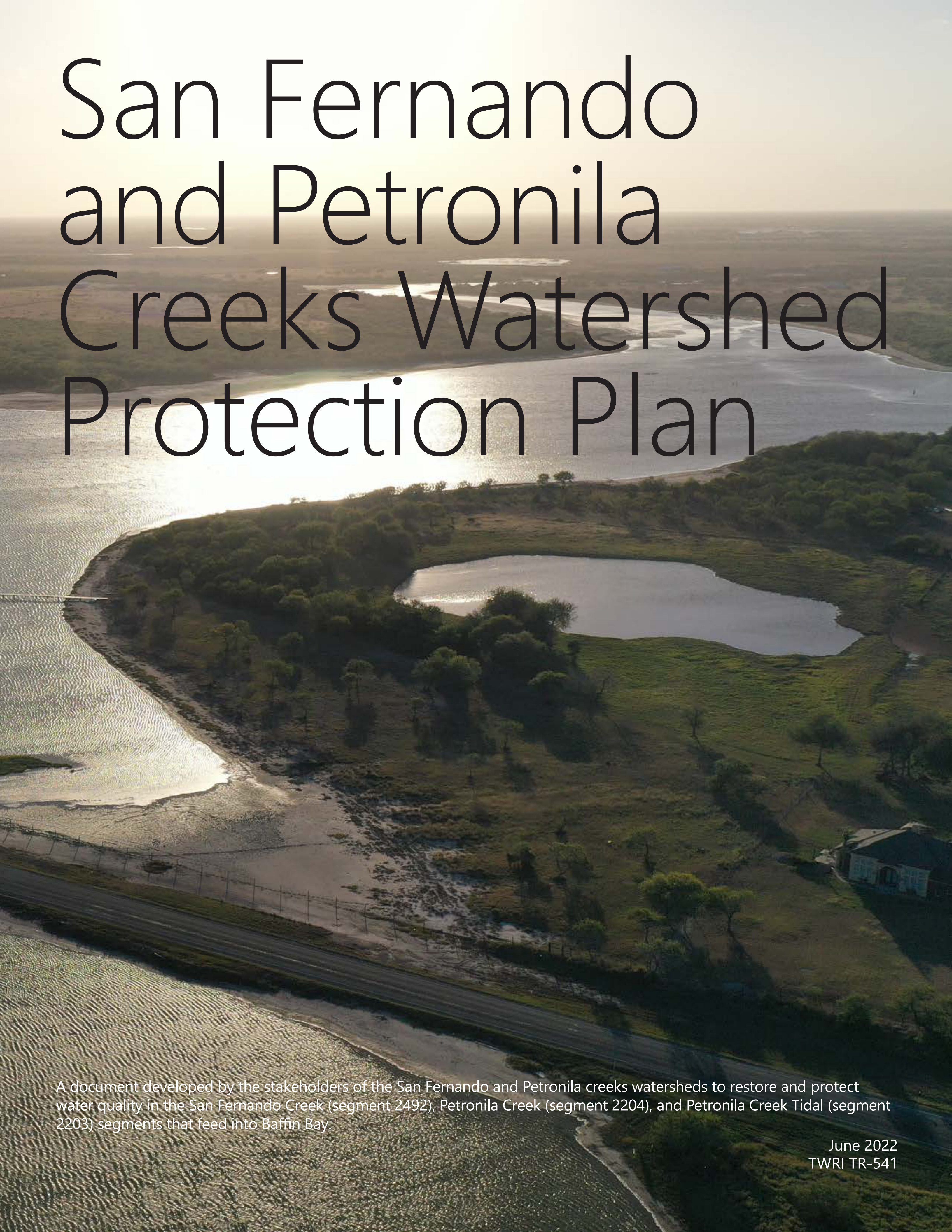
San Fernando and Petronila Creeks Watershed Protection Plan



A document developed by the stakeholders of the San Fernando and Petronila creeks watersheds to restore and protect water quality in the San Fernando Creek (segment 2492), Petronila Creek (segment 2204), and Petronila Creek Tidal (segment 2203) segments that feed into Baffin Bay.

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Authored and prepared by:

Lucas Gregory, Clare Escamilla, and Ennis Rios

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Cover photos by Ennis Rios:
Front: Baffin Bay looking West at FM 628.
Back: Loyola Beach community on Baffin Bay.

Birds on Baffin Bay North of Kaufer-Hubert Memorial Park. Photo by Ennis Rios.

Acknowledgments

This document presents the strategies developed by the San Fernando and Petronila creeks watersheds stakeholders to restore and protect water quality in the creeks and in Baffin Bay, into which they ultimately flow. Stakeholders dedicated considerable time and effort discussing the watersheds, influences on water quality, and potential methods to address water quality concerns during the process to select appropriate strategies to improve water quality.

Special appreciation is extended to the many individual watershed landowners and residents who participated in numerous meetings and events to provide direct input to the plan. The direct involvement of landowners and residents was critical to ensuring the plan included feasible management measures that address sources of water quality impairments in the watersheds. The time and effort of landowners and residents are greatly appreciated, and their efforts are reflected in the contents of this plan.

Local and regional government agencies and organizations also played key roles in plan development. Representatives provided insight regarding their specific focus areas and ensured the inclusion of plan contents appropriate for the watersheds.

Contributing Stakeholder Groups and Agencies:

- Aqua Strategies
- Baffin Bay Stakeholders Group
- City of Kingsville
- Clean Coast Texas
- Coastal Bend Bays & Estuaries Program
- Duval, Jim Wells, Kleberg, and Nueces counties
- Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi
- King Ranch, Inc.
- Nueces River Authority
- Soil and Water Conservation Districts
    - Agua Poquita Soil and Water Conservation District #321
    - Jim Wells Country Soil and Water Conservation District #355
    - Kleberg-Kenedy Soil and Water Conservation District #356
    - Nueces Soil and Water Conservation District #357
- Texas A&M AgriLife Extension Service
- Texas A&M AgriLife Research
- Texas A&M University-Corpus Christi Faculty
- Texas Commission on Environmental Quality
- Texas Department of Transportation
- Texas Parks and Wildlife Department
- Texas Sea Grant
- Texas State Soil and Water Conservation Board
- The Voices of the Colonias
- U.S. Department of Agriculture Natural Resource Conservation Service

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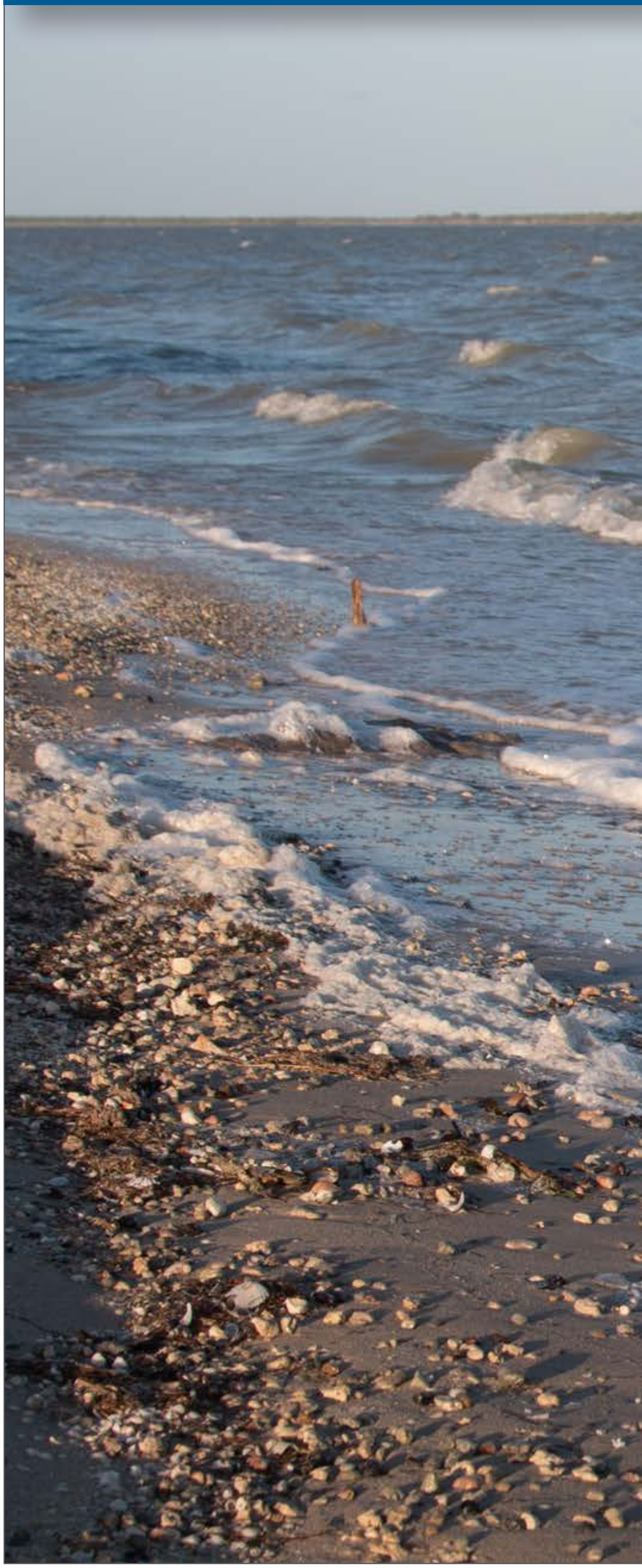
List of Abbreviations

Acronym	Meaning
ac	Acre
AgriLife Extension	Texas A&M AgriLife Extension Service
AnU	Animal Unit
AU	Assessment Units
AVMA	American Veterinary Medical Association
BMP	Best Management Practice
CBBEP	Coastal Bend Bay & Estuaries Program
CCT	Clean Coast Texas
cfu	Colony Forming Unit
cfs	Cubic Feet Per Second
CP	Conservation Plan
CRP	Clean Rivers Program
CSA	Critical Source Areas
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DAR	Drainage-Area Ratio
DMU	Deer Management Unit
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
g	Gram
GIS	Geographic Information System
HRI	Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi
HUC	Hydrologic Unit Code
I&I	Inflow and Infiltration
L	Liter
lb	Pound
LDC	Load Duration Curve
LIP	Landowner Incentive Program
LULC	Land Use and Land Cover
µg	Microgram

Acronym	Meaning
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
mi^2	Square Miles
mL	Milliliter
MPN	Most Probable Number
MSL	Mean Sea Level
NASS	National Agricultural Statistics Service
NLCD	National Land Cover Database
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NRA	Nueces River Authority
OSSF	On-site Sewage Facility
RCPP	Regional Conservation Partnership Program
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SEP	Supplemental Environmental Projects
SSO	Sanitary Sewer Overflow
STEPL	Spreadsheet Tool for Estimating Pollutant Loading
SWCD	Soil and Water Conservation District
Texas Integrated Report	*Texas Integrated Report of Surface Water Quality*
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WPP	Watershed Protection Plan
WQMP	Water Quality Management Plan
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

Executive Summary



Baffin Bay shoreline. Photo by Lucas Gregory.

This watershed protection plan (WPP) presents a course of action to restore and protect water quality in the San Fernando and Petronila creeks watersheds and ultimately Baffin Bay. By approaching water quality issues at the watershed level rather than political boundaries, this plan holistically identifies potential pollutant sources and solutions. This approach also incorporates the values, visions, and knowledge of individuals with a direct stake in water quality conditions.

Problem Statement

Water quality monitoring indicates that sections of San Fernando and Petronila creeks do not meet water quality standards established to protect contact recreation uses. *Escherichia coli (E. coli)* and enterococci concentrations measured are typically above what is considered acceptable levels and signify a potentially increased health risk to waterbody users engaged in contact recreation. Tidal and above tidal segments of Petronila Creek were first identified as impaired in the *2016* and *2010 Texas Integrated Report and 303(d) List,* respectively, while San Fernando Creek was first identified as impaired in the *2006 Texas Integrated Report and 303(d) List.* Elevated chlorophyll-a concentration concerns also exist and signify the presence of excessive algal growth within the creeks associated with nutrient inputs from across the watershed.

With water quality impairments, a need to plan and implement measures that restore water quality and ensure safe and healthy water for stakeholders arises. An assessment and planning project was undertaken to develop the San Fernando and Petronila Creeks Watershed Protection Plan to meet this need.

Action Taken

Prior to drafting the WPP, a detailed watershed land and water resource analysis was conducted to understand water quality conditions and what watershed features were contributing to these conditions. This information and general watershed characteristics data were provided to watershed stakeholders who volunteered their time to participate in the planning process. Discussions ensued regarding the distribution and estimates of potential bacteria pollution source contributions and their impacts to water quality. Specific contributions from each named source are not known and vary greatly across space and time. Regardless of how much a single source contributes, it was acknowledged that it is up to watershed stakeholders to be good stewards of land and water resources across the watershed by doing what each person can to reduce downstream water quality impacts.

Ultimately, stakeholders decided to focus on addressing bacteria sources in the watershed that are feasible to manage with a priority for addressing human sources. Engaging watershed stakeholders was the critical part of the WPP development process and the time and energy contributed to the planning process was invaluable. Stakeholder energy to support improved land and water resources management through expanded stewardship efforts is evident in the collective efforts that are already occurring across the watershed and will ultimately lead to improved water quality, aquatic habitat and aquatic life in Baffin Bay for generations to come.

Watershed Protection Plan Overview

This document is the culmination of the stakeholder process undertaken to identify pollution sources and methods to reduce pollutant loads in San Fernando and Petronila creeks. By comprehensively considering multiple potential pollutant sources, this plan describes management strategies that will cost effectively reduce pollutant loadings when implemented. Despite extensive amounts of information gathered during WPP development, a better understanding of the watersheds and the effectiveness of management measures will undoubtedly develop over time. As such, this plan is a living document that will evolve as needed through the adaptive management process. Lessons learned from implementation and generation of new knowledge regarding factors that influence water quality will intermittently trigger updates or addenda to the WPP that will improve its overall effectiveness and impact on water resource stewardship.

Pollutant Sources

Stakeholder input, backed by credible science, was used to identify potential sources of fecal-derived bacteria pollutants and dissolved oxygen depressing nutrient pollutants. Sources of bacteria loading identified include deer, feral hogs, household pets, livestock, on-site sewage facilities, stormwater runoff, and wastewater treatment facilities. While other bacteria sources are present in the watersheds, available information was insufficient to reliably estimate loadings.

Recommended Actions

Seven primary recommended actions are included in the WPP to improve water quality in the San Fernando and Petronila creeks watersheds. Individual recommendations were crafted to address bacteria pollution but in many cases those recommendations will have ancillary effects on other pollutants such as nutrient and sediment. An alphabetical summary of these actions follows.

Feral Hog Control

Feral hog management was identified as an important need in the San Fernando and Petronila creeks watersheds due to this invasive species' impacts to water quality, landscape disturbances and economic losses. Feral hogs routinely congregate near water and thus have a higher potential to directly impact water quality than other animal species. Active and passive management controls will be voluntarily implemented throughout the watersheds to help control populations and reduce damage to lands and riparian areas. Landowners will be encouraged to continue voluntary trapping and removal of feral hogs on their own and with assistance from various agencies. Educational programs will be brought to the watersheds to discuss proper management techniques and highlight new methods to remove them from the watershed.

Illicit Dumping

Water quality impacts from illicit dumping are difficult to quantify in terms of impact on bacteria and nutrient loadings, but it can cause health and safety issues throughout the watersheds, is unsightly and is an environmental hazard. Watershed stakeholders expressed a strong desire to clean up and reduce future dumping across the watershed. Educational signage will be increased at bridges and road crossings to try to reduce dumping at these locations. Household and hazardous waste collection events are also recommended across the watersheds to provide an appropriate means of disposal.

On-Site Sewage Facilities

Failing on-site sewage facilities, especially those located close to a water body, are known to contribute to water quality impairments. Additionally, human pollution sources are viewed as a broader human health concern due to the potential for disease transmission to other watershed residents. Strategies to improve on-site sewage facilities management include educational programs on how to operate and maintain septic systems. Efforts will be implemented to identify, repair, and replace failing on-site sewage facilities as funds are available with priority placed on systems nearest water bodies and in close proximity to each other.

Pet Waste

Pet waste was identified as a significant potential contributor of bacteria and nutrient loading in isolated the watersheds – primarily around population centers. Outreach and education are key components to proper pet waste management by owners. Increasing the number of pet waste stations in public parks and apartment complexes will increase the likelihood of proper waste disposal but without education regarding the need for proper disposal behavior regarding pet waste disposal is unlikely to change.

Sanitary Sewer Overflows

Although infrequent, sanitary sewer overflows and unauthorized wastewater treatment facility discharges can contribute to bacteria loads. Identifying and repairing or replacing failing infrastructure is important to prevent unauthorized discharges. Education and outreach are also important to teach homeowners about proper fats, oils, grease, and other non-flushable disposal to prevent damage to sewer collection systems.

Urban Stormwater Runoff Management

Stormwater generation from urbanized, or developed areas, can be significant at times. Flooding is the primary stakeholder concern. Nature-based stormwater infrastructure provides an opportunity to manage stormwater and mitigate flooding while also yielding water quality improvements and providing aesthetic value to the community. This management recommendation focuses largely on educating decision makers about management practice options, developing management demonstration locations with educational signage to describe the practices and their benefits.

Water Quality Management Plans or Conservation Plans

Reducing bacteria and nutrient loadings from agricultural landscapes through voluntary implementation of site-specific water quality management plans and conservation plans is recommended. These plans include technical assistance to help landowners implement best management practices that improve land stewardship and protect water quality and may qualify some landowners for financial assistance to implement recommended practices. Each plan is unique to the individual landowner's needs and property. Example management practices are brush management, alternate water sources and shade areas for livestock, fencing, buffer strips, nutrient management and conservation tillage among others. Ultimately, the goal of these practices is to improve management of the landscape such that more water is retained on-site for forage production and less runoff leaves the property.

Education and Outreach

Providing continued information to stakeholders regarding watershed plan implementation and water quality status is necessary to maintain active participation and progress towards achieving defined water quality goals. Implementation progress updates, new findings and other relevant information will be delivered through Baffin Bay Stakeholder Group meetings and through presentations at meetings of other existing groups in and around the watershed. Specific education programs will be provided that deliver information regarding improved strategies to manage specific resource management concerns and simultaneously enhance water quality.

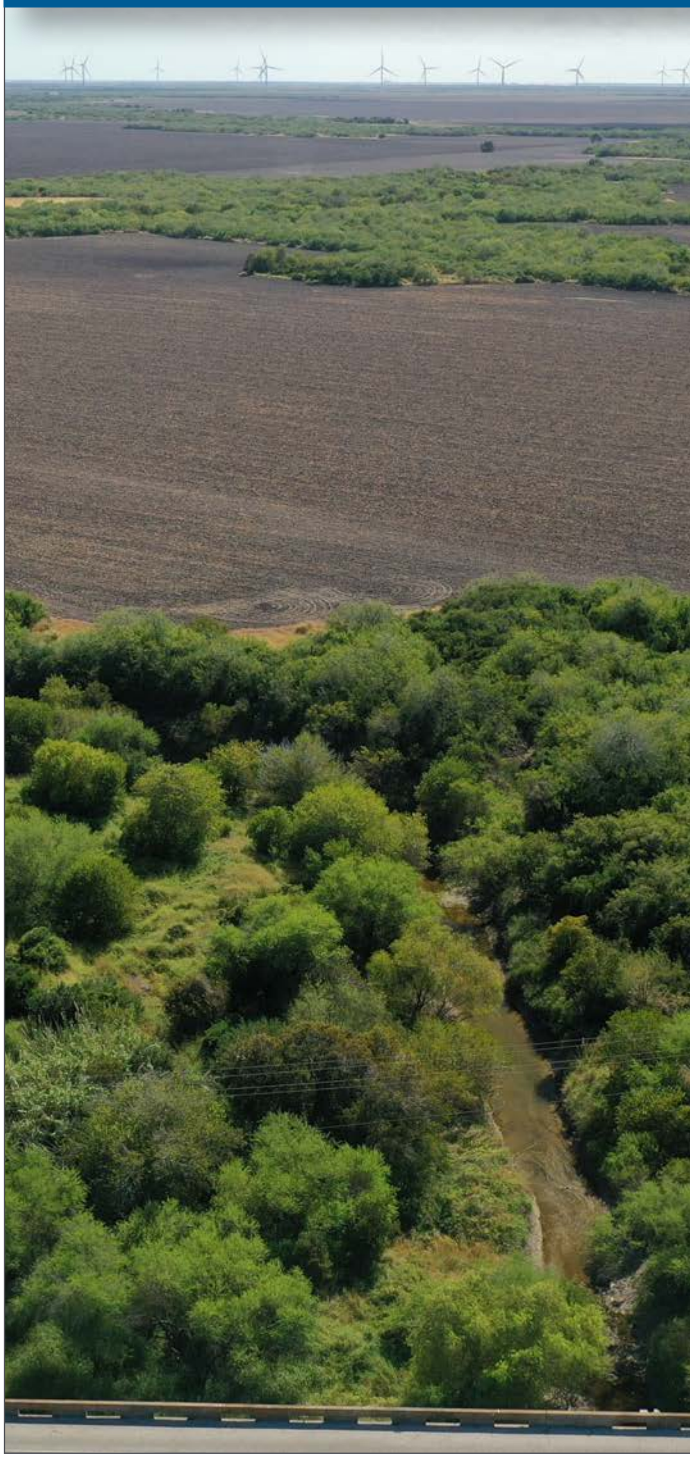
Tracking Progress

Progress implementing the WPP will ultimately be measured by improvements in water quality relative to the water quality standard. However, the number of individual management measures implemented and the extent of their coverage, events held in the watershed, and people engaged through activities or events will also signify implementation success. These metrics will all inform the adaptive management process and influence future watershed plan updates.

Plan Goals

The primary goal of this plan is to ultimately achieve bacterial water quality standards and reduce other pollutant concerns in both creeks through voluntary implementation of recommended management actions across the watershed following a 10-year implementation phase. While improvements can be made in managing most sources of pollution identified in the watershed, stakeholders identified human sources; on-site sewage facilities and wastewater treatment facilities, as those where focus should be placed. Ultimately, this plan sets forth a roadmap to improve land and water stewardship that facilitates continued use of watershed resources to sustain their livelihoods while restoring local water quality.

Chapter 1 Introduction to Watershed Management



Petronila Creek looking downstream from FM 665 in Nueces County. Photo by Ennis Rios.

The Watershed Approach

The watershed approach is widely accepted by state and federal water resource management agencies to facilitate water quality management. The U.S. Environmental Protection Agency (EPA) describes the watershed approach as "a flexible framework for managing water resource quality and quantity within a specified drainage area or watershed" (EPA 2008). The watershed approach requires engaging stakeholders to make management decisions supported by sound science (EPA 2008). One critical aspect of the watershed approach is that it focuses on hydrologic boundaries rather than political boundaries to address potential water quality impacts affecting all potential stakeholders.

A stakeholder is anyone who lives, works, or has interest within the watershed or may be affected by efforts to address water quality issues. Stakeholders may include individuals, groups, businesses, organizations, or agencies. Continuous involvement of stakeholders throughout the watershed approach is critical for effectively selecting, designing, and implementing management measures that address watershed water quality.

Watershed Protection Plan

Watershed protection plans (WPPs) are locally driven mechanisms to voluntarily address complex water quality problems across political boundaries. A WPP serves as a framework to better leverage and coordinate private, nonprofit, local, state, and federal agency resources.

The San Fernando and Petronila Creeks WPP follows EPA's nine key elements, which are designed to provide guidance for development of an effective WPP (EPA 2008). WPPs vary in methodology, content, and strategy based on local priorities and needs. However, successful plans have common fundamental elements (see Appendix C – Elements of Successful Watershed Protection Plans). These include:

1. Identification of causes and sources of impairment
2. Expected load reductions from management strategies

3. Proposed management measures
4. Technical and financial assistance needed to implement management measures
5. Information, education, and public participation needed to support implementation
6. Schedule for implementing management measures
7. Milestones for progress of WPP implementation
8. Criteria for determining successes of WPP implementation
9. Water quality monitoring

Adaptive Management

Adaptive management consists of developing a natural resource management strategy to facilitate decision-making based on an ongoing science-based process. Such an approach includes results of continual testing, monitoring, evaluating applied strategies, and revising management approaches to incorporate new information, science, and societal needs (EPA 2000). An adaptive management strategy allows the management measures recommended in a WPP to be adjusted in their focus and intensity as determined by the plan's success and the dynamic nature of each watershed. Throughout the life of this WPP, water quality and other measures of success will be monitored, and adjustments will be made as needed to the implementation strategy.

Education and Outreach

WPP development and implementation depends on effective education, outreach, and engagement efforts to inform stakeholders, landowners, and residents of its associated activities and practices. Education and outreach events provide an information delivery platform for stakeholders throughout the WPP implementation process. Education and outreach efforts are integrated into many management measures detailed in the WPP.

Chapter 2 Watershed Characterization

Harvested wheat with subdivision in the background. Photo by Lucas Gregory.

This chapter provides geographic, demographic, and water quality overviews of the San Fernando and Petronila creeks watersheds, which are the focus of this WPP. Information in this chapter draws heavily on state and federal data sources and local stakeholder knowledge and provides context for the remainder of the document. Collating this information allowed a reliable assessment of water quality, identified potential water quality impairment causes, and facilitated development of recommended management measures to address these concerns. Baffin Bay receives water from both creeks and several other smaller tributaries. Harmful algal blooms and declining water quality in Baffin Bay have increased awareness and concern about the impacts of upstream water quality on the bay's aquatic resources. Water quality in Los Olmos, San Fernando, and Petronila creeks, together with activities on the shoreline of Baffin Bay that negatively influence water quality, constitute the primary concerns for local stakeholders. These stakeholder concerns plus documented water quality impairments in San Fernando and Petronila creeks were the impetus for developing this WPP.

Watershed Description

Petronila Creek

Petronila Creek begins in western Nueces County near County Road 40 and flows approximately 44 miles downstream where it meets Tunas Creek in eastern Kleberg County before flowing into Cayo Del Mazón. The Petronila Creek watershed includes portions of Jim Wells, Nueces, and Kleberg counties (Figure 1, Table 1). The watershed covers 675 square miles (mi^2) of predominantly rural landscapes with several towns including Agua Dulce, Driscoll, Orange Grove, and the southern extent of Robstown. Urban sprawl from Corpus Christi is also starting to impact the northeastern portion of the watershed where farmland is being converted to subdivisions. Various smaller communities including colonias are also distributed throughout the watershed. In its upper reaches, Petronila Creek is freshwater, but as it nears Baffin Bay, it becomes brackish due to tidal influence.

Table 1. County and watershed area summary.

County	Area of total county (acres)	Area of watershed within the county (acres)	Percent of the total county within the watershed (%)	Percent of the watershed within each county (%)
Duval	1,149,259	421,469	36.7	33.8
Jim Wells	555,730	362,488	65.2	29.1
Kleberg	578,888	189,812	32.8	15.2
Nueces	549,498	273,333	49.7	21.9
Entire watershed		**1,247,102**		**100**

San Fernando Creek

San Fernando Creek is a freshwater creek that begins at the confluence of San Diego and Chiltipin Creek in Jim Wells County northeast of Alice. From there, it continues approximately 44 miles downstream to Cayo Del Grullo southeast of Kingsville. San Fernando Creek and its tributaries flow throughout portions of Duval, Jim Wells, Kleberg, and Nueces counties (Figure 1, Table 1). Its watershed covers approximately 1,270 mi² of largely rural land but does include the cities of Alice and Kingsville. Other small cities in the watershed include Benavides, Bishop, and San Diego. Numerous other small communities, neighborhoods, and colonias are also scattered across the watersheds.

Los Olmos Creek

The Los Olmos Creek watershed covers approximately 2,202 mi² of primarily rural land to the south of the San Fernando Creek watershed. This area is outside of the focus area for this WPP, but it can have a substantial influence on Baffin Bay water quality and is a significant concern for watershed stakeholders. Los Olmos Creek is the third largest tributary into Baffin Bay volumetrically; however, its watershed area is larger than the combined watershed area of San Fernando and Petronila creeks. The influence of Los Olmos Creek must not be discounted when evaluating the overall health of Baffin Bay. Local stakeholder desire is to include Los Olmos Creek in the WPP effort; however, water quality data is limited and does not allow for ample water quality assessment relative to watershed conditions that is necessary for developing an effective WPP. As a result, the Los Olmos Creek watershed is not included in this WPP, but it could be included in the future when sufficient data is available.

Baffin Bay

Los Olmos, San Fernando, Petronila, and other small creeks flow into Baffin Bay. An inlet of the larger Laguna Madre, Baffin Bay is considered a crown jewel of the Texas coast for its sport-fishing and recreation potential. This resource has been challenged by fish kills and declining water quality that are influenced by in-bay processes and inputs from the contributing watersheds. Stakeholder concerns over these issues led to the development of the Baffin Bay Stakeholder Group and were a major driver in local support for developing a WPP to address these concerns and pollutants.

Physical Characteristics

Soils and Topography

Watershed soils and topography are important components of watershed hydrology. Slope and elevation define where water will flow, while slope and soil properties influence water infiltration rates, runoff generation, and water movement through the soil. Soil properties may also limit the types of land development and activities that can occur in certain areas.

Watershed elevation ranges from a maximum approximate elevation of 241 feet above mean sea level (MSL) in the western part of the watersheds to a minimum approximate elevation of 1 foot above MSL near the mouths of both San Fernando and Petronila creeks where they ultimately flow into Baffin Bay (Figure 2). Elevation was determined using the U.S. Geological Survey (USGS) 10-meter 3D Elevation Program (3DEP 2019). The San Fernando and Petronila creeks watersheds' topography is comprised of mildly hilly terrain on its northwestern edge, quickly giving way to a gradual smoothing of topography until the watersheds meets the coast to the southeast.

Dominant soils in the San Fernando and Petronila creeks watersheds are alfisols, inceptisols, mollisols, and vertisols (Figure 3). Mollisols (47%; 744,625 acres [ac]) are more common as you get farther from the coast and are characterized by a dark surface layer indicative of high amounts of organic material, which make them very fertile and productive for agricultural uses. Vertisols (29%; 464,088 ac), most common northeast of San Fernando Creek and are clay-rich and exhibit a shrinking and swelling action with changes in moisture that can lead to wide cracks forming during dry periods. Alfisols (17%; 268,115 ac) tend to be found beneath mixed vegetative cover and are the result of the weathering process leaching clay minerals beneath the surface. Alfisols tend to hold water and provide moisture to

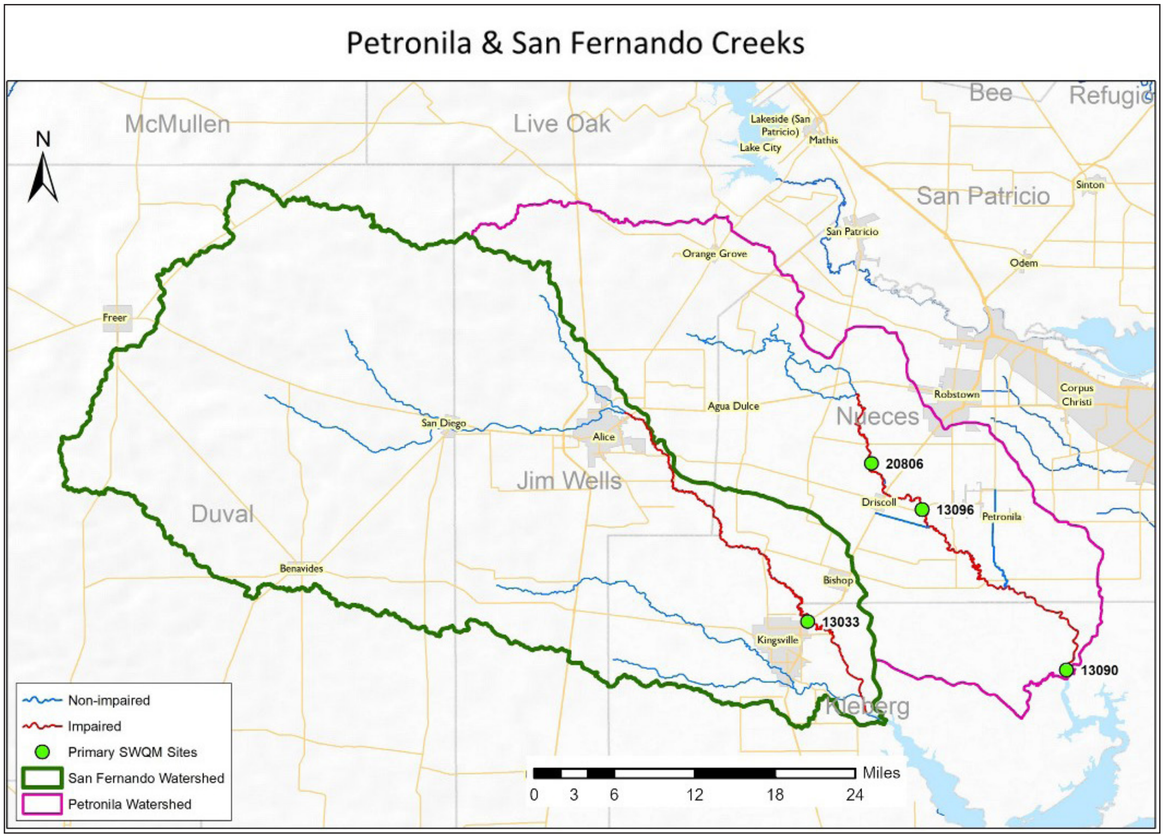


Figure 1. San Fernando and Petronila creeks watersheds map.

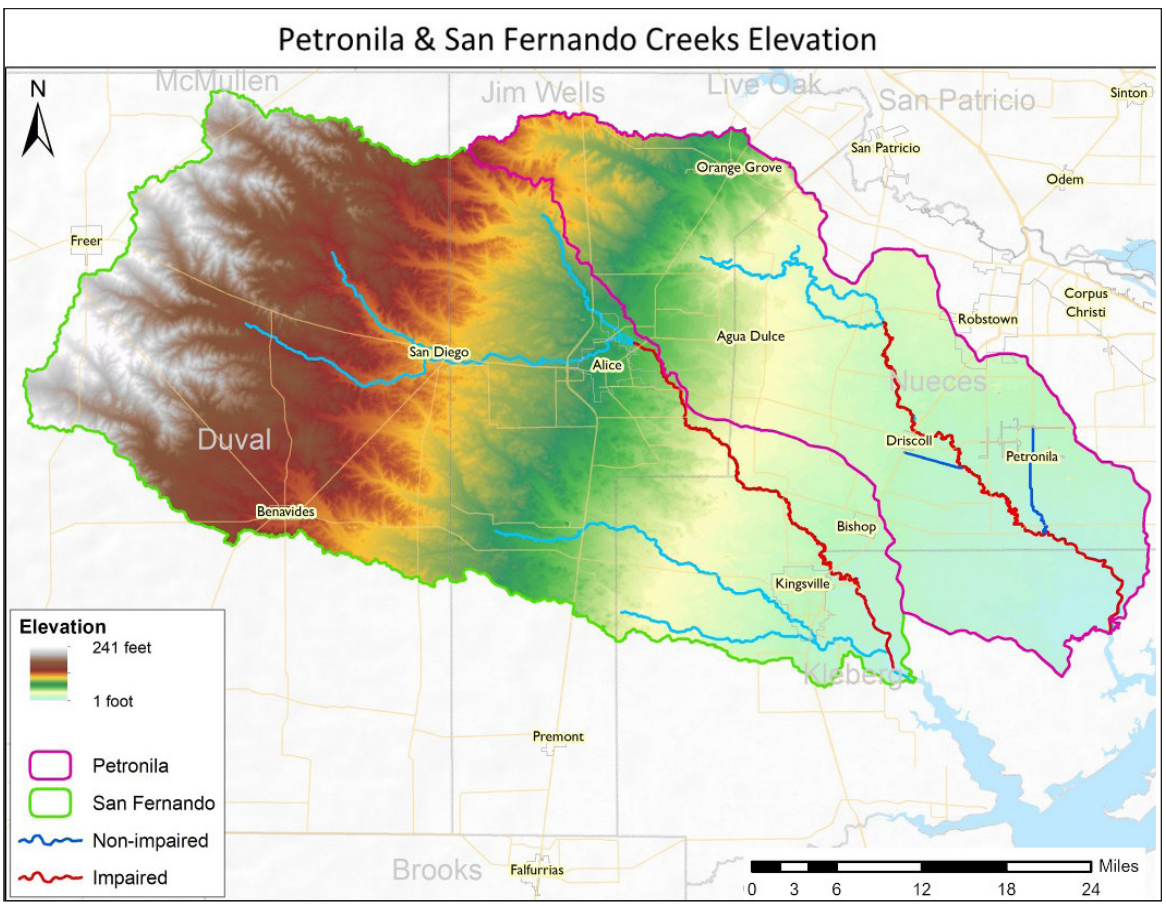


Figure 2. Watershed elevation.

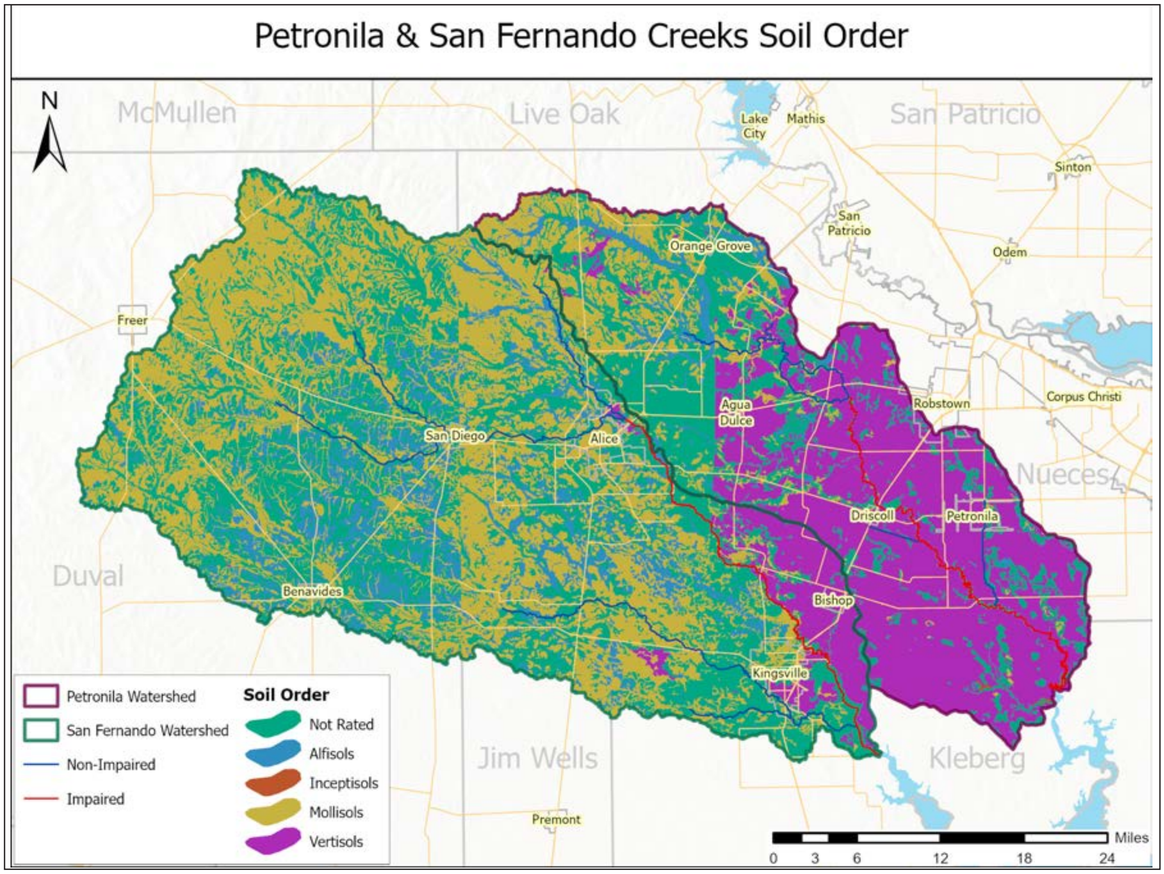


Figure 3. Watershed soil orders.

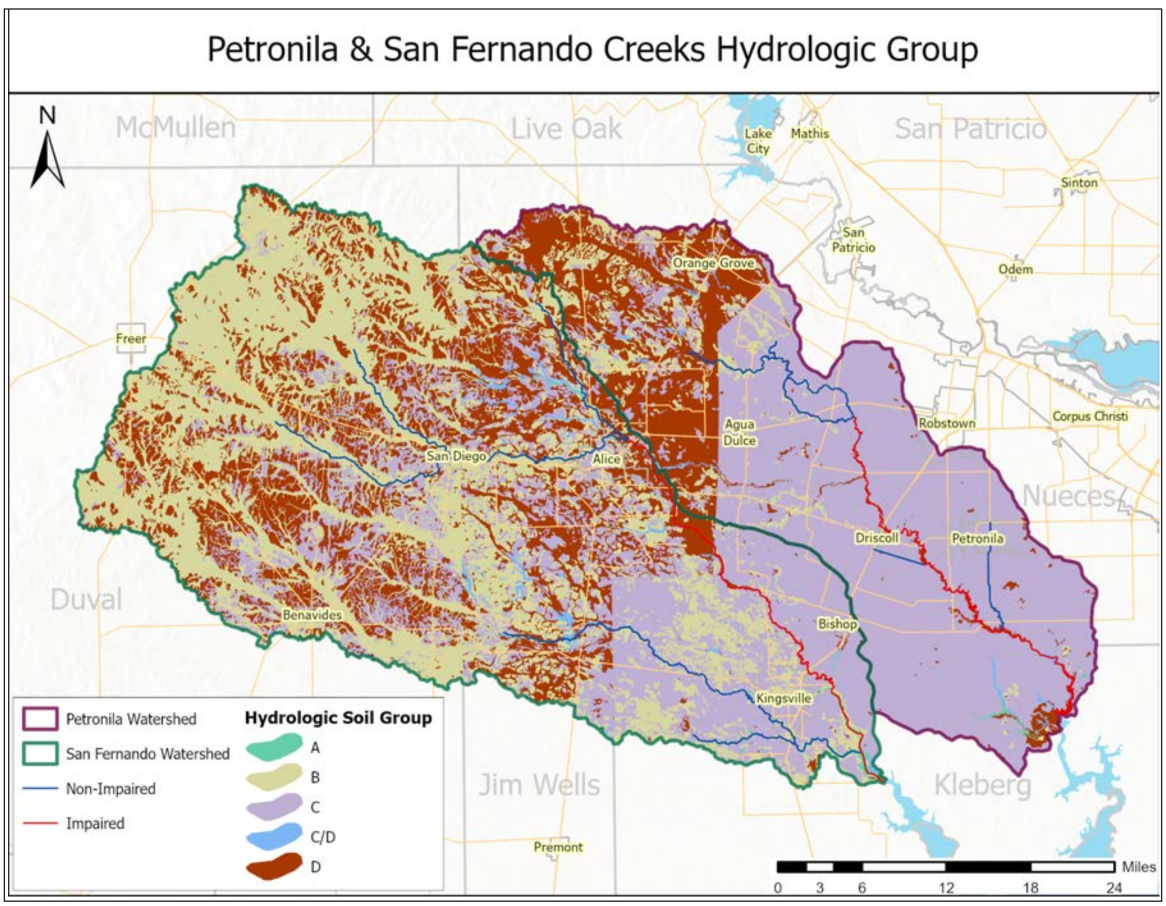


Figure 4. Hydrologic soil groups

Table 2. Land use and land cover summary.

Land cover class	Petronila Creek watershed acres (percent of watershed)	San Fernando Creek watershed acres (percent of watershed)	Total acres
Developed	16,201 (3.75%)	35,214 (4.32%)	51,415
Barren	1,868 (0.43%)	1,835 (0.23%)	3,703
Forests	4,371 (1.01%)	13,263 (1.63%)	17,634
Shrub/scrub	48,207 (11.15%)	514,725 (63.18%)	562,932
Grassland/herbaceous	6,268 (1.45%)	8,689 (1.07%)	14,957
Pasture/hay	57,762 (13.36%)	137,163 (16.84)	194,925
Cultivated cropland	287,546 (66.49%)	82,819 (10.17%)	370,365
Wetland	9,520 (2.20%)	20,199 (2.48%)	29,719
Open water	735 (0.17%)	762 (0.09%)	1,497
Total acreage	**432,478**	**814,669**	**1,247,147**

plants during moderately dry conditions. Inceptisols (2.2%; 108,404 ac) are common in humid and subhumid regions and are sprinkled throughout the western portion of the San Fernando Creek watershed.

Hydrologic soil groups indicate runoff potential and are determined based on the measure of precipitation, runoff, and infiltration (NRCS 2009). There are four primary hydrologic soil groups. Group A is composed of sand, loamy sand, or sandy loam with low runoff potential and high infiltration. Group B is well drained with silt loam or loam type soils. Group C consists of finer soils and slower infiltration. Group D has high clay content, low infiltration, and high runoff potential. In the Group C/D, C represents the drained areas and D the undrained areas.

The western and central areas of the watersheds contain a nearly even split between moderate and high runoff potential soils (Figure 4). The eastern portion of the watersheds contains mostly slow infiltration soils with higher runoff potential. Soil Group C (45% of watershed soils), Group B (29% of watershed soils), and Group D (25% of watershed soils) dominate the watersheds, followed by Groups A and C/D, both at 1% of soils. Distinct difference in soil classifications along the Jim Wells, Nueces, and Kleberg County lines are the result of the Soil Survey Geographic Database model being continually updated by the U.S. Department of Agriculture (USDA). Historically, soil survey projects have been conducted within county political boundaries. While the inherent properties of soil bodies have not changed, the human aspect of creating soil survey models has. Soils across the two watersheds were mapped between 1965 and 2012. Soil science is a relatively young discipline and tremendous advancements have been made from 1965 to present. Old surveys are being updated with new mapping concepts that follow the natural landscape rather than political boundaries.

Land Use and Land Cover

According to the 2016 National Land Cover Database (NLCD), the dominant land use and land cover (LULC) categories are shrub/scrub (45.1%; 562,941 ac), cultivated crop (29.7%; 370,329 ac), and pasture/hay (15.6%; 194,917 ac; Figure 5; Table 2). Developed or urban areas are also present in the watersheds but only comprise 4.1% (51,414 ac) of the total land use.

Ecoregions

Ecoregions are land areas that contain similar quality and quantity of natural resources (Griffith 2007). Ecoregions have been delineated into four separate levels. Level I is the most unrefined classification, while level IV is the most refined. The watersheds flow primarily through two ecoregions (level IV ecoregions): the Texas-Tamaulipan Thornscrub (31c) in the western part of the watershed in Duval and Jim Wells counties and the Southern Subhumid Gulf Coast Prairies (34b) in Kleberg and Nueces counties (Figure 6). At the southern tip of the Petronila Creek watershed, a small area of Laguna Madre Barrier Islands and Coastal Marshes (34i) exists.

Climate

The San Fernando and Petronila creeks watersheds are characterized as a humid subtropical climate zone with hot summers and mild winters. Average annual precipitation from 2011 to 2021 ranged between 21 inches (in) to 30 in (Figure 7) across the watersheds. Peak monthly average precipitation occurs in May and September. The driest months are typically January, July, and November. The warmest months on average are July and August with an average temperature of 97°F (Figure 8). January is the coldest month with average lows around 47°F (NOAA 2021).

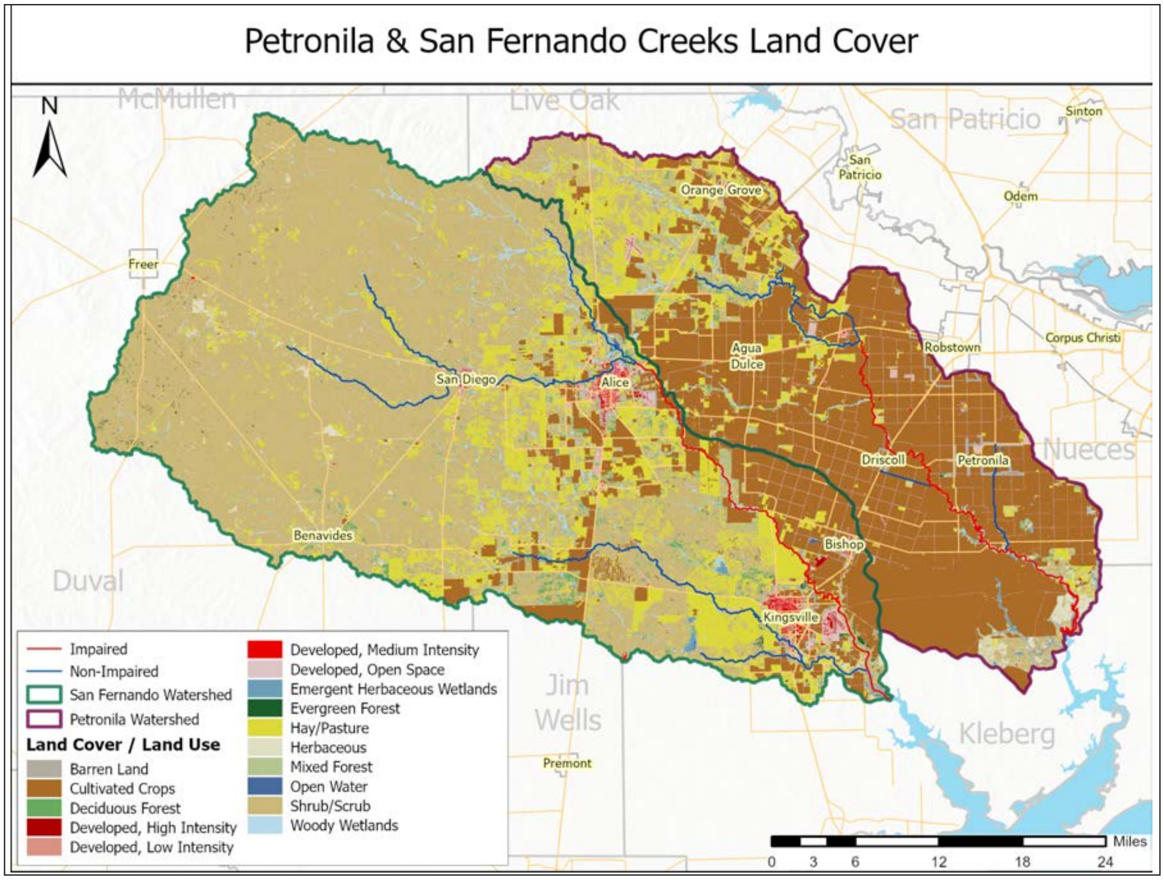


Figure 5. Watershed land use and land cover.

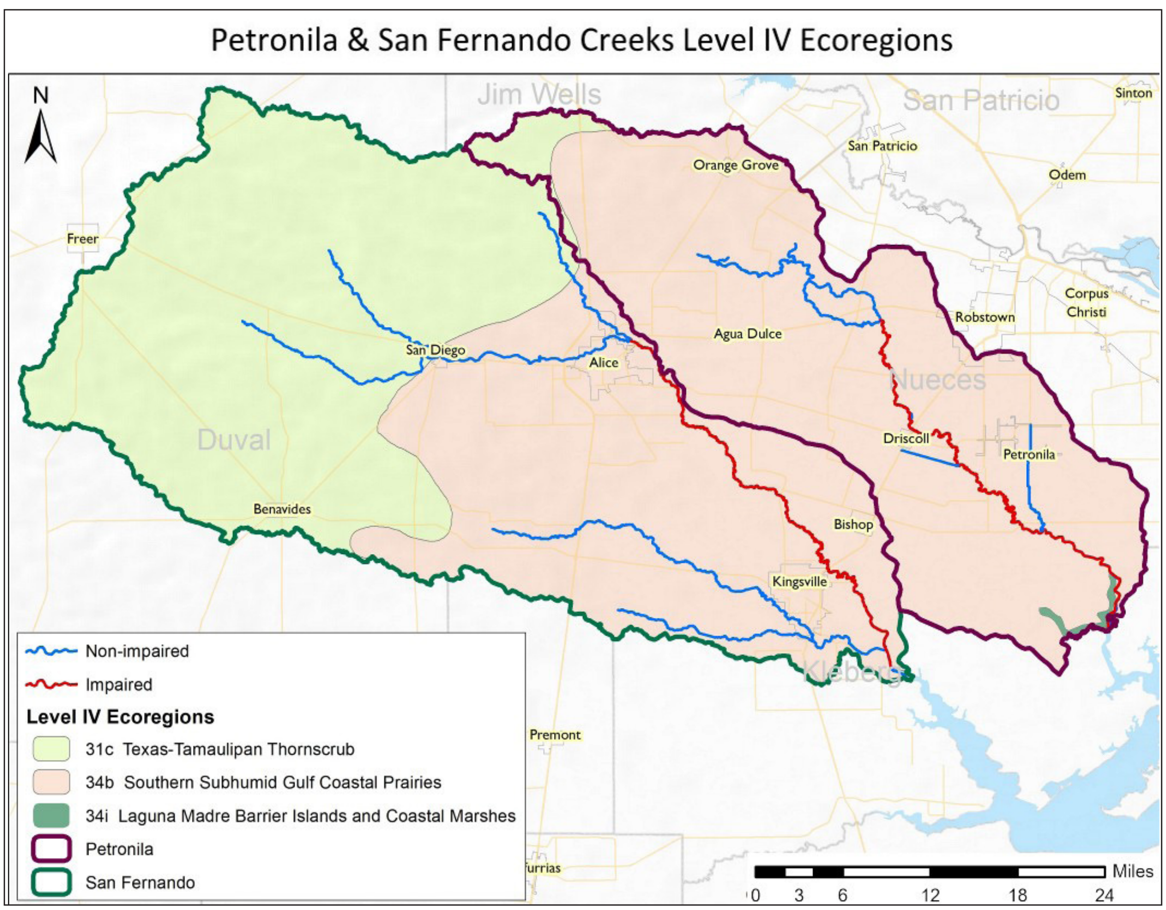


Figure 6. Level IV ecoregions.

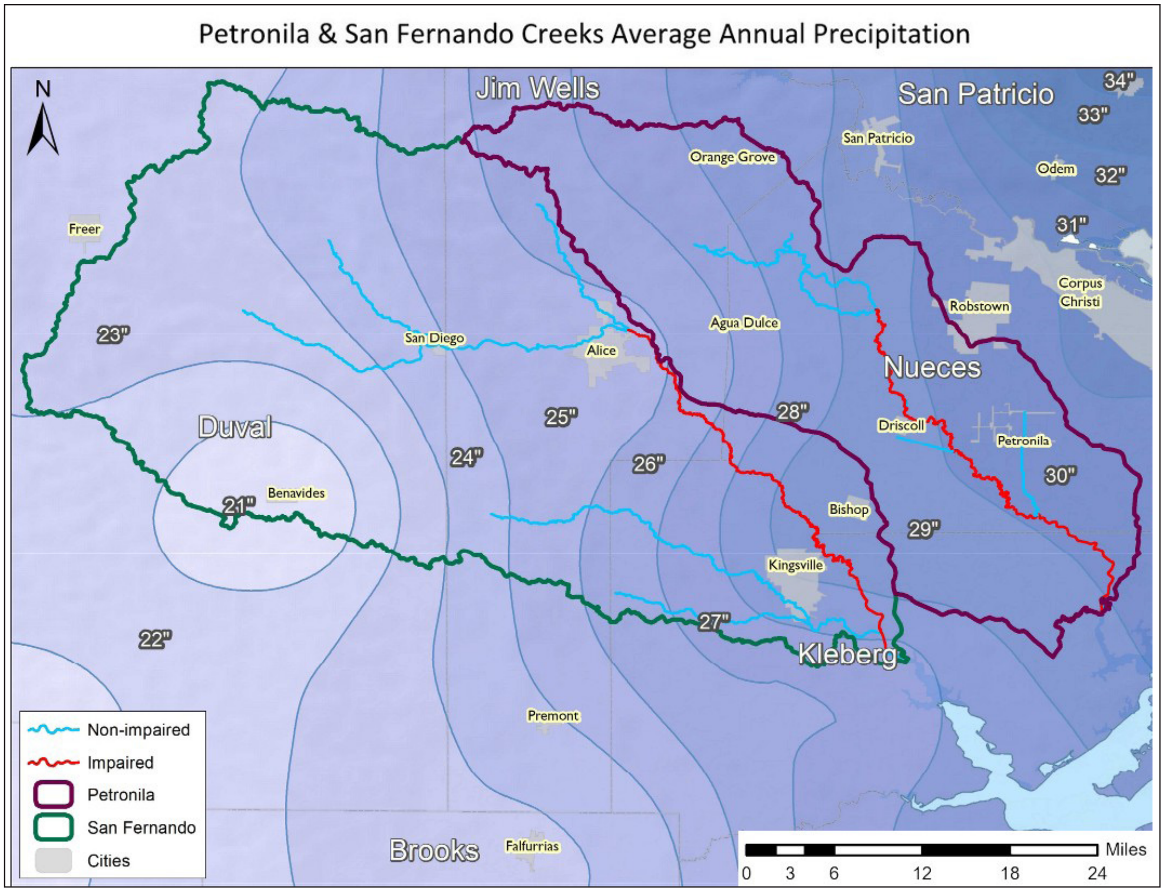


Figure 7. Annual normal precipitation in inches.

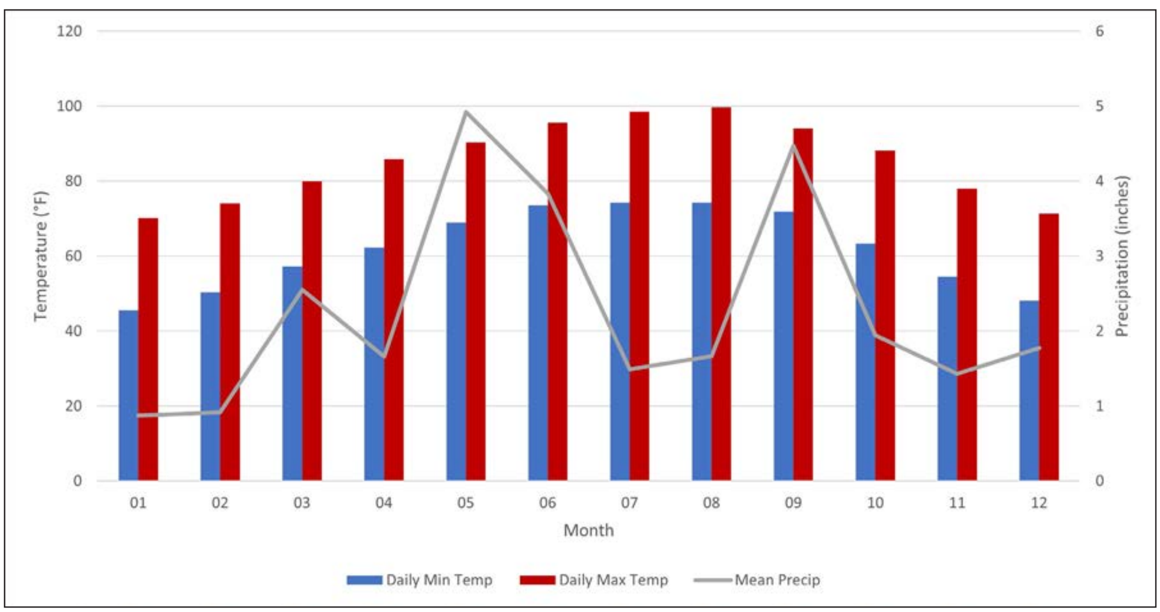


Figure 8. Monthly mean maximum and minimum air temperatures (°F) and monthly mean rainfall (inches) measured at Alice International Airport, Texas (NOAA 2021).

Table 3. County population projections through 2070.

County	2020	2030	2040	2050	2060	2070	Population increase
Duval	12,715	13,470	14,098	14,644	15,080	15,435	21%
Jim Wells	44,987	48,690	52,052	55,533	58,600	61,410	37%
Kleberg	35,567	38,963	42,202	45,324	48,251	50,989	43%
Nueces	374,157	407,534	428,513	440,797	449,936	465,056	24%
Total in watersheds	**467,426**	**508,657**	**536,865**	**556,298**	**571,867**	**592,890**	**27%**

Population

According to 2010 U.S. Census data, the highest population densities in the watersheds are along SH-44, US-281, and US-77. These highways, along with ancillary roads, connect the major population concentrations found in the cities/communities of Kingsville, Bishop, Driscoll, Petronila, Alice, Agua Dulce, Orange Grove, Banquete, Benavides, San Diego, and a small area of Robstown (Figure 9). The population in the watersheds was approximately 83,846 based on the 2010 U.S. Census data from U.S. Census Bureau (USCB). Recent estimates from the USCB (2021) also place an average of 2.89 people per household across the combined watershed area. Between 2020 and 2070, significant population growth is expected in Duval, Jim Wells, Kleberg, and Nueces counties (Table 3). With this growth, increases in residential and commercial development are expected. This will adversely affect natural watershed function, further strain existing drainage and wastewater infrastructure, and generally increase adverse water quality effects across the watersheds.

Aquifers

Texas has nine major and 22 minor aquifers, but only one underlies the San Fernando and Petronila creeks watersheds. The Gulf Coast Aquifer spans the entire substrate of the watersheds. Near the Gulf Coast, the aquifer tends to yield water too high in salinity for irrigation with levels between 1,000 and 10,000 milligrams per liter (mg/L) of dissolved solids. As distance from the coast increases, the aquifer is less impacted by saltwater intrusion and has a low enough salinity that it can be used for drinking and irrigation.

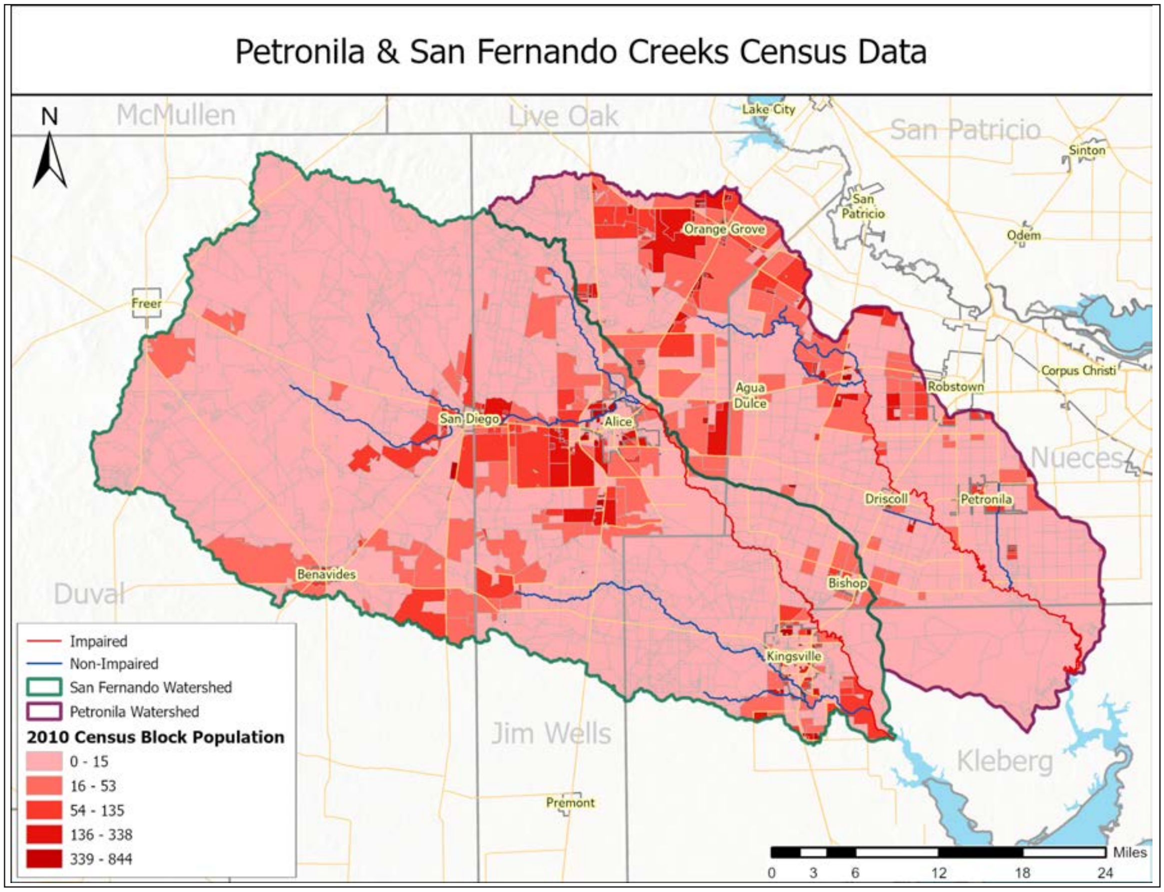


Figure 9. 2010 U.S. Census population estimates.

Chapter 3 Water Quality

Baffin Bay. Photo courtesy of the Coastal Bend Bays and Estuaries Program.

Surface water is monitored in Texas to ensure that its quality supports designated uses defined in the Texas Water Code. Designated uses and associated standards are developed by the Texas Commission on Environmental Quality (TCEQ) to fulfill requirements of the Clean Water Act (CWA), which addresses toxins and pollution in waterways and establishes a foundation for water quality standards. It requires states to set standards that maintain and restore biological integrity in the waters, protect fish, wildlife, and recreation in and on the water (must be fishable/swimmable), and consider the use and value of state waters for public supplies, wildlife, recreation, agricultural, and industrial purposes. The CWA (33 USC § 1251), administered by EPA (40 CFR § 130.7), requires states to develop a list that describes all water bodies that are impaired and are not within established water quality standards (commonly called "303(d) list" in reference to Texas Water Quality Inventory and 303(d) List).

Water Body Assessments

TCEQ conducts a water body assessment on a biennial basis to satisfy requirements of federal CWA sections 305(b) and 303(d). The resulting Texas Integrated Report of Surface Water Quality (Texas Integrated Report) describes the status of water bodies throughout the state. The 2020 Texas Integrated Report is the most recent version published and includes an assessment of water quality data collected from December 1, 2011 to November 30, 2018.

The Texas Integrated Report assesses water bodies at the assessment unit (AU) level. An AU is a sub-area of a stream segment, defined as the smallest geographic area of use support reported in the assessment (TCEQ 2020). Each AU is intended to have relatively homogeneous chemical, physical, and hydrological characteristics, which provides a way to assign site-specific standards (TCEQ 2020). A segment identification number and AU are combined and assigned to each water body to divide a segment. For example, Petronila Creek is segment 2204 and has two AUs, designated 2204_01 and 2204_02. The tidal portion of Petronila Creek, which would be expected to have different characteristics than the non-tidal portions, is assigned a different segment identification number and AU, 2203_01.

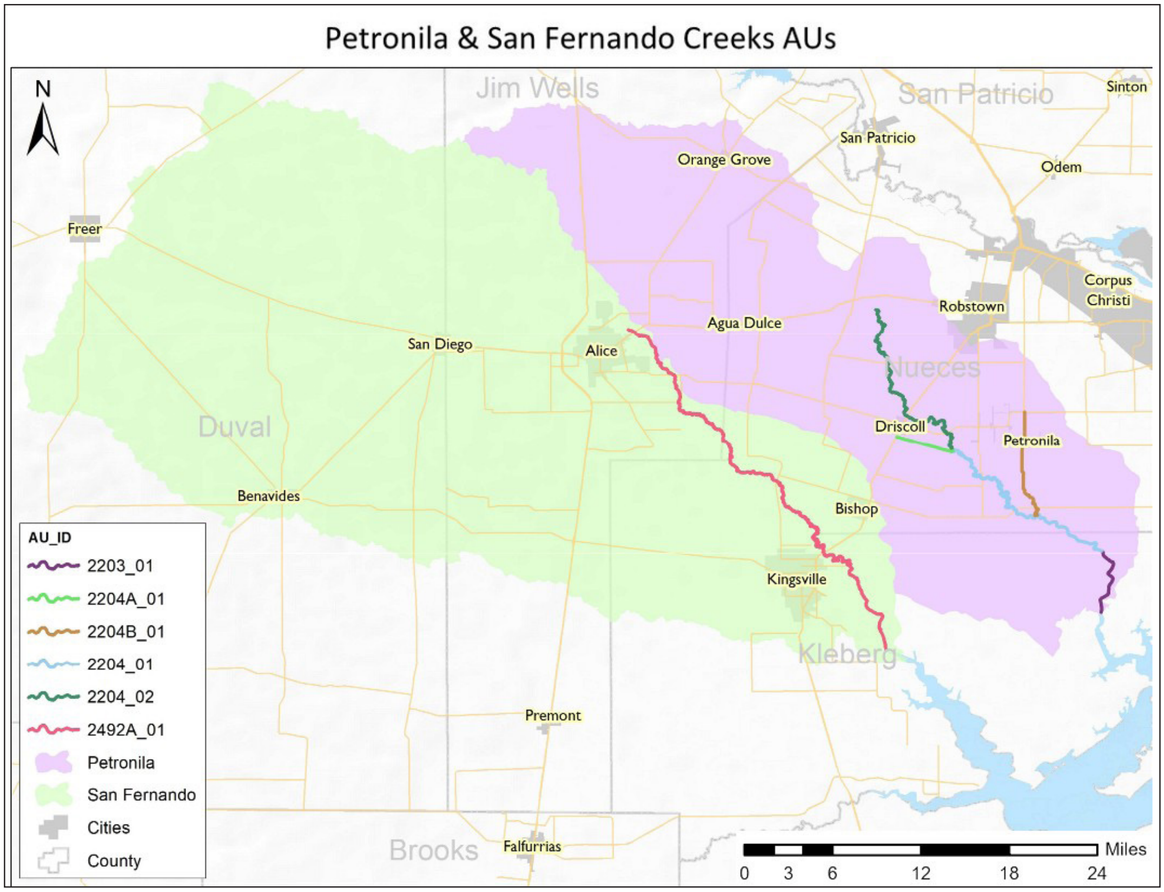


Figure 10. San Fernando and Petronila creeks assessment units (AUs).

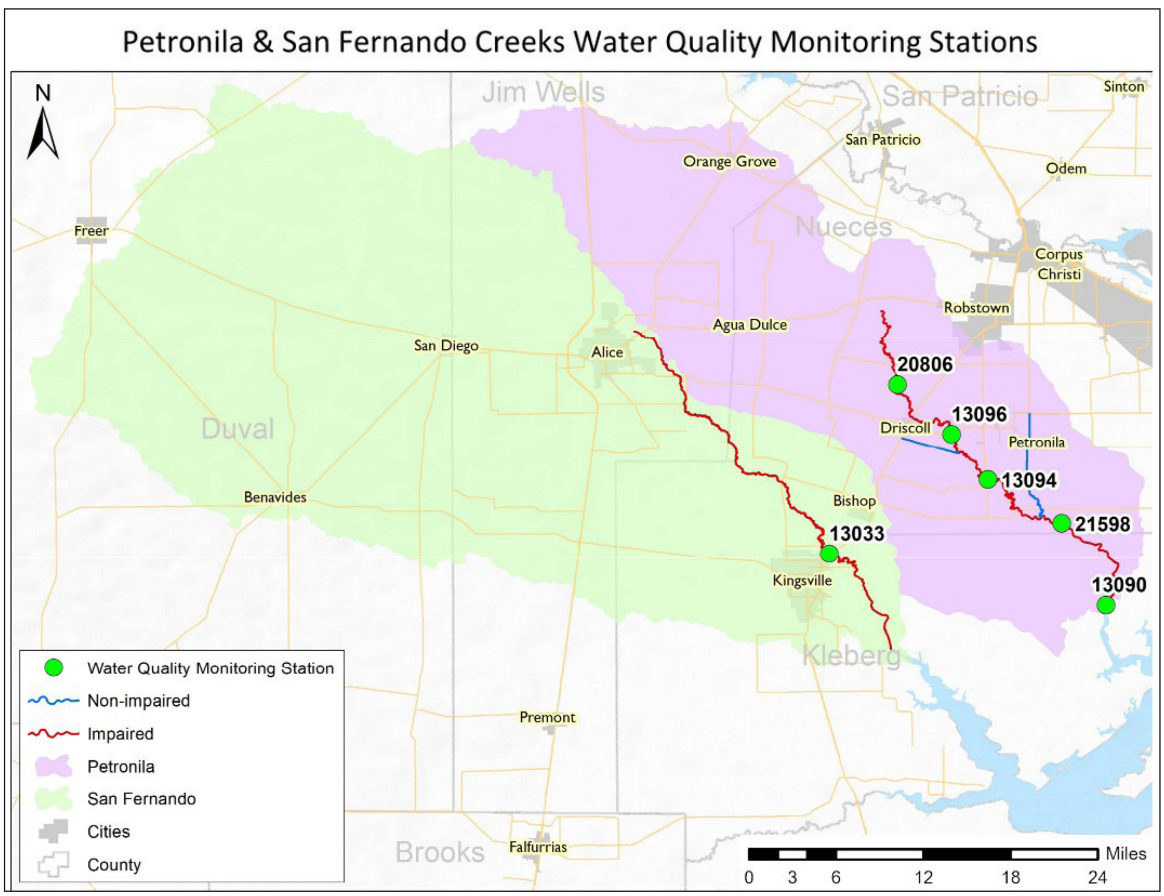


Figure 11. Water quality monitoring stations

Table 4. Water quality monitoring station summary from December 1, 2011, to November 30, 2018.

Station	Assessment unit	Sample numbers	Location
13033	2492A_01	60	San Fernando Creek at US 77
13090	2203_01	42*	Petronila Creek above Tunas Confluence
13094	2204_01	41	Petronila Creek at FM 892
21598		1	Outfall ditch to Petronila Creek from Cefe Valenzuela Landfill
13096	2204_02	53	Petronila Creek at FM 665
20806		40	Petronila Creek southwest of Alice Road and Lost Creek Road

Sample numbers are based on reported *E. coli,* IDEXX-Colilert samples.
*Sample number based on enterococci, IDEXX-Enterolert samples because AU 2203_01 is a tidal segment.

Table 5. Watershed impairments in 2020 *Texas Integrated Report*.

Parameter	Category	Assessment unit	Stream reach	Criteria
Bacteria	5c**	2203_01	Petronila Creek Tidal	35 cfu/100 mL
	5b*	2204_01	Petronila Creek Above Tidal	126 cfu/100 mL
		2204_02		
	5c**	2492A_01	San Fernando Creek	

Colony forming unit, cfu; milliliter, mL
*Category 5b – A review of the standards for one or more parameters will be conducted before a management strategy is selected, including a possible revision to the Texas surface water quality standards.
**Category 5c – Additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.

In total, there are six AUs in the San Fernando and Petronila creeks watersheds (Figure 10). Monitoring stations are located on several of the AUs and typically allow independent water quality analysis for each AU within a segment. At least 10 data points within the most recent 7 years of available data are required for all water quality parameters except bacteria, which requires a minimum of 20 samples. Water quality data from six monitoring stations in the San Fernando and Petronila creeks watersheds were reviewed (Figure 11; Table 4). For this WPP, stations 13033 and 13096 were identified for use generating load duration curves (LDCs). These two stations are representative of the water bodies where they are located and were chosen to allow for a single load reduction goal for each water body.

According to the 2020 Texas Integrated Report, four AUs in the watersheds are impaired due to elevated bacteria (AU 2203_01, 2204_01, 2204_02, and 2492A_01; Table 5). The criteria used for non-tidal, fresh recreational waters is 126 colony forming units (cfu) of E. coli/100 milliliter (mL), whereas in marine (tidal) recreational water, the criteria used is 35 cfu of enterococci/100 mL. Furthermore, several nutrient and chlorophyll-a concerns are identified in four AUs in the combined San Fernando and Petronila creeks watersheds (Table 6).

Table 6. Watershed nutrient concerns identified in the 2020 *Texas Integrated Report*.

Parameter	Assessment unit	Stream reach	Criteria
Chlorophyll-a	2203_01	Petronila Creek Tidal	>20% exceedance (21 µg/L screening level)
	2204_01	Petronila Creek Above Tidal	>20% exceedance (14.1 µg/L screening level)
	2204_02		
	2492A_01	San Fernando Creek	
Nitrate	2492A_01	San Fernando Creek	>20% exceedance (1.95 mg/L screening level)
Total phosphorus	2492A_01	San Fernando Creek	>20% exceedance (0.69 mg/L screening level)

milligram, mg; microgram, µg; liter, L

Table 7. Designated uses, use categories, and criteria for water bodies in the San Fernando and Petronila creeks watersheds.

Use	Segment number	Use category	Criteria	Measure
Contact recreation	2203	Primary contact recreation 1	35 cfu/100 mL (enterococci)	7-year geometric mean
	2204		126 cfu/100 mL (*E. coli*)	
	2492			
Aquatic life use	2203*	High	4.0/3.0 mg/L DO*	<10% exceedance based on the binomial method
	2204	Intermediate	4.0/3.0 mg/L DO	
	2492	High	5.0/3.0 mg/L DO	
General use standards	The criteria for the general use include aesthetic parameters, radiological substances, toxic substances, temperature (when surface samples are above 5° F and not attained due to permitted thermal discharges) and nutrients (screening standards or site-specific nutrient criteria)			

Colony forming unit, cfu; dissolved oxygen, DO; Fahrenheit, F; liter, L; milligram, mg; milliliter, mL
*Segment 2203 is the tidal portion of Petronila Creek. Saline water has less capacity for DO; therefore while 4.0 (24-hour average)/3.0 (minimum) mg/L DO is only considered intermediate in freshwater, it is considered high for tidal water.

Texas Surface Water Quality Standards

Water quality standards are established by the state and approved by EPA to define a water body's ability to support its designated uses, which may include aquatic life use (fish, shellfish, and wildlife protection and propagation), primary contact recreation (swimming, wading by children, etc.), public water supply, and fish consumption. Water quality indicators for these uses include dissolved oxygen (DO; aquatic life use), *E. coli* (freshwater) and enterococcus (tidal waters) (primary contact recreation), pH, temperature, total dissolved solids, sulfate, and chloride (general uses), and a variety of toxins (fish consumption and public water supply; Table 7; TCEQ 2020).

Bacteria

Concentrations of fecal indicator bacteria are evaluated to assess a water body's ability to meet its contact recreation use. In freshwater environments, *E. coli* concentrations are measured to evaluate the presence of potential fecal contamination in water bodies. The presence of these fecal indicator bacteria may indicate that associated pathogens from the intestinal tracts of warm-blooded animals or other sources could be reaching water bodies and may cause illness in people that recreate in them. Water quality standards for bacteria in freshwater and tidal waters differ. In freshwater, the standard for primary contact recreation is a geometric mean of 126 cfu of *E. coli*/100 mL of water. In tidal waters, the primary contact recreation standard is 35 cfu of enterococci/100 mL of water. Both standards must be assessed from at least 20 samples (30 TAC § 307.7). Common sources that indicator bacteria can originate from include wildlife, domestic livestock, pets, malfunctioning on-site sewage facilities (OSSFs), urban and agricultural runoff, sewage system overflows, and direct discharges from wastewater treatment facilities (WWTFs). Currently, four AUs are listed as impaired due to elevated indicator bacteria (Figure 12; TCEQ 2020).

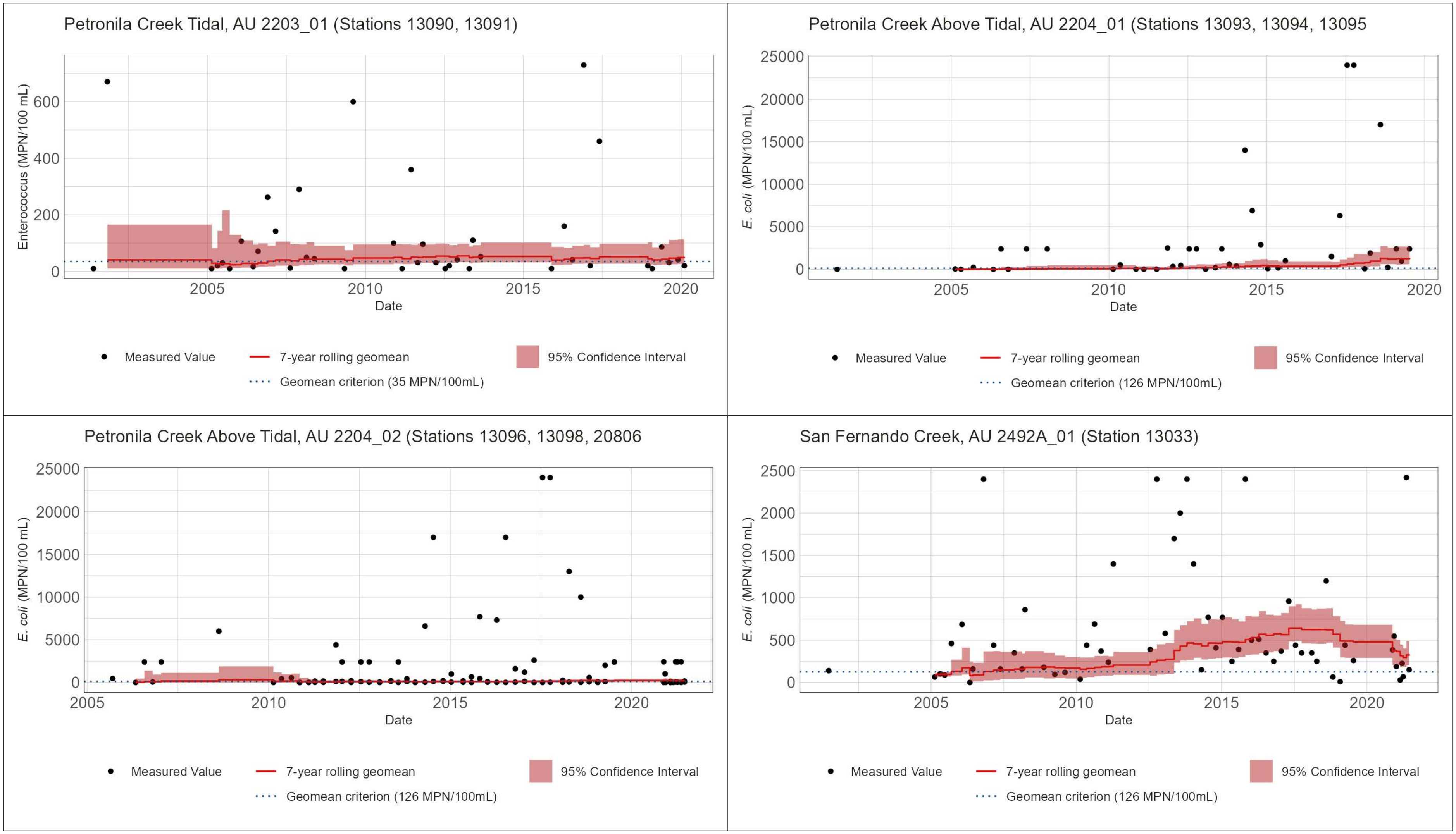


Figure 12. *E. coli* and enterococcus concentrations in impaired assessment units (AUs).

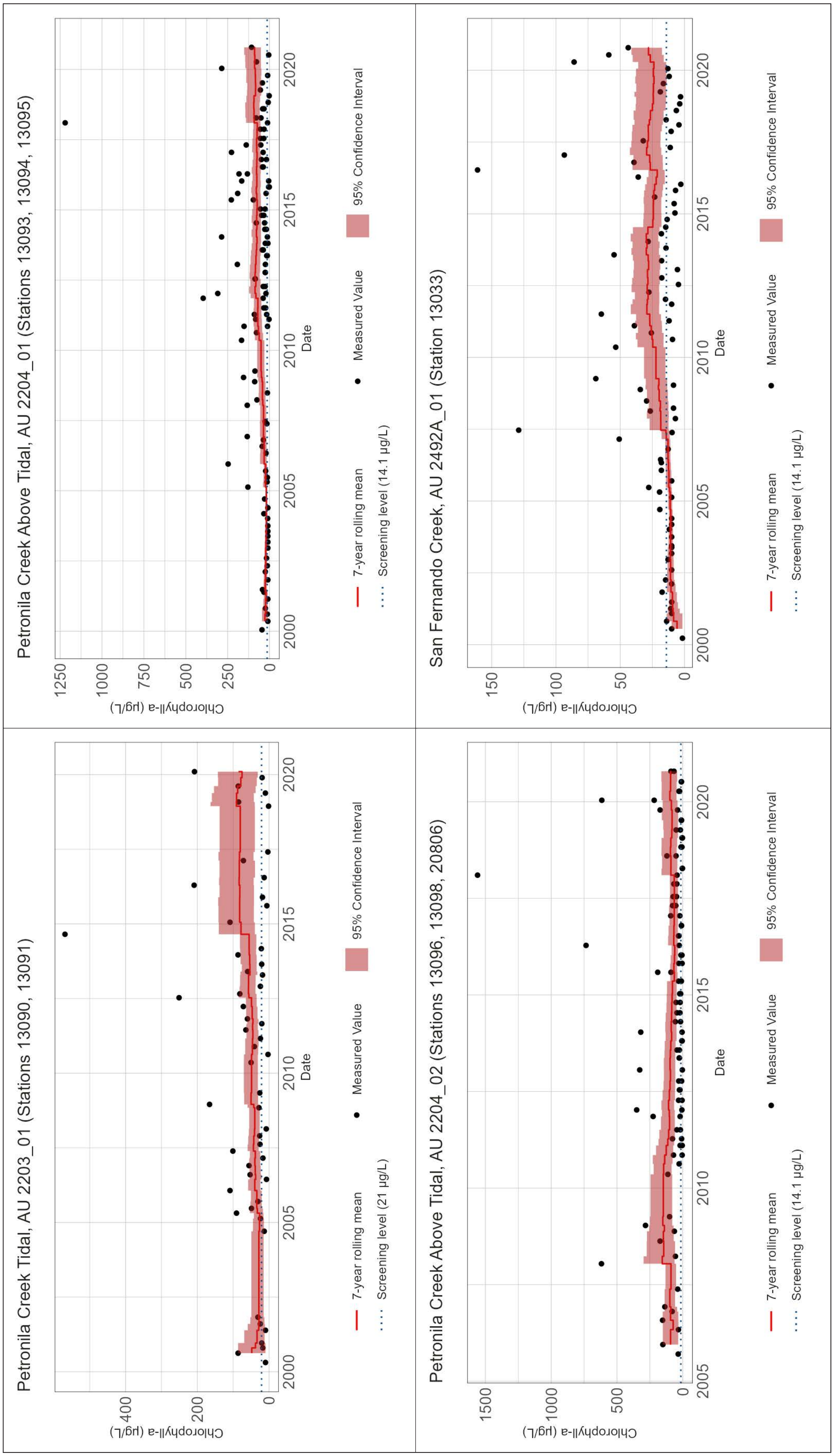


Figure 13. Chlorophyll-a concentrations.

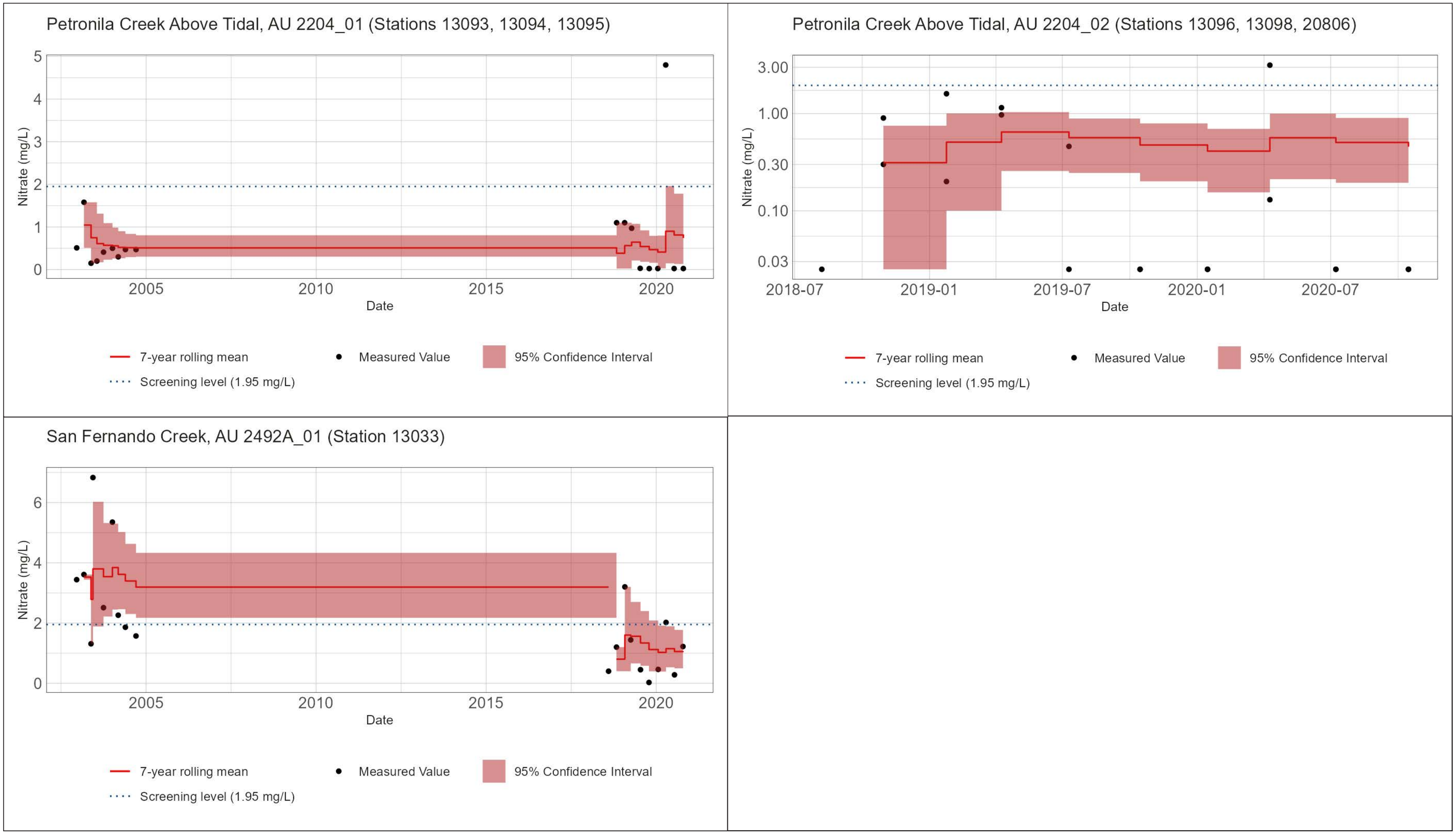


Figure 14. Nitrate concentrations.

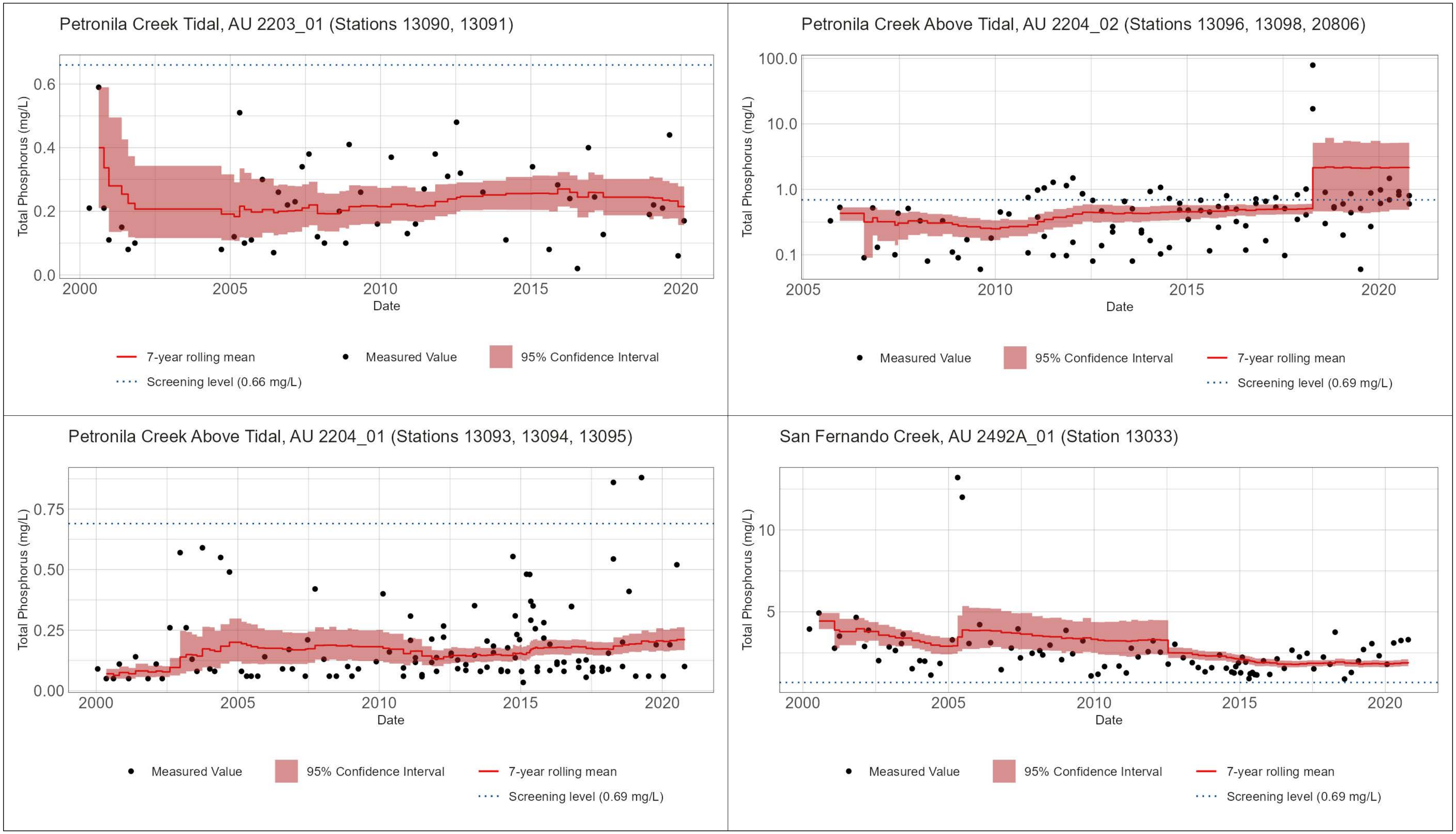


Figure 15. Total phosphorous concentrations.

Table 8. Watershed nutrient screening levels and criteria.

Parameter	Screening level	Criteria
nitrogen	0.33 mg/L	> 20% exceedance
Nitrate nitrogen (NO3-N)	1.95 mg/L	
Chlorophyll-a	14.1 µg/L **21 µg/L (tidal)**	
Total phosphorous	0.69 mg/L	

Liter, L; milligram, mg; microgram, µg

Dissolved Oxygen

DO is the main parameter used to determine a water body's ability to support and maintain aquatic life uses. If DO levels in a water body drop too low, fish and other aquatic species will not survive. Typically, DO levels fluctuate throughout the day, with the highest levels of DO occurring in mid to late afternoon due to plant photosynthesis. DO levels are typically lowest just before dawn as both plants and animals in the water continue to consume oxygen while natural production of DO typically slows overnight. Furthermore, seasonal fluctuations in DO are common because of decreased oxygen solubility in water as temperature increases; therefore, it is common to see lower DO levels during summer than the winter.

While DO can fluctuate naturally, human activities can also cause abnormally low DO levels. Excessive organic matter (vegetative material, untreated wastewater, etc.) can result in depressed DO levels as bacteria break down the materials and subsequently consume oxygen. Excessive nutrients from fertilizers and manures can also depress DO as aquatic plant and algae growth increase in response to nutrients. The increased respiration from plants and decay of organic matter as plants die off can also lower DO concentrations.

When evaluating DO levels in a water body, TCEQ considers that monitoring events need to be spaced over an index period and a critical period. The index period represents the warm-weather season of the year and spans from March 15th to October 15th. The critical period of the year is July 1st to September 30th and is the portion of the year when minimum streamflow, maximum temperatures, and minimum DO levels typically occur across Texas. At least half of the samples used to assess a stream's DO levels should be collected during the critical period, with one-fourth to one-third of the samples used coming from the index period. DO measurements collected during the cold months of the year are not considered because flow and DO levels are typically highest during the winter months (30 TAC § 307.7). Under the *2020 Texas Integrated Report,* none of the AUs in the San Fernando and Petronila creeks watersheds were listed as impaired for depressed DO.

Nutrients

Nutrients, specifically nitrogen and phosphorous, are used by aquatic plants and algae. However, excessive nutrients can lead to plant and algal blooms, which result in reduced DO levels. High nitrate and nitrite levels can directly affect fish respiration. Nutrient sources include effluents from WWTFs and OSSFs, direct deposition of animal fecal matter, illegal refuse dumping, groundwater return flows, and fertilizers in runoff from yards and agricultural fields. Additionally, nutrients bind to soil and sediment particles; therefore, runoff and erosion events that result in heavy sediment loads can increase nutrient levels in receiving water bodies.

Nutrient standards have not been set in Texas; however, nutrient screening levels developed for statewide use were established to evaluate which water bodies may be experiencing excess nutrient loadings. Screening levels are set at the 85th percentile for parameters from similar water bodies. If more than 20% of samples from a water body exceed the screening level, that water body is on average experiencing pollutant concentrations higher than 85% of the streams in Texas and is therefore considered to have an elevated nutrient concentration concern. Screening levels have been designated for ammonia, nitrate, orthophosphorus, total phosphorus, and chlorophyll-a (Table 8). The nutrient levels in several AUs were analyzed and results are shown in Figure 13 (chlorophyll-a), Figure 14 (nitrate), and Figure 15 (total phosphorus).

Flow

Generally, streamflow (the amount of water flowing in a river at a given time) is dynamic and always changing in response to both natural (e.g., precipitation events) and anthropogenic (e.g., changes in land cover or wastewater discharges) factors. From a water quality perspective, streamflow is important because it influences the ability of a water body to assimilate pollutants. There are four USGS streamflow gages located within the watersheds (Figure 16). One gage is decommissioned (USGS-8211900), and one is not located on either San Fernando Creek or Petronila Creek (USGS-8211800). Of the two remaining active gages,

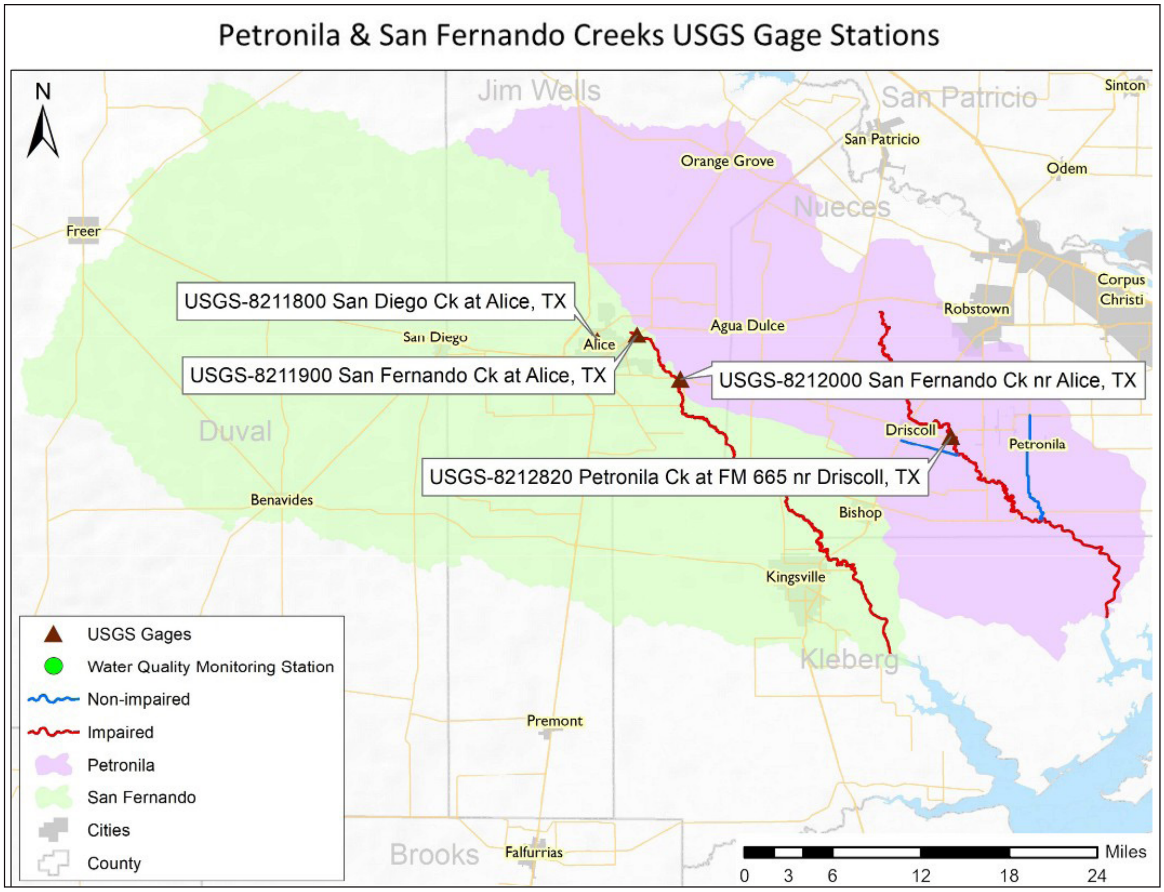


Figure 16. U.S. Geological Survey (USGS) streamflow gages.

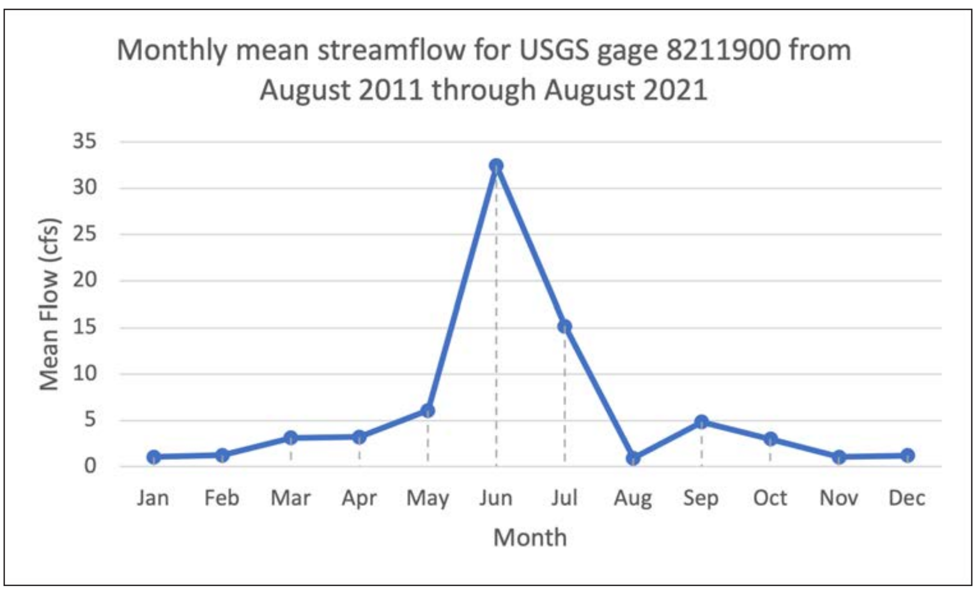


Figure 17. Mean monthly streamflow (cubic feet/second [cfs]) August 2011–August 2021.

USGS-08212000 is on San Fernando Creek, and USGS-08212820 is on Petronila Creek. These two gages provide the long-term instantaneous daily streamflow information used in this report. Over the previous 10 years, mean monthly stream flows rose sharply in May, peaking in June near 32.5 cubic feet/second (cfs) and then returning to mean levels below 5 cfs until the next May. Though the monthly means are presented here (Figure 17), it must not be discounted that the watersheds' proximity to the Gulf of Mexico subjects them to periods of heavy precipitation events that typically occur between May and July.

Chapter 4
Potential Sources of Pollution

Emergent marsh on Baffin Bay. Photo courtesy of the Nueces River Authority.

Water body impairments in the San Fernando and Petronila creeks watersheds are primarily due to excessive fecal indicator bacteria. Potential contributors of bacteria, causes, and impacts of other pollutants are summarized below (Table 9). Pollutant sources are categorized as either point sources or nonpoint sources (NPSs). Point sources enter receiving waters at identifiable locations, such as a pipe. NPSs includes anything that is not a point source and enters the water body by runoff moving over and/or through the ground. Potential pollution sources in the watersheds were identified through stakeholder input, watershed surveys, project partners, and watershed monitoring.

Point Source Pollution

Point source pollution is any type of pollution that can be traced back to a single point of origin, such as a WWTF. Generally, WWTFs discharges are permitted, which means they are regulated by permits under the Texas Pollutant Discharge Elimination System. Other permitted discharges include industrial or construction site stormwater discharges, and discharges from municipal separate storm sewer systems of regulated cities or agencies.

WWTFs

WWTFs, also known as wastewater treatment plants (WWTPs) in some cases, treat municipal wastewater before discharging the treated effluent into a water body. WWTFs are required to test and report indicator bacteria concentrations and sometimes nutrients as a condition of their discharge permits. WWTFs that exceed their permitted limits may require infrastructure or process improvements to meet the permitted discharge requirements.

There are currently 15 WWTFs operating in the watersheds (Figure 18). Generally, WWTF discharges are well below the permitted bacteria concentration limits. However, periodic exceedance of permitted bacteria and or flow limits as reported through the EPA Environmental Compliance History Online database are documented (Table 10). Annual nutrient loading reports were not available from this source.

Nonpoint Source Pollution

NPS pollution occurs when precipitation flows off the land, roads, buildings, and other landscape features and carries pollutants into drainage ditches, lakes, rivers, wetlands,

Table 9. Potential pollution source summary.

Pollutant source	Pollutant type	Potential cause	Potential impact
WWTFs/SSOs	Bacteria, nutrients	Inflows and infiltrations • Overload from large storm events • Conveyance system failures due to age, illicit connections, blockages, etc.	Untreated wastewater may enter watersheds or water bodies
OSSFs	Bacteria, nutrients	• System not properly designed for site specific conditions • Improper function due to age or lack of maintenance/sludge removal • Illegal discharge of untreated wastewater	Improperly treated wastewater reaches soil surface and may runoff into water bodies
Urban runoff	Bacteria, nutrients	Stormwater runoff from lawns, parking lots, dog parks, etc. • Improper application of fertilizers • Improper disposal of pet waste	Stormwater drains quickly route water directly to creek or river
Livestock	Bacteria, nutrients	• Manure transport in runoff • Direct fecal deposition to streams • Excessive runoff from pastures due to over grazing • Riparian area disturbance and degradation	Deposited directly into water body or may enter during runoff events
Wildlife	Bacteria, nutrients	• Manure transport in runoff • Direct fecal deposition to streams • Riparian area disturbance and degradation	Deposited directly into water body or enters during runoff events
Pets	Bacteria, nutrients	• Fecal matter not properly disposed of • Lack of dog owner education regarding effects of improper disposal	Bacteria and nutrients enter water body through runoff
Illegal dumping	Bacteria, nutrients, litter	Disposal of trash and animal carcasses in or near water body	Direct or indirect contamination of water body

On-site sewage facility, OSSF; sanitary sewer overflow, SSO; wastewater treatment facility, WWTF

coastal waters, and underground water resources. NPS pollution includes but is not limited to water polluted from leaking chemicals or improperly functioning OSSFs, fertilizers, herbicides, pesticides, oil, grease, toxic chemicals, sediment, fecal material, nutrients, and many other substances.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) can occur when sewer lines lose or exceed capacities due to age, lack of maintenance, inappropriate connections, or overload during storm events. Inflow and infiltration (I&I) are common issues to all sanitary sewer systems. Inflow most often coincides with large runoff events and can occur through uncapped cleanouts and gutter connections to the sewer system or through cross connections with storm sewers and faulty manhole covers. Infiltration happens slowly because it generally occurs through cracks and breaks in lateral lines on private property or sewer mains, through bad connections between laterals and sewer mains, and in deteriorated manholes.

These overflows and spills can reach water bodies, resulting in substantial periodic bacteria loading. Permit holders are required to report known SSOs that occur in their system to TCEQ. According to the TCEQ regional office, 19 SSO events were reported in the watersheds between January 1, 2016, and December 31, 2018 (Table 11, Table 12). Reported SSO causes vary, though most were the result of lift station or manhole overflows during heavy rain, power failures, or sewer lines clogged by materials not recommended for flushing or pouring down drains. Other than self-reported SSO event reports, no compliance or pollutant loading data associated with SSOs are available. Pollutant loads associated with individual events are likely to vary widely depending on the amount and makeup of the discharge.

OSSFs

OSSFs are common in the watersheds and may contribute *E. coli,* nutrients, and solids to water bodies if not properly functioning. The number of OSSFs, their locations, ages, types, and functional statuses in the watersheds are unavailable, making it difficult to determine actual water quality impacts. To estimate OSSF numbers and approximate locations, an approach using 911 address points, 2010 U.S. Census data, and recent satellite imagery was used (Gregory et al. 2013). This method associates 911 addresses with household structures by reviewing satellite imagery then cross referencing OSSF count estimates with 2010 U.S. Census household

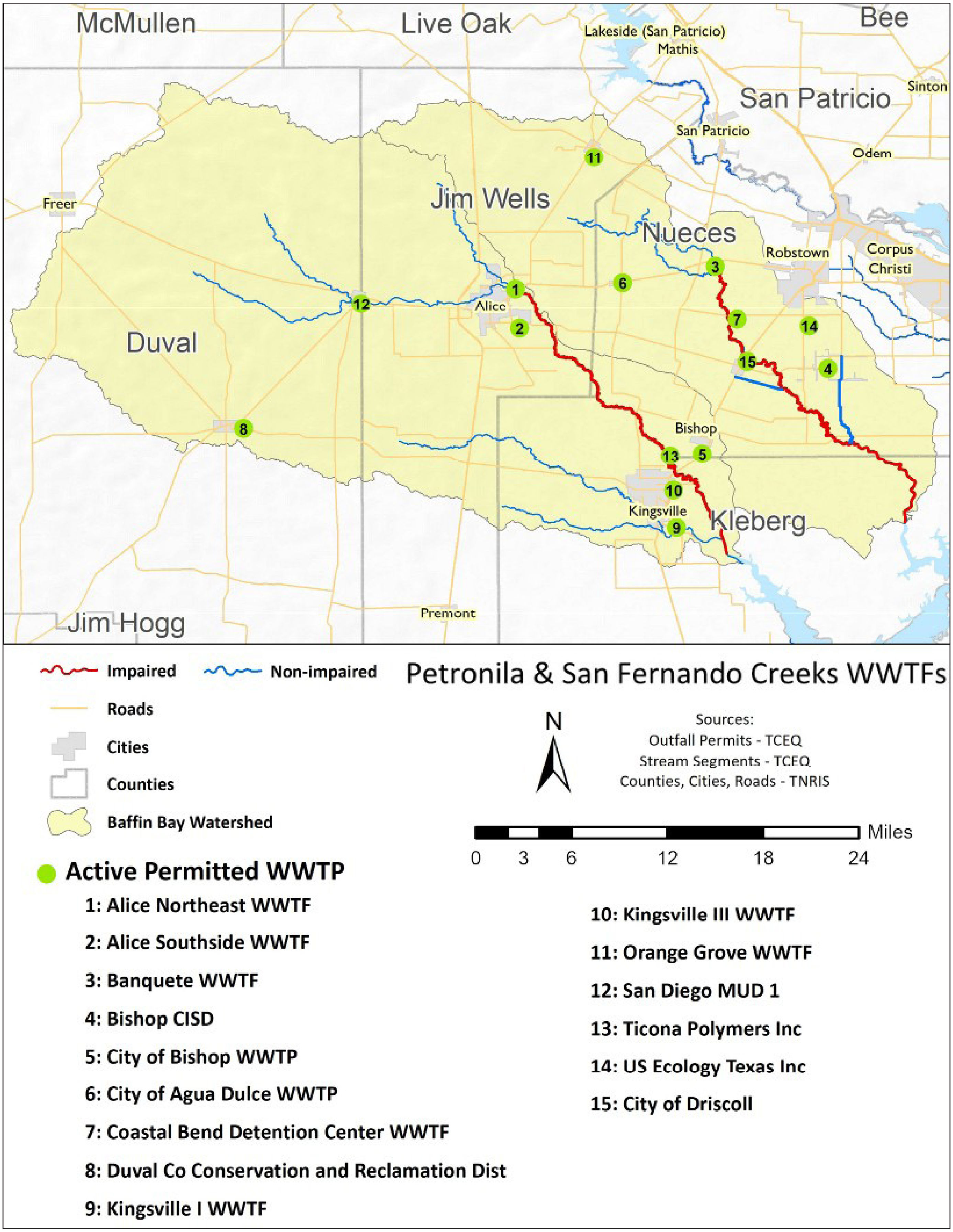


Figure 18. Permitted municipal wastewater treatment facilities. Consolidated independent school district, CISD; municipal utility district, MUD; wastewater treatment facility, WWTF; wastewater treatment plant, WWTP.

Table 10. Summary of municipal wastewater treatment facilities/wastewater treatment plants permitted discharges and compliance status.

Name	Receiving water body	Design flow (MGD)	Recent average flow (MGD)	Operation status	Quarters in noncompliance (10/17–09/20)*
Duval County Conservation and Reclamation District (Benavides WWTP)	San Fernando Creek	0.25	0.25	Active	0 (or no data reported)
Bishop Consolidated Independent School District	Petronila Creek	0.008	0.01	Active	0
City of Bishop WWTP	Caretta Creek	0.32	0.17	Active	12 (8 BOD, 9 *E. coli,* 1 total ammonia, 4 TSS)
Ticona Polymers Inc.	San Fernando Creek	3.5	2.68	Active	10 (2 BOD, 1 flow, 1 COD, 1 selenium, 1 nickel, 2 TSS)
San Diego Municipal Utility District 1	San Diego Creek	0.75	0.30	Active	12 (failure to report)
Agua Dulce WWTP	Agua Dulce Creek	0.16	0.11	Active	3 (missing measurements)
Banquete WWTF	Banquete Creek	0.1	0.81	Active	11 (1 BOD, 3 *E. coli,* 4 flow, 5 TSS, 1 reporting)
Orange Grove WWTF	Leon Creek	0.2	0.15	Active	1 (*E. coli*)
Kingsville III WWTF	Tranquitas Creek	3.0	2.51	Active	7 (3 copper, 1 flow, 4 reporting)
Kingsville I WWTF	Santa Gertrudis Creek	1.0	0.90	Active	7 (1 *E. coli,* 4 reporting)
Coastal Bend Detention Center WWTF	Petronila Creek	0.15	0.15	Active	12 (2 chlorine, 6 flow, 1 arsenic, 2 cadmium, 1 selenium, 8 reporting)
US Ecology Texas Inc.	Petronila Creek		0.003	Active	6 (3 arsenic, 2 pH, 4 reporting)
Southside WWTF (Alice)	Lattas Creek	2.6	1.75	Active	7 (3 *E. coli,* 4 reporting)
Northeast WWTF (Alice)	San Fernando Creek	2.02	0.90	Active	6 (1 BOD, 5 *E. coli*)
City of Driscoll WWTF	Petronila Creek	0.1	0.04	Active	9 (2 BOD, 2 *E. coli,* 1 DO, 6 TSS)

Biotechnical oxygen demand, BOD; chemical oxygen demand, COD; dissolved oxygen, DO; million gallons/day, MGD; total suspended solids, TSS; wastewater treatment facility, WWTF; wastewater treatment plant, WWTP

*There can be multiple violations for different parameters within a quarter violation period.

Table 11. Estimated sanitary sewer overflow volumes.

Water bodies	Total received gallons
Santa Gertrudis Creek	7,200
Tranquitas Creek	7,500
No water body provided	**23,910**

Table 12. Reported sanitary sewer overflow events and discharged volumes (January 1, 2016–December 31, 2018).

Facility	Number of events	Average gallons/event
Driscoll WWTF	1	1,000
Northeast WWTF (Alice)	2	10
Southside WWTF (Alice)	1	10
City of Kingsville I WWTF	5	1,440
City of Kingsville III WWTF	7	4,214
City of Bishop	1	600
Ticona Polymers Inc.	2	15

Wastewater treatment facility, WWTF

data. Addresses located outside of WWTF service areas are presumed to use OSSFs. This method of locating potential OSSF sites was used given the lack of actual OSSF locations from regional databases. This method produced an estimate of 9,086 OSSFs within the watersheds; of these, 25 OSSFs are within 100 yards of water bodies. OSSFs densities are highest in suburban areas just outside of wastewater service boundaries (Figure 19).

OSSF density can affect overall treatment performance. If the systems installed are not appropriately designed, the soil's treatment capacity may be exceeded and lead to widespread OSSF failure. Several areas, especially the central and northern areas of the watersheds, have higher OSSF densities than the surrounding areas and therefore may increase OSSF failure risk and subsequent water quality effects. Proximity to streams is important for determining OSSFs' potential impact on water quality. The closer a potentially failing system is to a stream, the more likely it is to impact instream water quality.

Typical OSSF designs include either anaerobic systems composed of septic tank(s) and an associated drainage or distribution field or aerobic systems with aerated holding tanks and typically an above ground sprinkler system to distribute the effluent. Many factors affect OSSF performance, such as systems' failure due to age, improper system design for specific site conditions, improper function from lack of maintenance/sludge removal, and illegal discharge of untreated wastewater. Adsorption field soil properties affect the final treatment effectiveness of all OSSFs. Soil suitability rankings developed by the USDA Natural Resources Conservation Service (NRCS) to evaluate the soil's ability to treat wastewater based on soil characteristics such as topography, saturated hydraulic conductivity, depth to the water table, ponding, flooding effects, and more (NRCS 2015). Soil suitability ratings are divided into three categories: not limited, somewhat limited, and very limited. Soil suitability dictates the type of OSSFs required to properly treat wastewater. If not properly designed, installed, or maintained, OSSFs in somewhat or very limited soils pose an increased risk of failure. Approximately 76% of the soils are considered very limited in the San Fernando and Petronila creeks watersheds (Figure 20).

Urban Runoff

Two primary pollutants in urban runoff are bacteria and nutrients that come from improper application of fertilizers and improper disposal of pet waste. Stormwater runoff from lawns, parking lots, and dog parks will wash fertilizers and waste into water bodies. Runoff from urban areas increases as population centers expand impermeable surface coverage in the watersheds. Housing developments, shopping centers, and industrial and/or business parks are development examples of urban expansion that increases impermeability within the watershed. Increased runoff from unmanaged urban development can affect water quality by accelerating creek erosion and habitat loss and by carrying more NPS pollutants like bacteria, nutrients, metals, and hydrocarbons into surrounding water bodies.

Livestock

Livestock grazing—predominately cattle and to a lesser extent, goats, horses, and sheep—occurs throughout the watersheds. These animals serve as a potential source of NPS pollution as they graze the landscape. Livestock deposit urine and fecal matter where they are allowed to graze and directly into accessible water bodies. Fecal matter deposited on the landscape can be transported to adjacent creeks during runoff events, which may contribute to increased bacteria loading in the water body.

Quantifying exact livestock populations in the watersheds is impossible due to birth, death, purchase, sale, and transport; however, county-level population estimates are available from the USDA National Agricultural Statistics Service (NASS) that help estimate total livestock within the watersheds. Recommended livestock stocking rates available from the USDA Farm Service Agency can also be used to

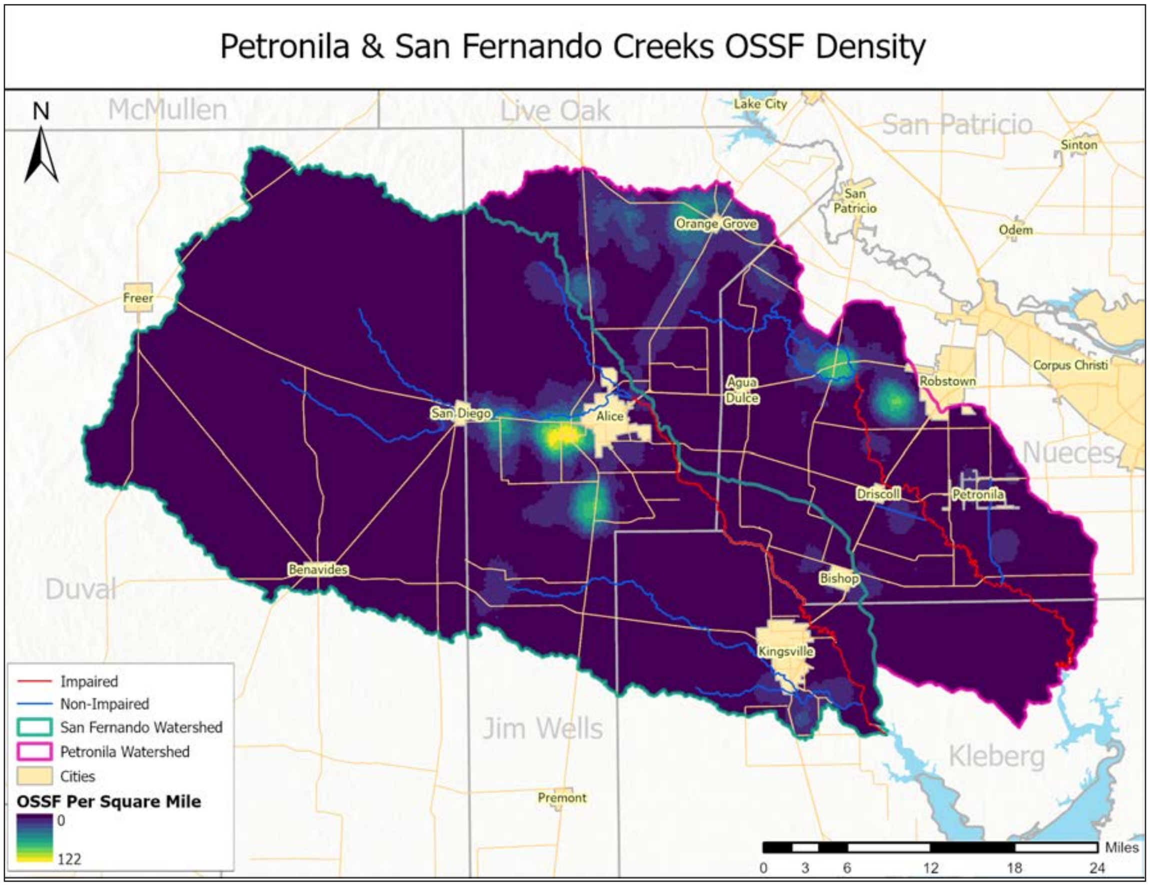


Figure 19. On-site sewage facility (OSSF) density.

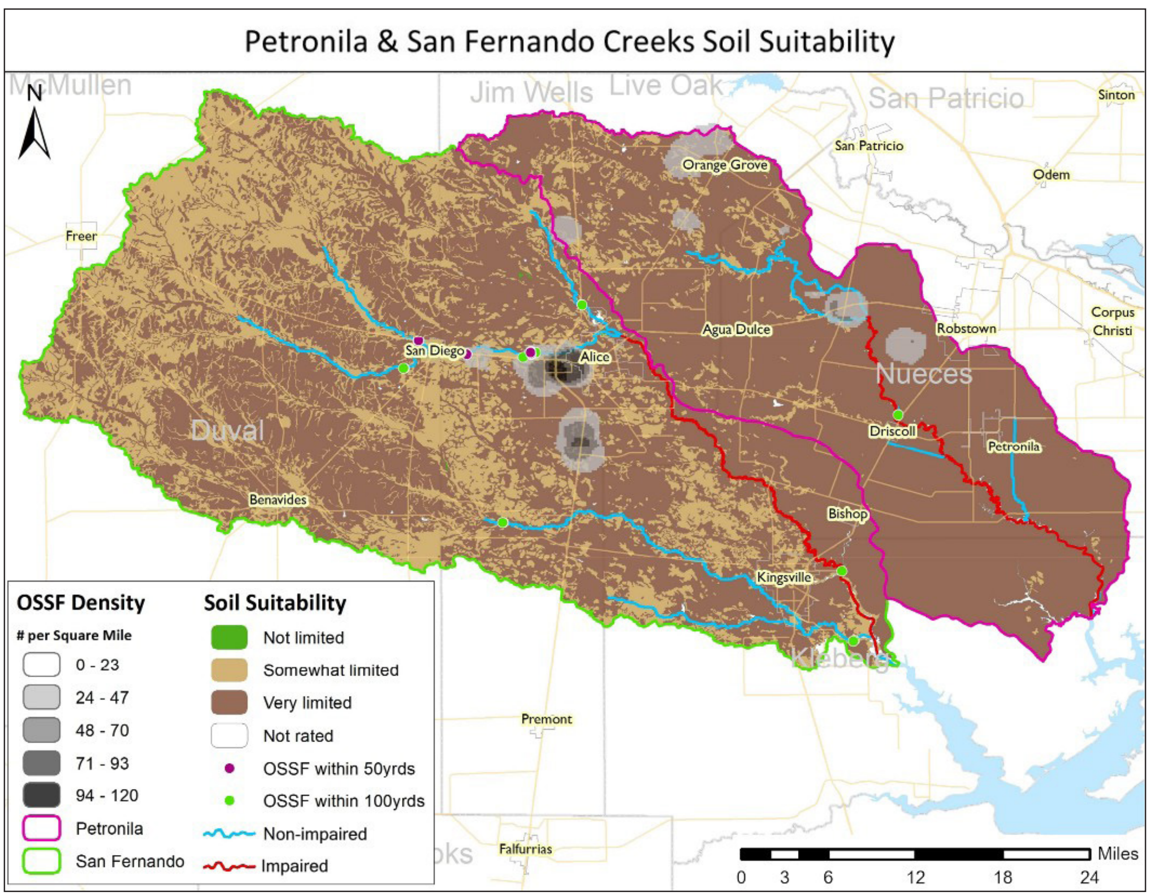


Figure 20. Soil suitability and on-site sewage facility (OSSF) density.

Table 13. Estimated livestock populations.

County	Livestock in watersheds				
	Cattle	Hog	Horse	Goat	Sheep
Duval	5,295	104	68	227	148
Jim Wells	22,012	130	643	1,670	338
Kleberg	6,252	63	112	295	103
Nueces	4,655	148	325	275	168
Total	**38,214**	**445**	**1,148**	**2,467**	**757**

Table 14. Estimated wildlife populations.

Watershed	Wildlife in watersheds	
	Feral hogs	Deer
Petronila Creek	3,933	4,071
San Fernando Creek	17,826	13,522
Total	**23,759**	**17,593**

Table 15. Estimated household pet population.

Watershed	Households*	Cats	Dogs
Petronila Creek	6,311	2,884	3,875
San Fernando Creek	26,885	12,286	16,507
Total	**33,196**	**15,171**	**20,382**

*Households from 2010 U.S. Census block data. Dog and cat estimations use the average number of pets owned per household provided by the American Veterinary Medical Association (2018).

generate these estimates. Comparing the results from both approaches, projected cattle populations were nearly identical when applying stakeholder confirmed average local stocking rates to improved pastures and rangeland identified in the NLCD data (Table 13). Estimates for other livestock were derived from NASS county statistics applied to pasture and rangeland land use types.

Wildlife

E. coli and nutrient loads are also contributed to the watersheds by wildlife. Riparian areas provide ideal habitat for wildlife, which leads to their congregation in these areas. Time spent in each area is directly related to the amount of fecal deposition for each animal. Therefore, wildlife feces can be a major source of pollution in the watersheds and in close proximity to the creeks. Wildlife population density estimates are not available for most wildlife species, making it impossible to quantify a total potential wildlife load.

White-tailed deer and feral hogs are two species that density estimates are available for, but they do not constitute the total wildlife population. The Texas Parks and Wildlife Department (TPWD) conducts annual deer population surveys at the deer management unit (DMU) level. DMUs are landscapes indexed by similar ecological characteristics within a defined area. The San Fernando and Petronila creeks watersheds are situated within two DMUs: DMU 8 East and DMU 9, both of which are considered South Texas Plains ecoregions. For this project, the most recent 5 years of density estimates were averaged and applied to appropriate land uses. The density average for DMU 8 East is 61.7 ac/deer and DMU 9 is 26.1 ac/deer. Stakeholders provided feedback regarding deer density in areas with heavy crop production in the watersheds, and it was agreed upon to apply only 10% of the average density in these areas due to the lack of available cover nearby. Using this combination of information, deer densities were applied to all LULC classes in the watersheds except for open water, baren land, and developed land yielding an estimate of 17,593 deer in the watersheds.

Feral hogs are a non-native, invasive species that are rapidly expanding throughout Texas and inhabit similar land use types as white-tailed deer. They are especially fond of places where there is dense cover with food and water readily available. Riparian corridors are prime habitat for feral hogs; therefore, they spend much of their time wallowing in or near creeks. This preference for riparian areas does not preclude their use of non-riparian areas. Reclusive by nature, feral hogs are a predominantly nocturnal species. They typically remain in thick cover during the day and venture away from cover at night into cropland, pastures, or rangeland. Feral hogs are significant contributors of pollutants to creeks and rivers across the state through direct and indirect fecal loading. Extensive rooting and wallowing in riparian areas also causes erosion and soil loss. Statewide feral hog density estimates have ranged from roughly 30 ac/hog to 72 ac/hog (Wagner and Moench 2009; Timmons et al. 2012). Considering these estimates and stakeholder input, a feral hog density of 39 ac/hog was applied to all land uses except barren, developed, and open water. Stakeholders provided feedback regarding feral hog density in cropland-dominated portions of the watersheds and agreed to apply only 10% of the average density in these areas due to the lack of available cover nearby. Using this combination of information, an estimated 23,759 feral hogs are in the watersheds.

Other Wildlife

Many other species of wild animals call the watersheds home, including a variety of birds and mammals that can contribute significantly to bacteria loading in the watersheds. The lack of information regarding population estimates for these animals and their fecal production rates prevent their impacts from being quantified. Additionally, reducing bacteria loading resulting from certain wild animal populations is impossible due to wildlife management and preservation laws. Bacteria from wildlife not specifically identified here contribute to bacteria in the creeks, but their impacts are not assessed and no management recommendations to address these sources are included.

Pets

Dogs and cats can contribute to fecal bacteria and nutrient loading in water bodies when waste is carried by runoff from lawns, parks, and other surfaces. Bacteria loading from pets can be reduced if pet owners properly dispose of waste in the garbage. According to the American Veterinary Medical Association (AVMA), the average household in the U.S. is home to 0.614 dogs and 0.457 cats (AVMA 2018). The number of pets in the watersheds was estimated by multiplying the average pets per household by the number of households represented in the U.S. Census block data. There are an estimated 20,382 dogs and 15,171 cats in the watersheds (Table 15). Cats routinely bury their excrement, or it is disposed of in the trash by owners cleaning litter boxes; thus their potential influence on water quality is considered meager compared to dogs.

Illegal Dumping

Watershed stakeholders identified illegal dumping as a considerable problem across the watersheds. While most items dumped are not considered major bacteria or nutrients sources, trash accumulation leads to additional dumping. Some items dumped, including animal carcasses and household waste, contain bacteria, while other discarded trash, such as electronic or automotive waste, contain harmful chemicals, metals, and more. Improper waste disposal is bad for the environment, and local stakeholders strongly desire to address this pollution source.

Nutrient Sources

Nutrient loading to area water bodies has been identified as a significant water quality concern in the creeks and Baffin Bay. Nutrients come from various sources, including nonpoint (animal waste, fertilizers, OSSFs, and natural) and point sources (domestic and industrial wastewater). Regardless of source, nutrient loading can cause excess aquatic plant growth, which may lead to water body eutrophication and fish kills. Chlorophyll-a is a measure of phytoplankton abundance in water and is a surrogate indicator for nutrient impacts in a water body.

A nonpoint nutrient source modeling exercise completed in 2019 evaluated nitrogen and phosphorus loading estimates across the watersheds (Parsons 2019). This assessment applied the Spreadsheet Tool for Estimating Pollutant Loading (STEPL), which considers land use, soil properties, households with septic tanks, and livestock populations. STEPL also estimates erosion rates and runoff generation in this assessment. Literature values and available population information are primary data inputs for this model. In Petronila Creek watershed, cropland was modeled to contribute 94% and 97% of nitrogen and phosphorus, respectively, while in San Fernando Creek watershed, cropland was estimated to contribute 56% and 78% of nitrogen and phosphorous, respectively. The report did acknowledge that modeled results should not be considered a comprehensive assessment because wastewater, wildlife, feral hogs, and confined animal feeding operations were not considered (Parsons 2019).

Other Baffin Bay Pollutant Sources

In addition to the pollutant sources described specifically for San Fernando and Petronila creeks watersheds, Baffin Bay is also influenced by pollutant contributions on adjacent lands that drain directly to the bay and by inputs from the Los Olmos Creek watershed. Around the bay, these influences include contributions from OSSFs and animals such as livestock, pets, and wildlife. Many homes on the western shore of Baffin Bay rely on OSSFs to treat waste. If these systems fail, they can potentially have significant influences on nearby water quality. Plans for additional housing developments adjacent to the bay also pose a future threat to water quality and have adverse aquatic and human health impacts. Thorough consideration should be given to fostering partnerships between stakeholders and land developers to guide future development to less ecologically sensitive areas or to encourage low impact development practices.

Chapter 5
Pollutant Source Assessment

Baffin Bay and shoreline. Photo courtesy of the Coastal Bend Bays and Estuaries Program.

Multiple approaches were used to assess watershed pollutant loadings and provide a more complete evaluation of each respective source and its impacts on water quality. Each approach provides a piece of information used to define and address specific pollutant sources. No single method provides a perfect result or definitive answer because each method analyzes data differently. Methods used included water quality data analysis, LDCs, and spatial analysis of potential *E. coli* sources.

Water Quality Monitoring

The *2020 Texas Integrated Report* identified AUs 2203_01, 2204_01, 2204_02, and 2492A_01 as impaired due to elevated bacteria concentrations and reveals concerns for elevated chlorophyll-a levels. Additionally, AU 2492A_01 has elevated levels of nitrates and total phosphorous. San Fernando and Petronila creeks are routinely monitored by the Nueces River Authority (NRA) and the TCEQ regional office and less frequently through special projects and studies conducted by organizations within or near the watersheds. Historically, measured data from these entities have indicated similar concerns for bacteria and nutrient concentrations across the watersheds.

E. coli and Enterococcus Data Assessment

Routinely collected data from five water quality monitoring stations in the San Fernando and Petronila creeks watersheds demonstrate that the creeks are hydrologically dynamic and that *E. coli* and enterococcus loading is spatially and temporally variable. Streamflow volume strongly influences measured bacteria concentrations. Monitoring sites with sustained flow for much of the year tend to have lower geometric means under routine conditions. Monitoring stations upstream in the watersheds tend to experience drier conditions more frequently. Stormwater runoff dominates flow at these stations and leads to commonly higher *E. coli* concentrations than downstream stations.

Bacteria concentrations across the watersheds exhibit a wide range of measured values (Figure 21, Table 16). In the freshwater portions of San Fernando and Petronila creeks, *E. coli* is commonly found above the water quality standard except for at station 20806. In the tidal segment of Petronila Creek, enterococcus concentrations measured at station 13090 are also above the applicable water quality standard (Figure 21, Table 16).

Table 16. *E. coli* and enterococcus summary (2001 through 2021).

Station	Assessment unit	Samples	Creek segment	Minimum (MPN/100 mL)	Maximum (MPN/100 mL)	Geometric mean (MPN/100 mL)
13033	2492A_01	57	San Fernando	1	2,400	303.6**
13090*	2203_01	42	Petronila Tidal	10	730	44.9
13094	2204_01	42	Petronila	1	24,000	419.4
21598		1	Petronila	-	-	-
13096	2204_02	53	Petronila	1	2,420	592.5
20806		40	Petronila	1	2,400	28.8

Milliliter, mL; most probable number, MPN
*The enterococcus standard of 35 MPN/100 mL applies at this station.
**Bolded cells indicate bacteria standard exceedances.

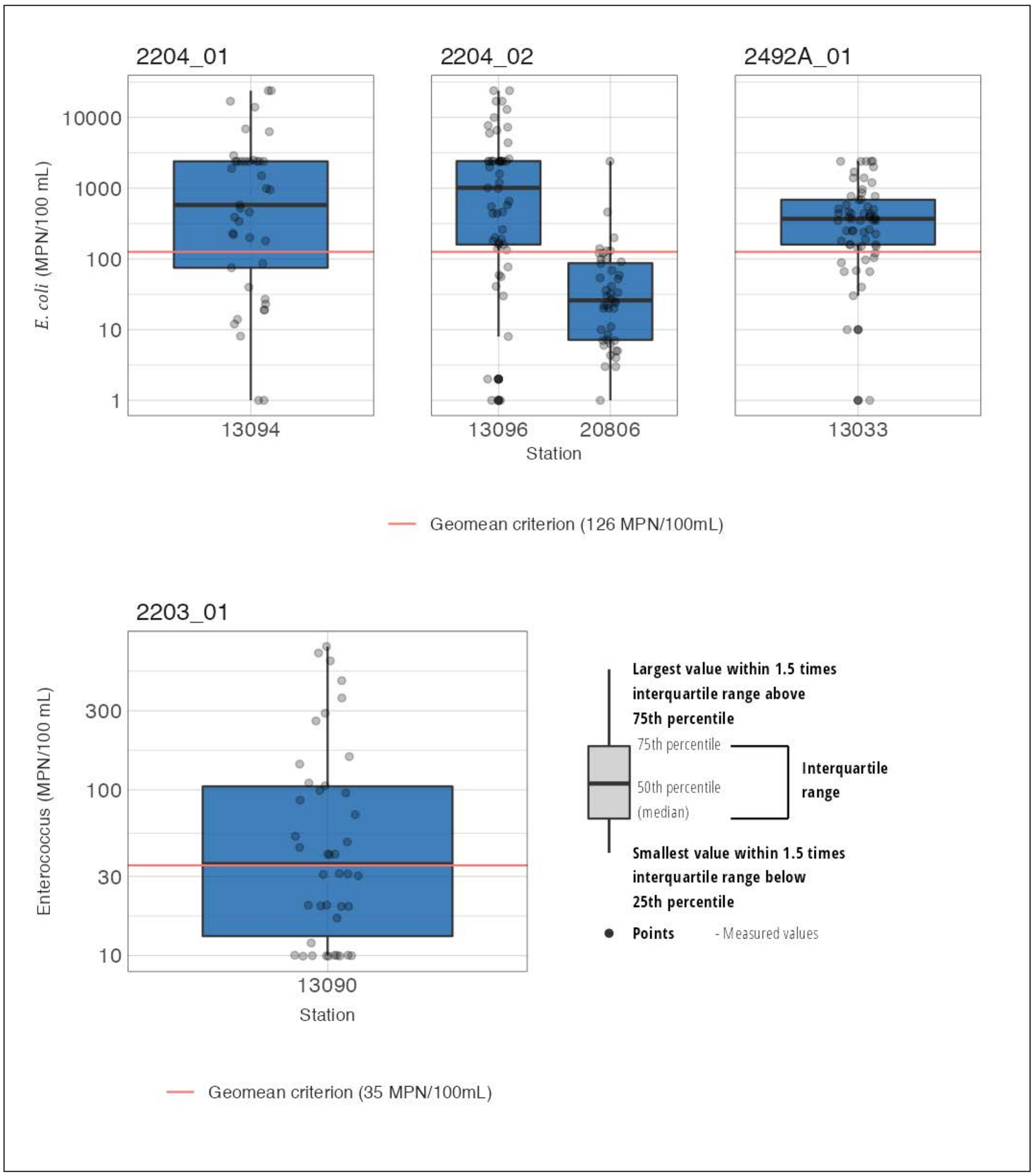
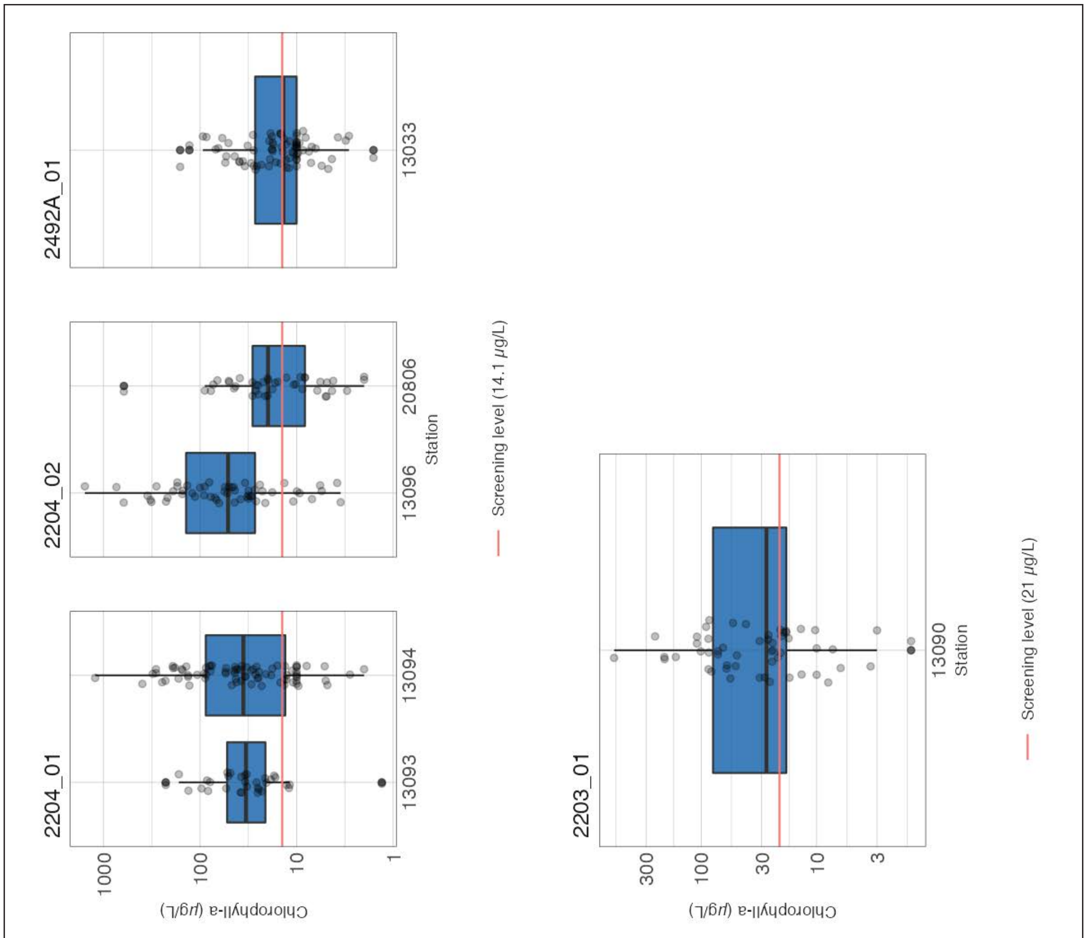
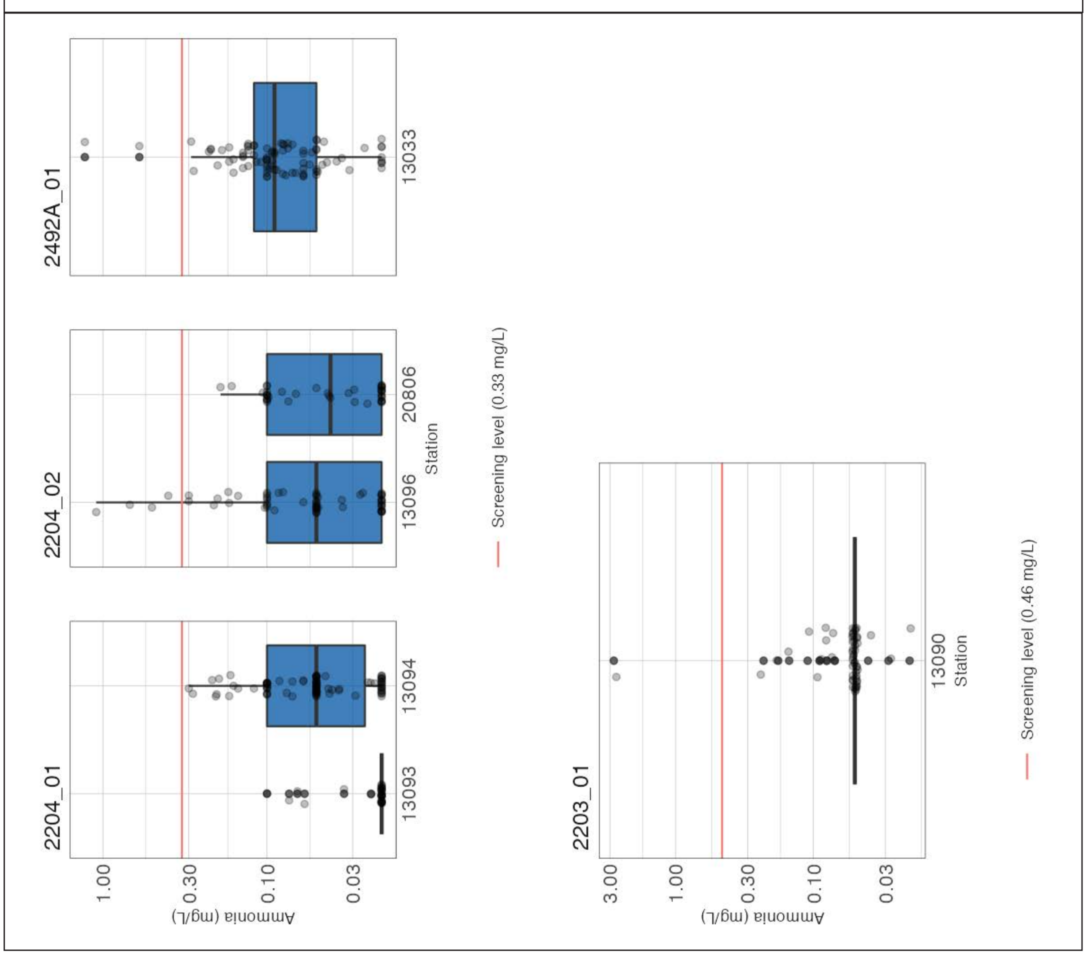


Figure 21. *E. coli* and enterococcus concentration measurements taken between 2000 and 2021.


2204_01
2204_02
2492A_01
2203_01
13093
13094
13096
20806
13033
13090
Station
Chlorophyll-a (µg/L)
1000
100
10
1
300
30
3
Screening level (14.1 µg/L)
Screening level (21 µg/L)


2204_01
2204_02
2492A_01
2203_01
13093
13094
13096
20806
13033
13090
Station
Ammonia (mg/L)
3.00
1.00
0.30
0.10
0.03
Screening level (0.33 mg/L)
Screening level (0.46 mg/L)

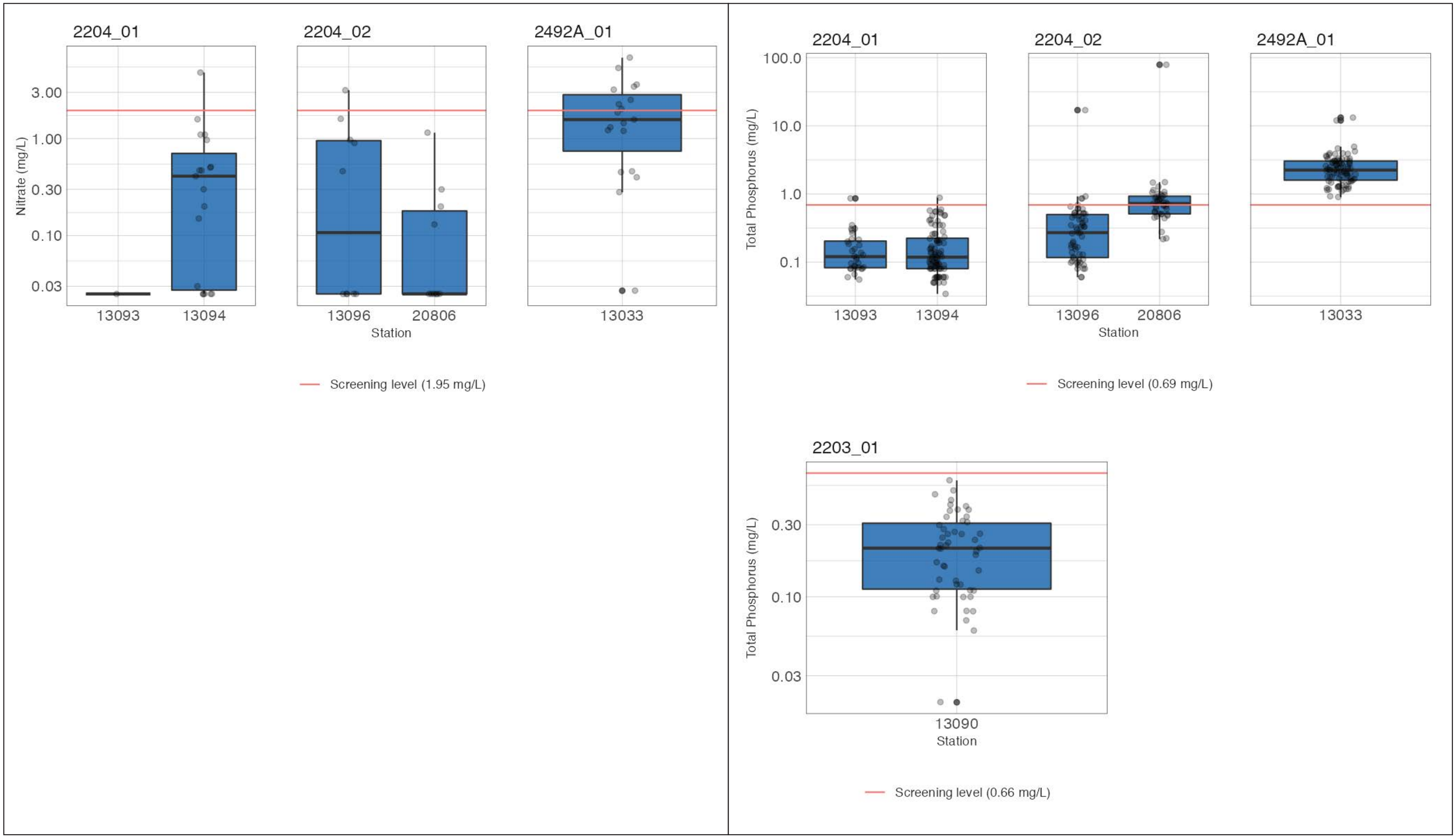


Figure 22. Boxplots of ammonia, chlorophyll-a, nitrate, and total phosphorous at stations with more than five measurement values 2001–2021.

Table 17. Nutrient summary statistics.

Station identification number	Assessment unit	Water body	Mean nitrate (mg/L)	Mean ammonia (mg/L)	Mean chlorophyll-a (µg/L)	Mean total phosphorus (mg/L)
13033	2492A_01	San Fernando Creek	2.08*	0.11	23.48	2.56
13090	2203_01	Petronila Creek Tidal	0.5	0.11	61.9	0.23
13094	2204_01	Petronila Creek Above Tidal	0.67	0.07	82.19	0.19
21598			No data	No data	No data	No data
13096	2204_02		0.72	0.11	131.07	0.6
20806			0.19	0.06	38.3	2.65

Liter, L; microgram, µg; milligram, mg
*Bold values exceed respective screening levels.

Nutrients

Nutrient concentrations in all AUs in the watersheds are typically below state screening criteria (Figure 22 and Table 17); however, all AUs have higher chlorophyll-a concentrations than the screening level. Chlorophyll-a is an indicator of excess nutrient loading in a water body. Though these data seem to contradict each other, organic forms of nutrients not measured in current sampling also influence chlorophyll-a concentrations. Recent data analysis and comparison of organic and inorganic nutrient concentrations in Baffin Bay suggest that elevated organic nutrient concentrations are higher than in other Texas bay complexes and are the driver of elevated chlorophyll-a concentrations and harmful algal blooms (Wetz et al. 2017).

Load Duration Curve Analysis

The relationship between flow and pollutant concentration in the watersheds was established using LDCs. This approach allows existing pollutant loads to be calculated and compared to allowable loads. It is the basis for estimating needed pollutant load reductions to achieve the established water quality goal. LDCs can also help determine whether point or nonpoint pollutant sources primarily cause stream impairments by identifying flow conditions when impairments occur. Although LDCs cannot identify specific pollutant sources (e.g., urban vs. agricultural), they can identify the likely pollutant type (point vs. nonpoint). For example, if allowable load exceedances primarily occur during high flow or mid-range flow categories, NPS is a primary contributor. If exceedances occur during low flow conditions, point sources are the most likely source. Instream disturbances, such as those caused by increased flow velocity (e.g., a release from a dam) or physical agitation (e.g., an animal walking in the stream), are also known to cause *E. coli* increases under all flow conditions.

For planning purposes, bacteria LDCs were completed at two monitoring sites in the San Fernando and Petronila creeks watersheds (Stations 13033 and 13096, respectively) due to the amount of available *E. coli* data collected from 1990 to 2021 (Figure 11). Load distributions across flow regimes and needed load reductions at these stations were considered representative of their respective watersheds. Although these monitoring stations are not located at each watershed's outlet, each does have the most robust data record available and is representative of conditions across each watershed. Nutrient LDCs were not developed because nutrient standards have not been established for Texas. Despite the lack of nutrient water quality standards and focused efforts to address loading to the stream, the practices aimed at reducing bacteria loads will also yield nutrient load reductions when implemented in the watersheds.

Flow records at both sites were limited and not representative of the full flow regime. To account for the broad range of flows in these systems, the drainage-area ratio (DAR) method (Asquith et al. 2006) was used to extend representative USGS flow gage data to the monitored locations. For both stations, the USGS gage near Alice (08211900) was used to approximate flows. Daily average streamflow from the previous 22 years were available for this assessment and were paired with *E. coli* concentrations collected at known flow rates. DAR is used to equate the ratio of streamflow of an unknown stream location to that of a nearby drainage area with enough data. This method was reviewed jointly by USGS and TCEQ using 7.8 million values of daily streamflow data from 712 USGS streamflow gages in Texas and was found to be a sufficient method for interpolating stream¬-flow measurements.

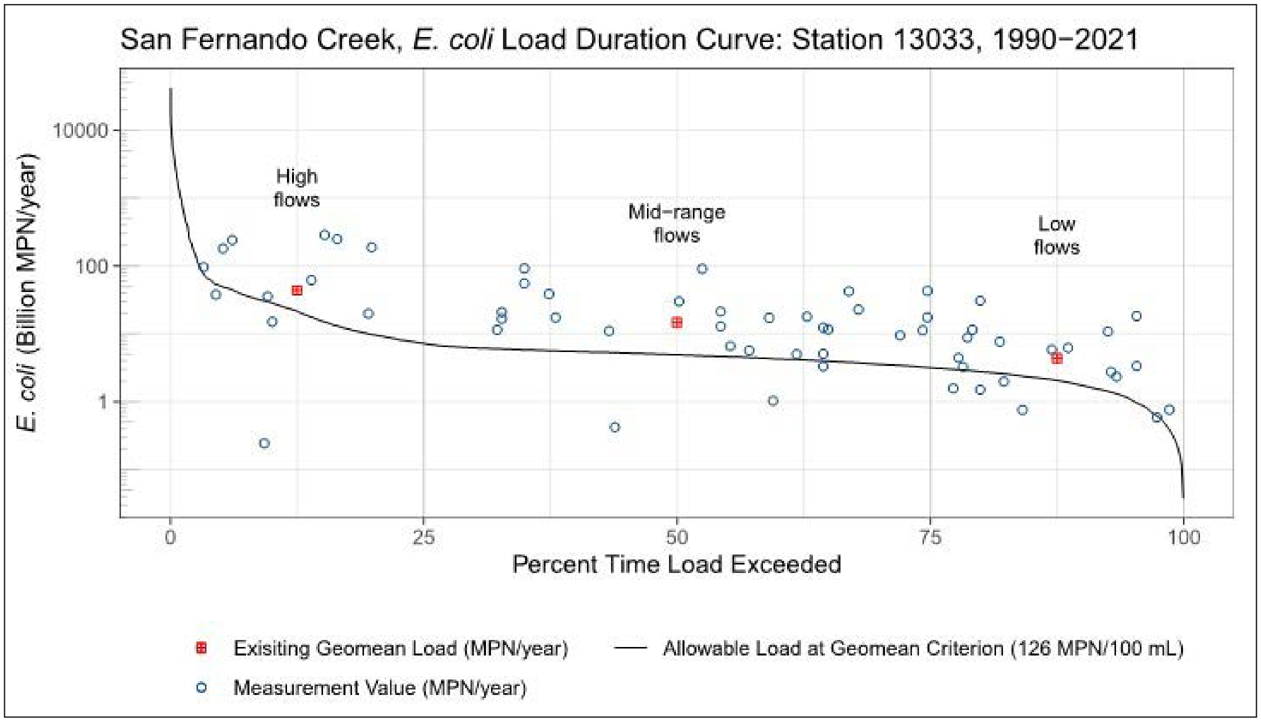


Figure 23. San Fernando Creek station 13033 *E. coli* load duration curve.

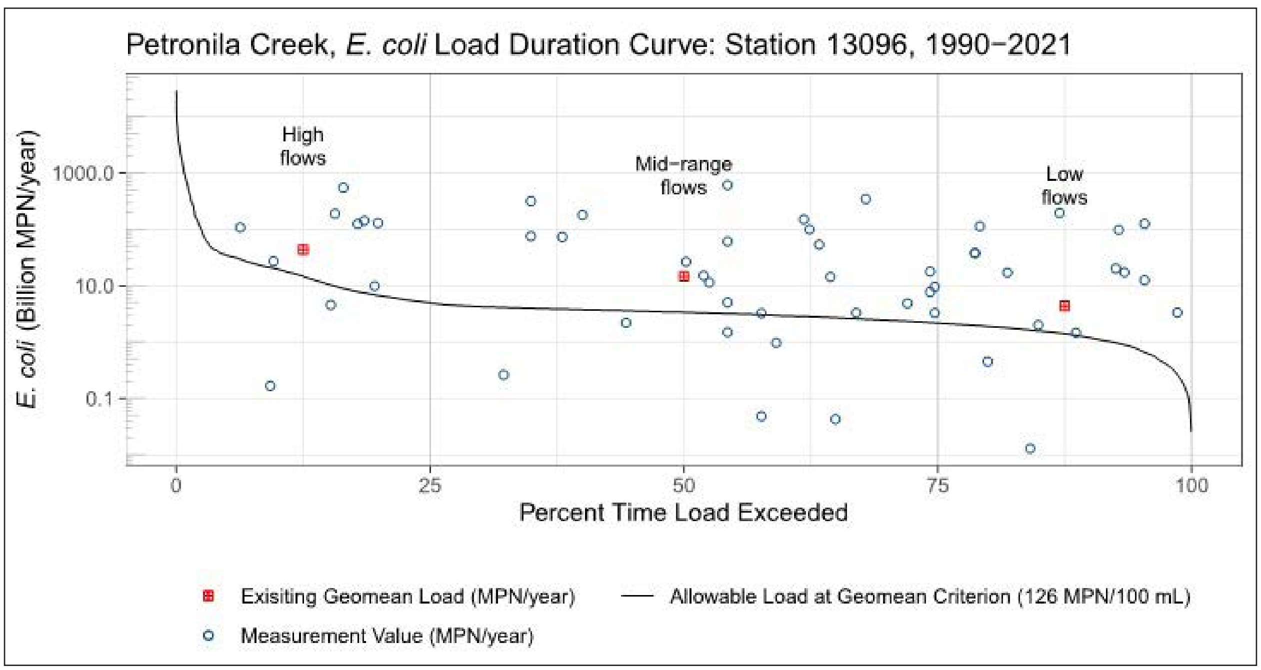


Figure 24. Petronila Creek station 13096 *E. coli* load duration curve.

Station 13033

Station 13033 is located on San Fernando Creek north of Kingsville at the US 77 road crossing. Quarterly grab sampling and instantaneous flow measurements are conducted by NRA at this location. The LDC for this station indicates that *E. coli* loads generally exceed allowable amounts under all flow conditions (Figure 23). This suggests that a combination of point and nonpoint *E. coli* sources are influencing instream water quality.

Station 13096

Station 13096 is located on Petronila Creek at FM 665 east of Driscoll. Quarterly grab sampling and instantaneous flow measurements are conducted by NRA at this location. The LDC for this station indicates that *E. coli* loads generally exceed allowable amounts under all flow conditions (Figure 24). This suggests that a combination of point and nonpoint *E. coli* sources are influencing instream water quality.

Table 18. Estimated *E. coli* load reductions needed to meet primary contact water quality criteria in San Fernando Creek (based on the 126 colony forming units/100 milliliters of water standard).

San Fernando Creek	Flow conditions		
Station 13033	**Low**	**Mid-range**	**High**
Days/year	91.25	182.5	91.25
Median flow (cfs)	0.673	1.595	7.033
Existing geomean concentration (MPN/100 mL)	265.647	376.154	252.875
Allowable daily load (billion MPN)	2.075	4.917	21.68
Allowable annual load (billion MPN)	189.311	897.33	1,978.35
Existing daily load (billion MPN)	4.374	14.678	43.511
Existing annual load (billion MPN)	399.13	2,678.84	3,970.33
Annual load reduction needed (billion MPN)	209.82	1,781.51	1,992.08
Percent reduction needed	52.57%	66.50%	50.17%
Total annual load (billion MPN)	7,048.39		
Total annual load reduction (billion MPN)	3,983.41		
Total percent reduction	56.52%		

Cubic feet/second, cfs; milliliter, mL; most probable number, MPN

Table 19. Estimated *E. coli* load reductions needed to meet primary contact water quality criteria in Petronila Creek (based on the 126 colony forming units/100 milliliters of water standard).

Petronila Creek	Flow conditions		
Station 13096	**Low**	**Mid-range**	**High**
Days/year	91.25	182.5	91.25
Median flow (cfs)	0.463	1.097	4.838
Existing geomean concentration (MPN/100 mL)	1103.478	480.515	419.054
Allowable daily load (billion MPN)	1.427	3.382	14.914
Allowable annual load (billion MPN)	130.239	617.16	1,360.90
Existing daily load (billion MPN)	12.499	12.897	49.601
Existing annual load (billion MPN)	1,140.61	2,353.61	4,526.12
Annual load reduction needed (billion MPN)	1,010.37	1,736.45	3,165.22
Percent reduction needed	88.58%	73.78%	69.93%
Total annual load (billion MPN)	8,020.34		
Total annual load reduction (billion MPN)	5,912.04		
Total percent reduction	73.71%		

Cubic feet/second, cfs; milliliter, mL; most probable number, MPN

Annualized Reductions

Based on LDC analysis, both San Fernando and Petronila creeks exhibit bacteria load exceedances under all flow conditions. Estimated annual load reductions needed to meet water quality standards were developed based on LDCs for station 13033 and 13096 for San Fernando and Petronila creeks, respectively (Tables 18 and 19). These needed load reduction estimates will serve as numeric targets for recommending management activity across the watersheds to reduce bacteria loading and improve instream water quality.

Spatial Analysis of Potential *E. coli* Loading

The distribution of potential pollutant loadings across the watersheds were evaluated using a geographic information system (GIS)-based approach similar to the Spatially Explicit Load Enrichment Calculation Tool (SELECT; Teague et al. 2009) methodology. By estimating relative potential contributions of different fecal bacteria sources across the watersheds, critical source areas (CSAs) can be prioritized for management measures. Publicly available information

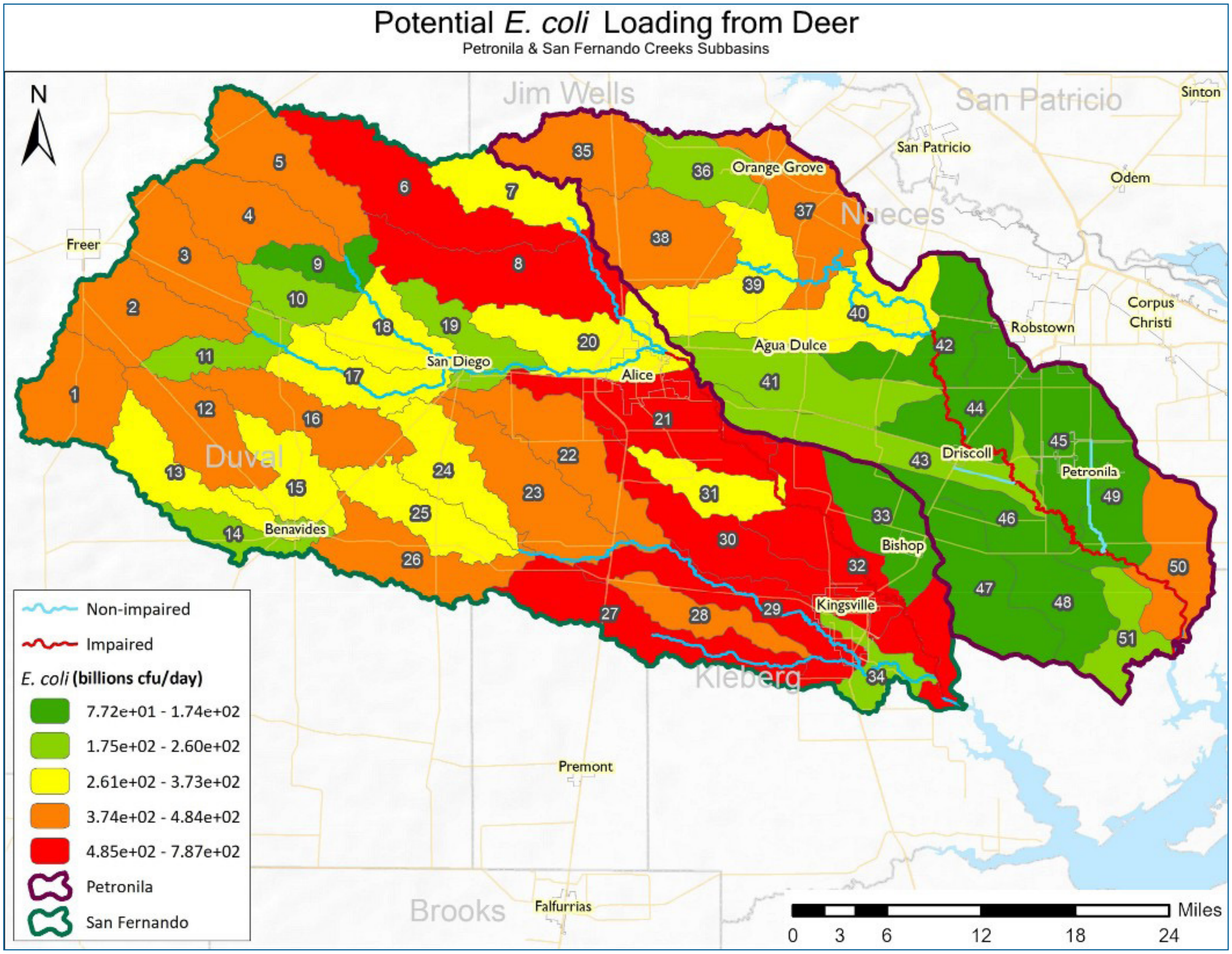


Figure 25. Estimated potential *E. coli* loads from deer.

described in previous sections discussing pollutant sources, LULC, and soils data, combined with stakeholder feedback, was used to identify potential bacteria loading estimates across the watersheds from evaluated sources. Specific calculations used to estimate loads for each bacteria source discussed are presented in Appendix A.

To facilitate this assessment, the watersheds were subdivided into smaller subbasins using 12-digit hydrologic unit codes (HUCs). HUCs are defined by USGS according to hydrological features and are generally of similar size. In this WPP, HUCs are referred to as subbasins and are given a numeric identification number. The San Fernando Creek watershed includes subbasins 1–34, and the Petronila Creek watershed includes subbasins 35–51 (Figure 25). Subbasin identification numbers are used to identify CSAs and management recommendation priorities later in the WPP.

It should be noted that HUC boundaries are based purely on hydrology and do not take land use dissimilarities into account. For example, subbasin 30 includes most of the City of Kingsville yet extends roughly 23 miles northwest near the community of Ben Bolt. This subbasin is largely rural with over 70 percent grazing land and only 13 percent developed area. However, the urban influence causes this subbasin to be identified as a high potential loading area for urban derived bacteria sources (pets and wastewater) and more commonly rural sources (deer and livestock) alike. As a result, map outputs (Figures 25 – 31) may seem inappropriate. These color-coded maps are simply a visual aid that illustrate potential bacteria loading estimates between subbasins which can help facilitate best management practice (BMP) implementation prioritization (Figures 25–31). Loading estimates presented are potential loading estimates that do not consider naturally occurring bacteria fate and transport processes in the environment. Therefore, this analysis presents a worst-case bacteria-loading scenario in the watersheds and does not represent actual bacteria loading to area water bodies.

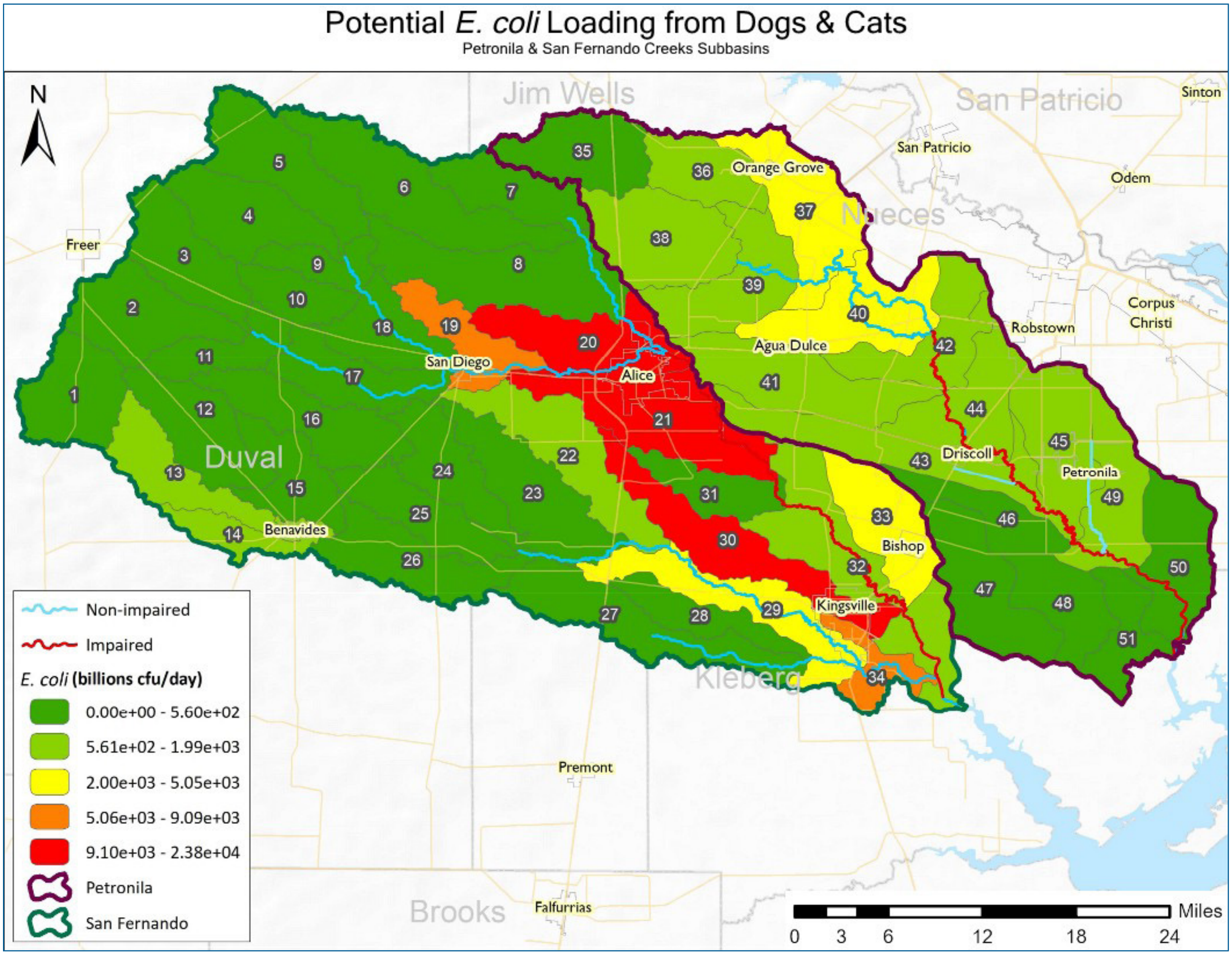


Figure 26. Estimated potential *E. coli* loads from dogs and cats.

Deer

White-tailed deer are the only true wildlife species in the watersheds with reasonable population estimates and fecal bacteria contributions available. Other wildlife and exotic species are present in the watersheds, but their distribution and numbers are not known. White-tailed deer prefer habitats with ample food and cover, but they are adaptable animals known to feed on crops and vegetation around homesteads. Based on white-tailed deer density estimates, the San Fernando Creek watershed was found to contain the most deer in the area. When runoff occurs across the watershed, fecal matter deposited on the landscape can be transported to nearby waterways. Subbasins 6, 8, 21, 27, 29, 30, and 32 were identified as having the highest potential deer *E. coli* loading (Figure 25). In the Petronila Creek watershed, subbasins 35, 37, 38, and 50 have the highest potential *E. coli* load from deer (Figure 25).

Domestic Pets

Dogs and cats can contribute significant quantities of *E. coli* to a watershed if their waste is not properly disposed of and allowed to remain on the landscape. Picking up after dogs and disposing of cat litter boxes in municipal solid waste effectively removes this source from a watershed. However, a considerable amount of pet waste, especially from dogs, is left in parks, yards or near homesteads in rural areas and can enter waterways during runoff events. Because dogs and cats are most often associated with people, the highest potential *E. coli* loading areas are near population centers in the watersheds. In the San Fernando Creek watershed, subbasins with the largest potential loading from pets are 20, 21, and 30, followed closely by 19 and 34 (Figure 26). The human population in the Petronila Creek watershed is much lower; thus the number of pets is also lower. Compared to other subbasins in the Petronila Creek watershed, subbasins 37 and 40 have the highest potential *E. coli* loading from pets (Figure 26).

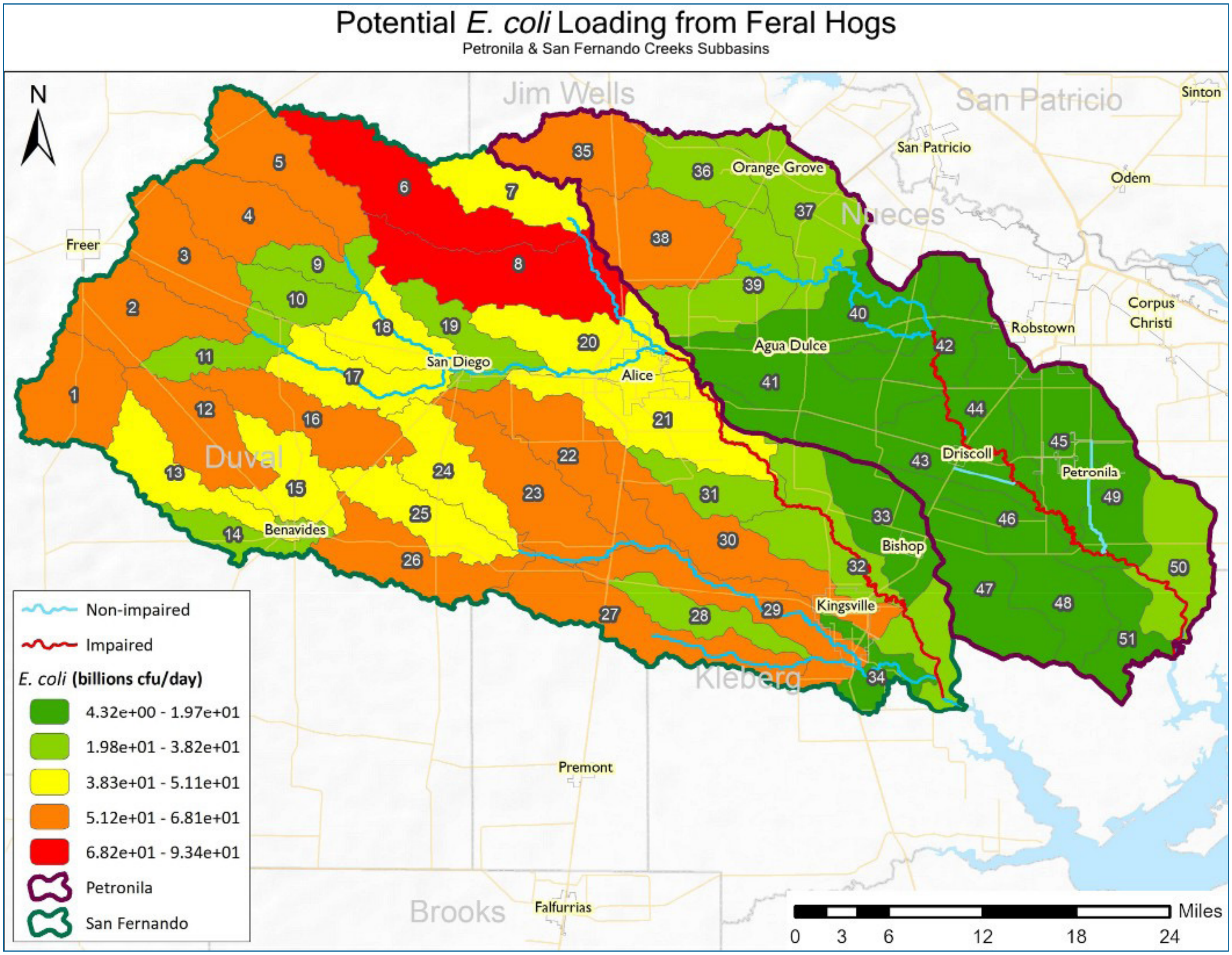


Figure 27. Estimated potential *E. coli* loads from feral hogs.

Feral Hogs

Feral hog population estimates in Texas range from one to three million individuals (Mayer 2009; Mapston 2010) but are largely unknown. Feral hogs contribute *E. coli* bacteria loading through direct deposition of fecal matter into streams while wading or wallowing in riparian areas and through fecal deposition across the landscape. Feral hogs create extensive land disturbance in riparian and upland areas that can contribute to increased soil erosion and pollutant runoff. Riparian areas provide ideal habitat and travel corridors for feral hogs as they search for food. While complete removal of feral hog populations is impossible, food source management and trapping programs can reduce populations and associated damage. Assessment results indicate the highest feral hog loading potential occurs in subbasins 6 and 8 in San Fernando Creek watershed and subbasins 35 and 38 in the Petronila Creek watershed (Figure 27).

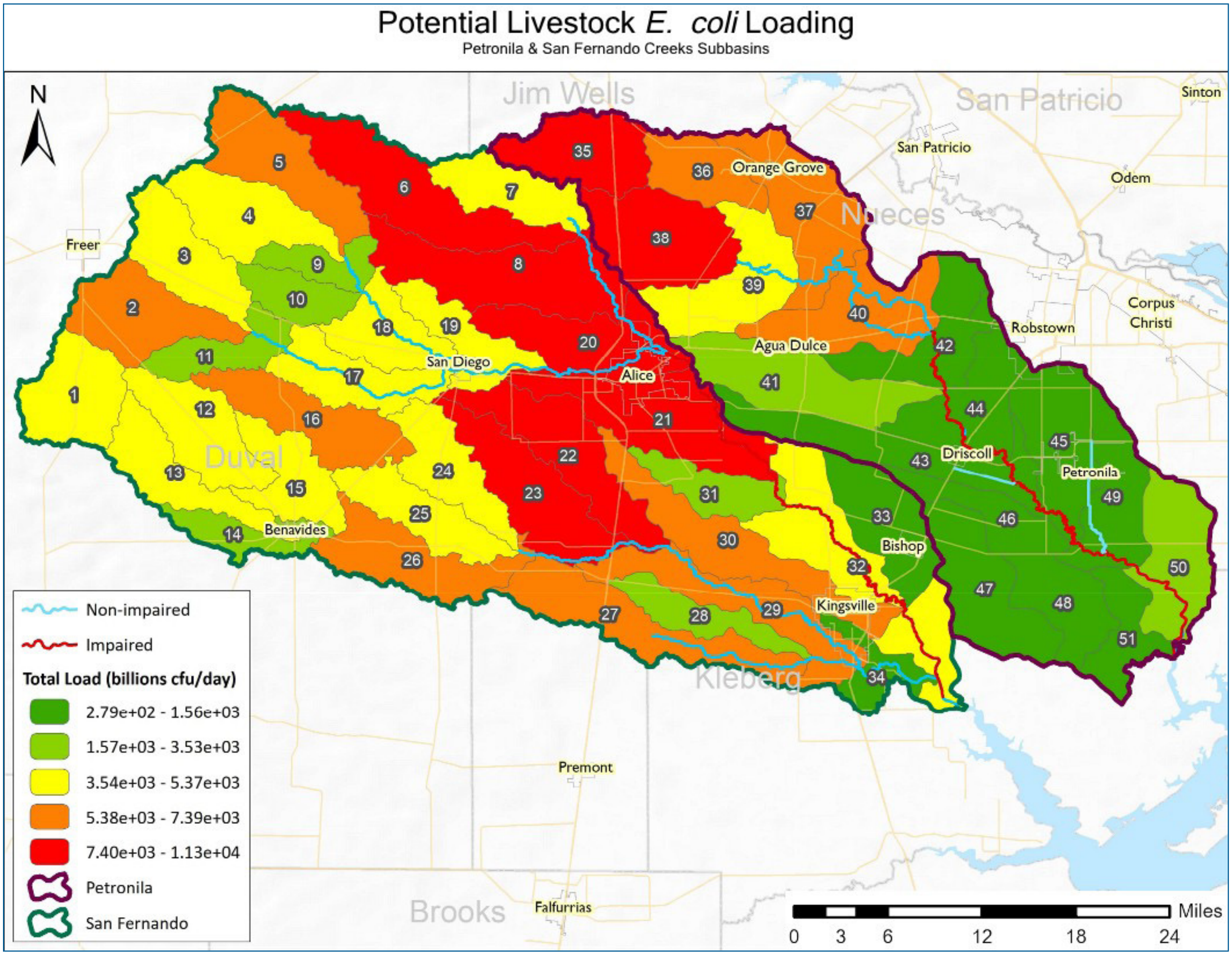


Figure 28. Estimated potential *E. coli* loads from livestock.

Livestock

Cattle, goats, horses, and sheep are all potential *E. coli* bacteria loading contributors in the watersheds. Livestock estimates derived from USDA Census of Agriculture (USDA 2017) county population data and stakeholder input were used to estimate potential *E. coli* loads. Spatial distribution of relative *E. coli* loading potential for each type of livestock was calculated and combined to produce the total potential livestock *E. coli* load across the watersheds (Figure 28). The highest *E. coli* loading potentials exist in subbasins 6, 8, 20, 21, 22, and 23 in San Fernando Creek watershed and in subbasins 35 and 38 in the Petronila Creek watershed.

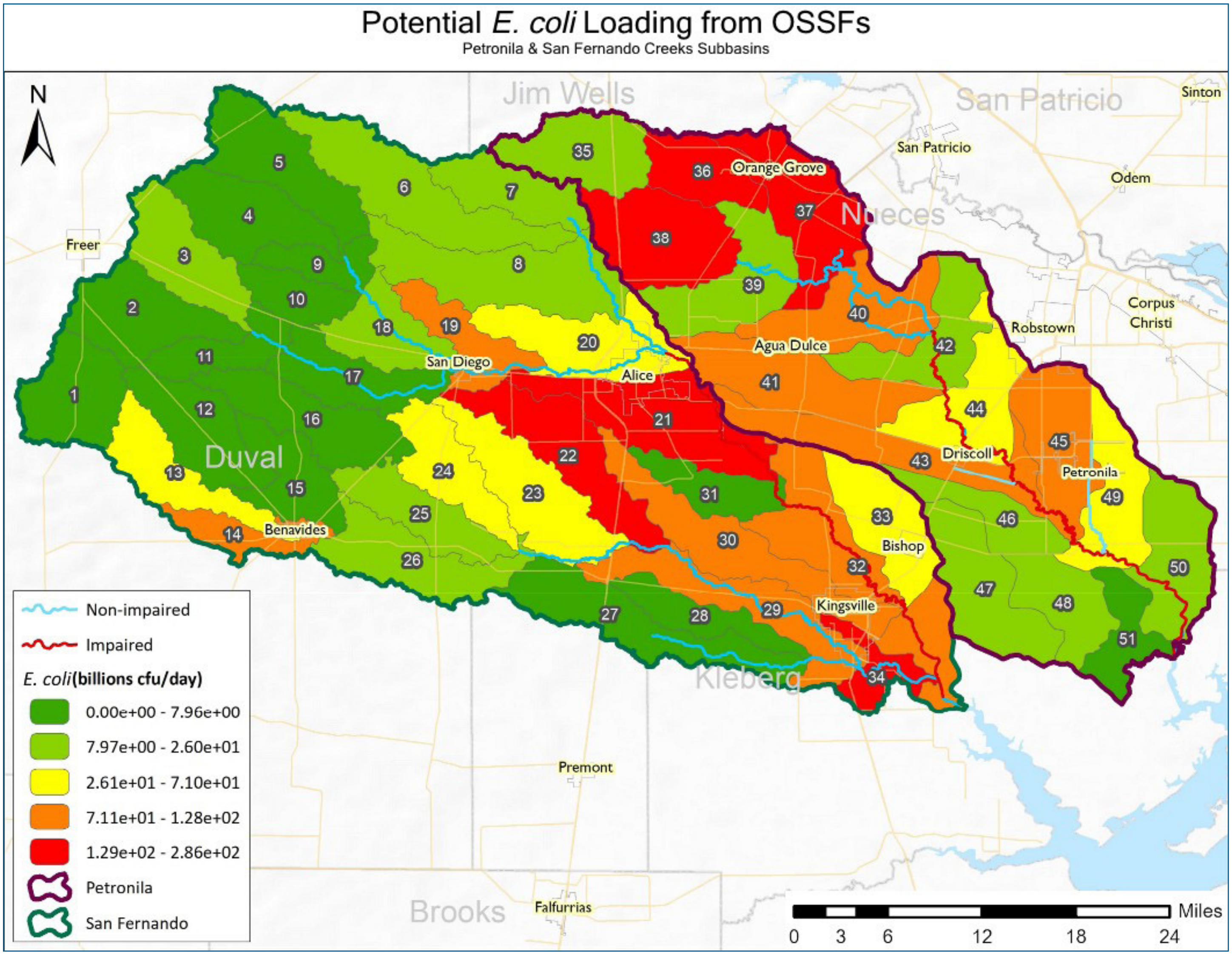


Figure 29. Estimated potential *E. coli* loads from on-site sewage facilities.

OSSFs

Failing OSSFs can contribute bacteria loads to water bodies, especially where effluent is released near water bodies. Approximately 15% of OSSFs in the watersheds are assumed to fail according to stakeholder input. Actual failure rates are unknown and can only be determined through physical OSSF inspections. It was estimated that there are 9,086 OSSFs within the watersheds based on recently available data. The highest *E. coli* loading potentials from OSSFs exist in subbasins 21, 22, and 34 in San Fernando Creek watershed and in subbasins 36, 37, and 38 in the Petronila Creek watershed (Figure 29).

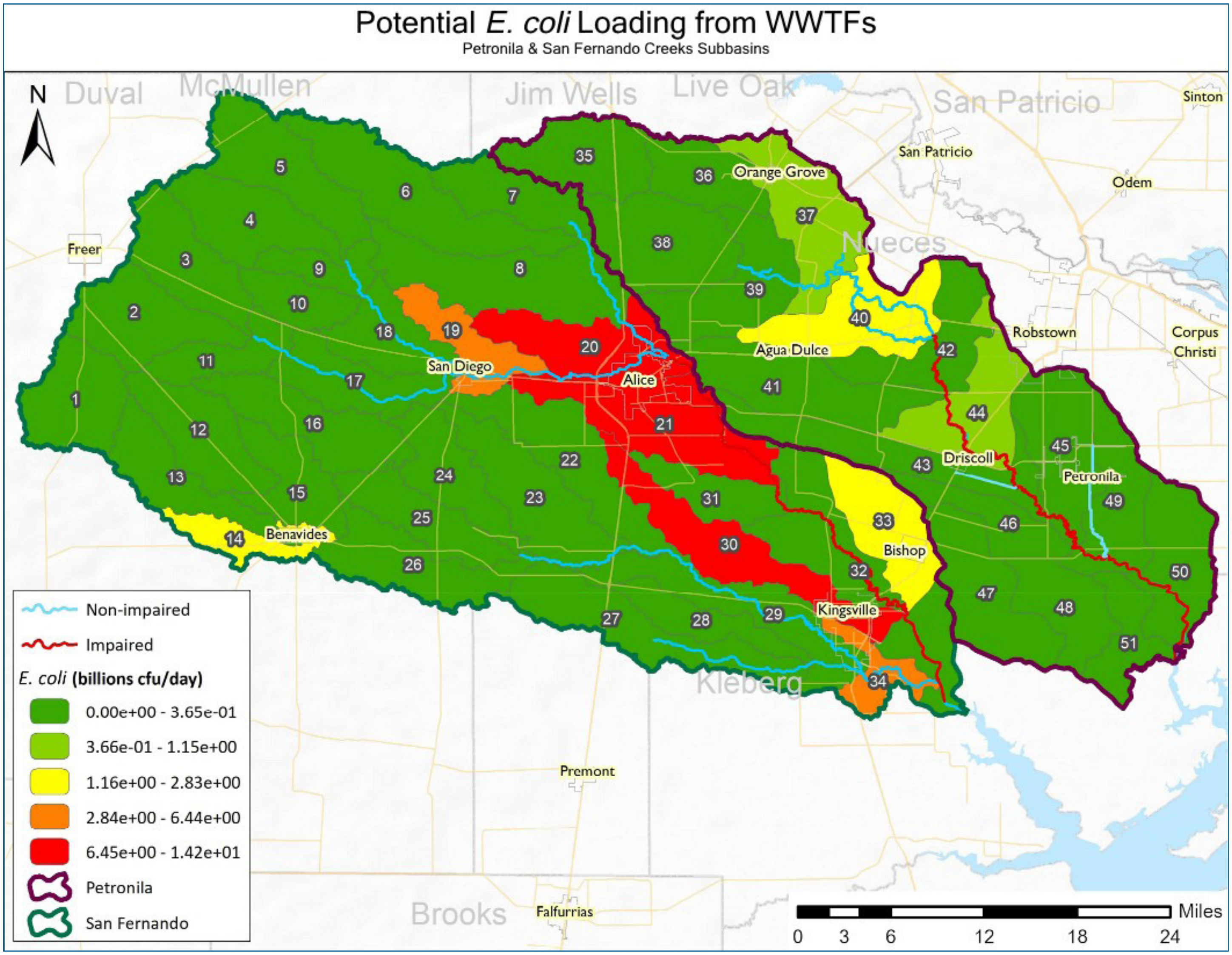


Figure 30. Estimated potential *E. coli* loads from wastewater treatment facilities.

WWTFs

There are 15 active permitted wastewater dischargers in the watersheds. To estimate potential *E. coli* load from WWTFs, the maximum permitted discharges and concentrations were used to assess the maximum potential load. Potential *E. coli* loading from WWTFs is highest in San Fernando Creek watershed subbasins 20, 21, and 30 (Figure 30). Comparatively, the Petronila Creek watershed does not have substantial WWTF contributions. Of those that do exist, the highest *E. coli* loading potential is in subbasins 37 and 40 (Figure 30).

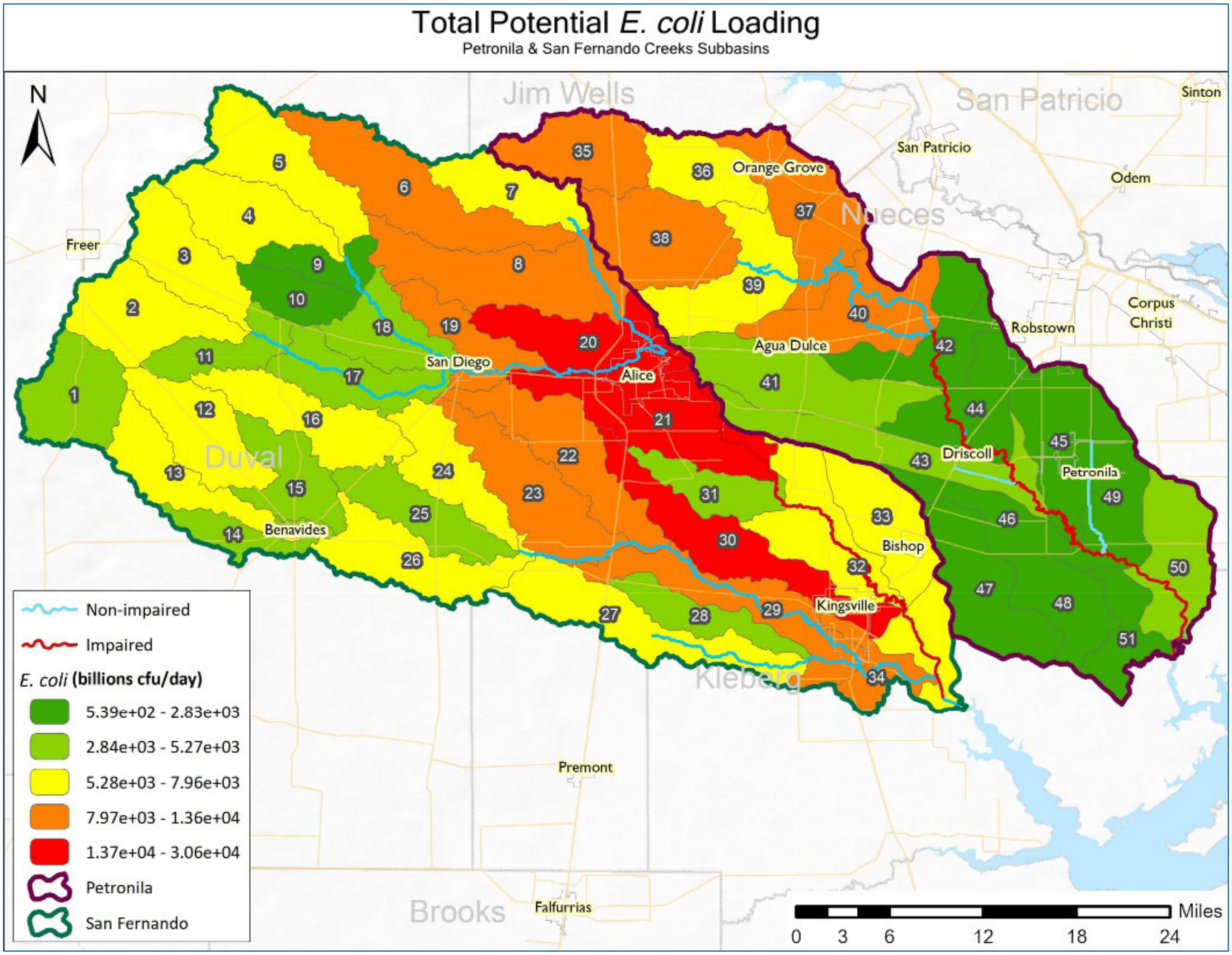


Figure 31. Estimated potential *E. coli* loads from all assessed sources.

Total Potential E. coli Load

Total potential *E. coli* loading estimates across the watersheds were generated by combining potential loadings from each source evaluated. In the San Fernando Creek watershed, the highest total potential loads are estimated to occur in subbasins 20, 21, and 30. In the Petronila Creek watershed, the highest total potential loads are estimated in subbasins 35, 37, 38, and 40 (Figure 31).

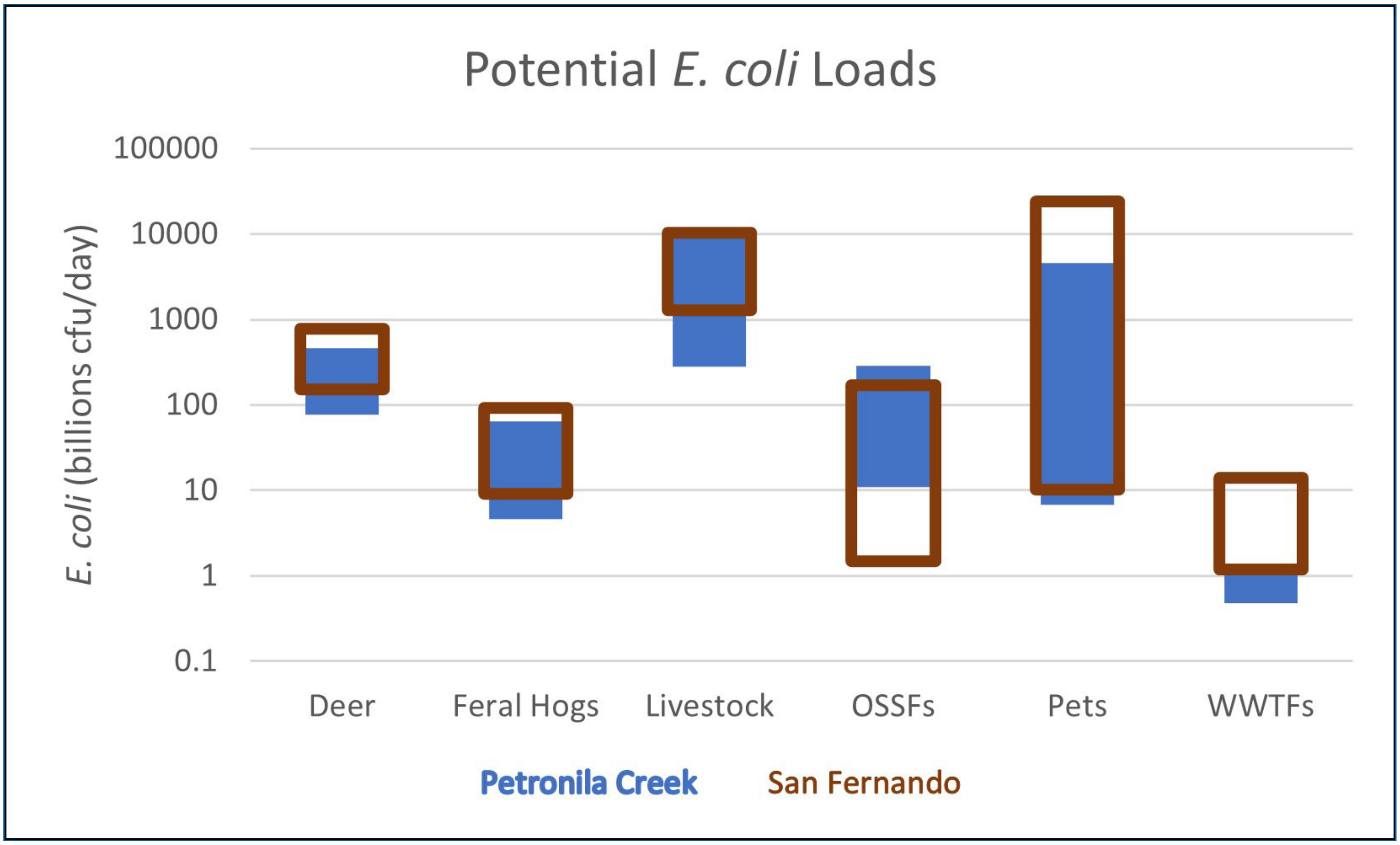


Figure 32. Differences in potential *E. coli* loading across the watershed by source (data from Figures 25 - 30).

Source Loading Summary

Analysis indicates that *E. coli* concentrations and loads present in both creeks are commonly higher than necessary to meet the applicable water quality standards. LDCs indicate that excessive *E. coli* are found in the creeks during all flow conditions with mid-range and low flows exhibiting slightly higher loads than high flow events. This suggests that point and nonpoint pollutant sources are contributing approximately equally to the overall bacteria loading.

E. coli sources and loads are diverse and widely distributed across the watersheds. Source assessments completed through this project were not designed to identify specific amounts of bacteria contribution from each source. Instead, potential *E. coli* production across the watershed was estimated for sources with sufficient data simply as a means of helping prioritize where management efforts should be implemented. Potential bacterial loads are sometimes large; however, all bacteria does not make it to the creek. Potential loads also vary greatly in volume within and between watersheds (Figure 32). The actual influence of these sources on instream water quality is unknown, but all bacteria sources can degrade water quality. Implementing management strategies throughout the watersheds reduces potential for these sources to enter waterways and will ultimately reduce the *E. coli* load in each creek.

Chapter 6 Recommended WPP Implementation Strategies

Petronila Creek riparian corridor and surrounding cropland. Photo by Ennis Rios.

No single bacteria source is the primary cause of current water body impairments in the watersheds. Deer, livestock, OSSFs and pets were estimated to have the highest potential to contribute *E. coli* across the watersheds; however, all potential sources contribute to overall bacteria loading. Due to potential source diversity, various management strategies are recommended to address manageable *E. coli* sources in the watersheds. Recommended management strategies were developed based on stakeholder feedback relative to pollutant removal efficiencies, feasibility and likelihood of adoption, and applicability to the watershed.

Estimated potential bacteria load reductions from each management measure are presented with each recommended action discussed in this chapter and further explained in Appendix A. Loading reduction estimates are based on predicted worst-case scenario loading. As a result, these estimates do not accurately predict actual loading reductions expected to occur instream. Actual reductions will depend on implementation volume, proximity of the practice to waterways, and other watershed changes that may trigger the need for adaptive implementation. Potential annual load reductions from management measures are discussed throughout this chapter and indicate that it is feasible to reduce bacteria loads entering San Fernando and Petronila creeks to levels that support primary contact recreation use.

Many management measures recommended to address bacteria loading also yield nutrient load reductions when implemented. Where appropriate, potential nutrient reductions are presented for select management practices, although nutrient load reduction targets were not established.

CSAs for each recommended management strategy were identified based on spatial analysis and stakeholder feedback. While management measures can be implemented throughout the watersheds, priority locations were selected where management strategies may most effectively reduce potential loading. In all cases, management activity should be implemented as close to waterways as possible to increase potential instream water quality improvements. CSAs will help guide initial implementation in each watershed.

Table 20. Available cropland, pasture, and rangeland practices to improve water quality.

Practice	NRCS code	Focus area or benefit
Brush management	314	Livestock, water quality, water quantity, wildlife
Conservation cover	327	Water quality, soil moisture, wildlife
Fencing	382	Livestock, water quality
Filter strips	393	Livestock, water quality, wildlife
Grade stabilization structures	410	Water quality
Grazing land mechanical treatment	548	Livestock, water quality, wildlife
Heavy use area protection	562	Livestock, water quantity, water quality
Livestock pipeline	516	Livestock, water quality, wildlife
No tillage	329	Water quality, soil moisture
Pond	378	Livestock, water quantity, water quality, wildlife
Prescribed burning	338	Livestock, water quality, wildlife
Prescribed grazing	528	Livestock, water quality, wildlife
Pumping plant	533	Livestock, water quality, wildlife
Range/pasture planting	550/512	Livestock, water quality, wildlife
Reduced tillage	345	Water quality, soil moisture
Shade structure	N/A	Livestock, water quality, wildlife
Stream crossing	578	Livestock, water quality
Supplemental feed location	N/A	Livestock, water quality
Water well	642	Livestock, water quantity, wildlife
Watering facility	614	Livestock, water quantity, wildlife

Natural Resources Conservation Service, NRCS

No-till planting into a terminated covercrop. Photo by Ed Rhodes.

Stakeholder input was crucial throughout the decision-making process for these suggested management strategies. Stakeholders were engaged throughout the process through virtual and in-person meetings. Management measures suggested in this chapter are voluntary and will rely on stakeholder adoption for successful implementation. Therefore, receiving stakeholder input on willingness to adopt these practices is the first step to ensuring successful implementation of the plan. All management measures were discussed with and approved by stakeholders to ensure community support and successful implementation.

Cattle grazing on a well managed pasture. Photo by Lucas Gregory.

Management Measure 1 – Developing and Implementing Water Quality Management Plans or Conservation Plans

Potential bacteria loadings from cattle and other livestock are relatively high compared to other evaluated sources due to the large livestock population. Livestock waste is mostly deposited in upland areas and transported to water bodies during runoff events. Therefore, most bacteria in livestock waste dies before reaching a water body; however, livestock can spend significant time near or in water bodies, which increases the risk of water quality degradation. Livestock distribution across the landscape is highly dependent upon food, water, and shelter availability within accessible areas. This allows livestock to be managed easily compared to other species. Time that livestock spend in and near riparian areas can be reduced with fencing and by providing strategically placed water, feed, shade, and forage around a property. This can reduce bacteria volume entering nearby water bodies during runoff by increasing distance between deposition locations and water bodies.

Various BMPs are available to improve forage quality, diversify water resource availability, and better distribute livestock across a property (Table 20). However, the practices appropriate for implementation vary by operation due to landscape features and landowner goals. Technical assistance is available to landowners upon request to help identify appropriate practices to meet specific property goals. NRCS develops conservation plans (CPs), while the Texas State Soil and Water Conservation Board (TSSWCB), in partnership with local soil and water conservation districts (SWCDs) and NRCS, develops water quality management plans (WQMPs). Currently, there are 93 WQMPs and 1,010 individual NRCS practices implemented under CPs in the Petronila Creek watershed and 43 WQMPs and 890 individual NRCS practices implemented in the San Fernando Creek watershed for cropland and grazing (Table 20). Stakeholders indicated that developing an additional 200 plans (CPs/WQMPs) for both grazing land and cropland is feasible in each watershed (400 total) over the next 10 years. Bacteria loading from cropland is predominantly from wildlife and is not considered manageable through land conservation practices. Bacteria load reductions on grazing lands achieved from these CPs/WQMPs will vary depending on specific conservation measures implemented. Based on land cover in each watershed, it is assumed that grazing land management will be the focus of 28% (56 of 200) of CPs/WQMPs developed in the Petronila Creek watershed and 89% (178 of 200) in the San Fernando Creek watershed. Load reduction estimates from CPs/WQMPs are based on these numbers and management practices likely to be implemented that are known to reduce livestock bacteria loading. These include fencing, grazing management, and alternative water sources.

Implementing CPs/WQMPs is beneficial, regardless of location in the watersheds, because these practices aim to keep water on the landscape by improving forage for livestock and wildlife and maintaining increased ground cover. Increasing vegetation amount and quality on a landscape aids the natural filtration process that can reduce pollutant loading to nearby water bodies. Overall CP/WQMP effectiveness can be maximized on properties with riparian habitat. Therefore, all properties with riparian areas are considered a priority. Properties without riparian habitat are also encouraged to participate in implementation activities because the cooperative effect is still consequential. Priority subbasins for livestock related practice implementation are 6, 8, 20, 21, 22, 23, 35, and 38 (Table 21).

Table 21. Management measure 1: Develop and implement water quality management plans or conservation plans.

<table>
<tr><th colspan="4">Pollutant source: Cattle and other livestock</th></tr>
<tr><td colspan="4">Problem: Direct and indirect fecal bacteria loading due to livestock in streams, riparian degradation, and overgrazing, which can increase pollutant loading to water bodies</td></tr>
<tr><td colspan="4">Objectives:
• Work with landowners to develop property-specific CPs/WQMPs that improve grazing practices, enhanced ground cover, increase pollutant retention, and improved water quality.
• Develop funding to hire WQMP technician.
• Deliver education and outreach information, programs, and workshops to landowners.
• Reduce fecal loadings attributed to livestock.</td></tr>
<tr><td colspan="4">Location: Entire watershed</td></tr>
<tr><td colspan="4">Critical Areas: All livestock operations with riparian habitat and subbasins 6, 8, 20, 21, 22, 23, 35, and 38</td></tr>
<tr><td colspan="4">Goal: Develop and implement CPs/WQMPs that reduce time spent in riparian areas by livestock and improve grazing resource management across the property.</td></tr>
<tr><td colspan="4">Description: CPs/WQMPs will be developed upon producer request to implement BMPs that reduce water quality impacts from grazing livestock. Practices will be identified and developed in consultation with NRCS, TSSWCB, and local SWCDs as appropriate. Education information, programs, and workshops will support and promote the adoption of these practices.</td></tr>
<tr><th colspan="4">Implementation strategy</th></tr>
<tr><th>Participants</th><th>Recommendations</th><th>Period</th><th>Capital costs</th></tr>
<tr><td>TSSWCB, SWCDs</td><td>Develop funding to hire WQMP technician</td><td>2023–2032</td><td>Estimated $75,000/year</td></tr>
<tr><td>Producers, NRCS, TSSWCB, SWCDs, landowners, lessees</td><td>Develop, implement, and provide financial assistance for 400 livestock CPs and WQMPs over 10 years</td><td>2023–2032</td><td>$6,000,000 (estimated $15,000/plan)*</td></tr>
<tr><td>Texas A&M AgriLife Extension, Texas Water Resources Institute, watershed coordinator</td><td>Deliver education and outreach information, programs, and workshops to landowners</td><td>2023, 2027, 2032</td><td>N/A</td></tr>
<tr><th colspan="4">Estimated Load Reduction</th></tr>
<tr><td colspan="4">Prescribed management will reduce bacteria loadings associated with livestock by reducing runoff from pastures and rangeland and by reducing direct fecal deposition in water. Nutrient reductions are possible from some implemented practices. Grazing associated CP/WQMP implementation is estimated reduce loadings by:</td></tr>
</table>

	Number of CP/WQMP planned for grazing operations	*E. coli* (cfu/year)	Nitrogen (lbs/year)	Phosphorus (lbs/year)
Petronila Creek	56	8.15×10^{13}	16,633	8,763
San Fernando Creek	178	1.50×10^{14}	30,610	16,128

Effectiveness	High: Decreasing time livestock spend in riparian areas and reducing runoff by managing vegetative cover will reduce nonpoint source contributions of bacteria and other pollutants to creeks.
Certainty	Moderate: Landowners acknowledge the value of good land stewardship practices; however, financial incentives are often needed to encourage CP/WQMP implementation.
Commitment	Moderate: Landowners are willing to implement stewardship practices shown to improve productivity; however, costs are often prohibitive and financial incentives are needed to increase implementation rates.
Needs	High: Financial costs are a major barrier to implementation. Education and outreach are needed to demonstrate benefits of plan development and implementation to producers.

Best management practice, BMP; colony forming units, cfu; conservation plan, CP; Natural Resources Conservation Service, NRCS; pound, lb; soil and water conservation district, SWCD; Texas State Soil and Water Conservation Board, TSSWCB; water quality management plan, WQMP;

*Unit costs for NRCS conservation plans vary widely depending on plan specifics.

Management Measure 2 – Promote Technical and Direct Operational Assistance to Landowners for Feral Hog Control

Potential bacteria loading from feral hogs represents a considerable potential influence on instream water quality. While other sources of bacteria are potentially larger in volume, feral hogs congregate in riparian areas due to the presence of dense habitat, food sources, and water. As a result, feral hogs can have an increased potential impact on instream water quality. Common feral hog behavior, such as rooting and wallowing, affects water quality by degrading ground cover, which increases erosion. Through a combination of agency technical assistance, education, and landowner implementation of feral hog management techniques, the goal of this management measure is to reduce and maintain feral hog populations at 15% below current numbers in both the San Fernando and Petronila creeks watersheds (Table 22). A 15% reduction in current feral hog populations would amount to removing 2,674 hogs annually from the San Fernando Creek watershed and 590 hogs annually from the Petronila Creek watershed.

Physically removing hogs is the best strategy for reducing their impact on water quality. While the complete eradication of feral hogs from the watersheds is not feasible, a variety of methods are available to manage or reduce populations. Trapping is the most effective method currently available to landowners. With proper planning and diligence, trapping can successfully remove large numbers of hogs at once. Furthermore, costs of purchasing or building live traps can be split among landowners. Comparatively, shooting feral hogs removes fewer than trapping because the animals tend to quickly move away from hunting pressure. However, aerial gunning has been successful in other areas of Texas and should be considered a viable option to further reduce the feral hog population within the watersheds.

Excluding feral hogs from supplemental feed is also an effective management tool. Given the opportunistic feeding nature of feral hogs, minimizing available food from deer feeders is important. Constructing exclusionary fences around feeders can reduce food ability (Rattan et al. 2010). Locating feeders away from riparian areas can also reduce hog's impacts on water quality.

Education programs and workshops will be used to improve feral hog removal efficiency. Texas A&M AgriLife Extension provides various educational resources for landowners that are available online at: http://feralhogs.tamu.edu. Programs and resources are available virtually and in-person to increase outreach. Delivering up-to-date information and resources to landowners through these workshops can lead to more landowner success removing feral hog populations in the watersheds. Landowner-developed wildlife management plans outlining their goals and management practices can also benefit the watersheds' wildlife, habitat, and water quality.


Feral hogs caught in a box trap. Photo by Lucas Gregory.

Based on spatial analysis, subbasins 6 and 8 have the highest potential for feral hog loadings based on available habitat. However, given feral hogs' propensity to travel great distances along riparian corridors in search of food and habitat, priority areas will include all subbasins with high importance placed on properties containing or adjacent to riparian habitat.

Table 22. Management measure 2: Promote technical and direct operational assistance to landowners for feral hog control.

Pollutant source: Feral hogs			
Problem: Direct and indirect pollutant loading and riparian habitat destruction from feral hogs			
Objectives: • Reduce fecal contamination and land disturbance from feral hogs • Work with landowners to reduce feral hog populations • Reduce food availability for feral hogs • Provide education and outreach to stakeholders			
Critical Areas: All subbasins with high importance placed on riparian properties			
Goal: Manage feral hog population through all available means to reduce populations by 15% (2,674 hogs in the San Fernando Creek watershed and 590 in the Petronila Creek watershed) and maintain them at this level.			
Description: Voluntarily implement feral hog population management practices including trapping, reducing access to food supplies, and educating landowners and others as they are available.			
Implementation strategy			
Participants	**Recommendations**	**Period**	**Capital costs**
Landowners, land managers, and lessees	Voluntarily construct fencing around deer feeders to prevent feral hog use	2023–2032	$300/feeder
	Voluntarily trap/remove/shoot feral hogs to reduce numbers	2023–2032	N/A
Landowners, producers, TPWD	Develop and implement wildlife management plans and wildlife management practices	2023–2032	N/A
Texas A&M AgriLife Extension, Texas Wildlife Services, TPWD	Deliver feral hog education workshop	2024, 2027, 2030	$3,000 each

Estimated load reduction

Removing and maintaining feral hog populations directly reduces fecal bacteria, nutrient, and sediment loading to water bodies. Reducing the population by 15% in the San Fernando and Petronila creeks watersheds by:

	Hogs to be removed	*E. coli* (cfu/year)	Nitrogen (lbs/year)	Phosphorus (lbs/year)
Petronila Creek	590	2.05×10^{13}	3,768	1,345
San Fernando Creek	2,674	9.28×10^{13}	17,080	6,100

Effectiveness	Moderate: Reducing feral hog populations will decrease bacteria and nutrient loading to the streams. However, substantial reduction of the population is difficult.
Certainty	Low: Feral hogs are transient and adapt to changes in environmental conditions. Population reductions require landowner diligence. Combined, there is considerable uncertainty in the ability to remove 15% of the population annually.
Commitment	Moderate: Many landowners are actively battling feral hog populations and will continue to do so if resources remain available. Feral hogs adversely affect their livelihood.
Needs	Moderate: Landowners benefit from technical and educational resources to inform them about feral hog management options. Funds are needed to deliver these workshops and to increase removal resources available to landowners.

Colony forming units, cfu; pound, lb; Texas Parks and Wildlife Department, TPWD

Management Measure 3 – Identify and Repair or Replace Failing On-Site Sewage Systems

OSSFs are used to treat wastewater where centralized WWTFs are not available. Conventional systems use a septic tank and gravity-fed drain field that separates solids from wastewater prior to its distribution into soil where treatment occurs. In the San Fernando and Petronila creeks watersheds, approximately 76% of the watersheds' soils are considered very limited. This indicates that conventional septic tank systems are not suitable for the proper treatment of household wastewater. In these areas, advanced treatment systems, most commonly aerobic treatment units, are suitable alternative options for wastewater treatment. While advanced treatment systems are highly effective, operation and maintenance needs for these systems are rigorous compared to conventional septic systems. Limited awareness and lack of maintenance can lead to system failures.

Failing or nonexistent OSSFs can provide significant bacteria and nutrient loading into the watersheds. The exact number of failing OSSFs is unknown; however, it is estimated that 15%, or 1,363 systems, may be malfunctioning across the watersheds. Specific locations of failing OSSF are not known and can only be determined through physical inspections. Factors contributing to OSSF failure include improper system design or selection, improper operation and maintenance, and lack of financial resources for proper maintenance.

Providing educational workshops to homeowners regarding OSSF operation and maintenance will help address these issues. Repairs and replacements are also needed. Over the next 10 years, it is recommended that 100 failing septic systems in the watersheds be replaced (40 in the San Fernando Creek watershed and 60 in the Petronila Creek watershed) or connected to a centralized sewer system if feasible (Table 23). While OSSFs should be replaced and repaired as needed across both watersheds, subbasins 21, 22, 36, 37, and 38 are considered CSAs due to OSSF densities. Additional priority should be given to OSSFs within 100 yards of perennial water bodies. Significant technical and financial resource are needed to support OSSF repairs and replacements.

Failing OSSF system replacement installation. Photo by Ryan Gerlich.

Table 23. Management measure 3: On-site sewage facilities (OSSFs).

Pollutant source: Failing or nonexistent OSSFs

Problem: Pollutant loading reaching streams from untreated or insufficiently treated household sewage

Objectives:
- Inspect failing OSSFs in the watersheds and secure funding to promote OSSF repairs
- Repair or replace OSSFs by working with counties and communities
- Educate homeowners on system operations and maintenance

Location: Entirety of San Fernando and Petronila creeks watersheds

Critical Areas: Subbasins 21, 22, 36, 37, and 38 and systems within 100 yards of perennial waterways

Goal: Identify, inspect, and repair or replace 100 failing OSSFs in the watershed (40 in the San Fernando Creek watershed and 60 in the Petronila Creek watershed), especially within critical areas. Where feasible, leverage resources to address failing OSSFs adjacent to Baffin Bay.

Description: Deliver education programs and workshops on proper maintenance and operation of OSSFs to homeowners. Failing or nonexistent systems should be repaired or replaced as needed and as funding allows. Extend education and outreach resources to residents around Baffin Bay. Work with county to leverage additional resources to address failing OSSFs in the watersheds and near the bay.

Implementation strategy

Participants	Recommendations	Period	Capital costs
Counties, contractors	Identify, inspect, and repair or replace OSSFs as funding allows	2023–2032	\$8,000–\$12,500/ system (estimate)
Counties, municipalities, homeowners, NRA	Inspect and identify the possibility of connecting to existing/planned infrastructure	2023–2032	N/A
NRA, Texas A&M AgriLife Extension, TWRI, watershed coordinator, Voices of the Colonias	Operate an OSSF education, outreach, and training program for installers, service providers and homeowners	2024, 2028, 2032	N/A
AgriLife Extension, TWRI, watershed coordinator, Voices of the Colonias	Develop and deliver materials (postcards, websites, handouts, etc.) to educate homeowners	2023–2032	N/A

Estimated load reduction

As planned, 100 OSSFs will be repaired or replaced between the San Fernando and Petronila creeks watersheds. Estimated potential *E. coli* load reductions and potential nutrient reductions from these efforts are:

	OSSFs planned for repair or replacement	*E. coli* (cfu/year)	Nitrogen (lbs/year)	Phosphorus (lbs/year)
Petronila Creek	60	6.78×10^{14}	1,477	369
San Fernando Creek	40	4.52×10^{14}	985	246

Effectiveness	High: Replacing or repairing failing OSSFs yields direct *E. coli* reductions.
Certainty	Low: Funding available to identify, inspect and repair or replace OSSFs is uncertain; however, funding sources are available for assistance.
Commitment	Moderate: Watershed stakeholders acknowledge failing OSSFs as a considerable bacteria source. Addressing this source has the greatest human health benefit and is a top priority.
Needs	High: Financial resources are needed to identity, repair, and replace systems as many homeowners do not have the resources to fund replacement themselves. Education is also critical because many homeowners with failing systems may not realize their system is failing or understand the associated human health or environmental implications.

Colony forming units, cfu; Nueces River Authority, NRA; on-site sewage facility, OSSF; pound, lb; Texas Water Resources Institute, TWRI

Management Measure 4 – Lawn and Landscape Management and Maintenance

Bacteria and nutrient loading from improper lawn and pet waste maintenance can be a significant pollutant source. Potential pollutant loading from pet waste was identified as a large bacteria source in the watersheds. If not managed properly, pet waste and the *E. coli* it contains can be transported to local water bodies during runoff events. Proper pet waste disposal in the trash is a simple and effective way to reduce *E. coli* and nutrient loads in the watersheds. Nutrient loading is also a concern from improper lawn fertilization. Excessive fertilization or improper application can lead to nutrient losses in sprinkler or rainfall runoff.

Management strategies to address pet waste and fertilizer emphasize reducing the transport to streams via runoff (Table 24). Potential strategies include providing waste bag dispensers and collection stations in areas of high pet density (e.g., parks, neighborhoods) and handing out waste bag carriers for pet owners at events and programs around the watersheds. These strategies encourage pet owners to pick up waste before it is transported to streams. Several parks in the watersheds have pet waste stations, but there are opportunities to expand their numbers. Ongoing pet waste station maintenance should be addressed as new stations are installed.

Providing education and outreach materials to pet owners about bacteria and nutrient pollution contributed by pet waste can increase the number of residents who pick up and dispose of pet waste. Recognizing that domestic pets in rural portions of the watersheds likely have large areas to roam and that picking up pet waste is likely not feasible for all owners, management measures should target areas of the watersheds with high housing and pet densities. Priority areas for this management measure are urbanized and public areas in subbasins 20, 21, and 30.

Education and outreach materials and programs regarding proper lawn maintenance will help encourage homeowners to manage fertilizer and pesticide use and irrigation on their lawn. Existing programs are available through Texas A&M AgriLife to address these needs and are discussed in Chapter 7.

Pet waste station at dog park in Kingsville. Photo by Lucas Gregory.

Table 24. Management measure 4: Lawn and landscape management and maintenance.

Pollutant source: Dog waste

Problem: Direct and indirect fecal bacteria loading from household pets and nutrient loading from fertilizers

Objectives:
- Furnish education and outreach messaging on disposal of pet waste and proper fertilization
- Install and maintain pet waste stations in public areas

Location: Entirety of San Fernando and Petronila creeks watersheds

Critical Areas: High pet concentration areas and urbanizing areas, subbasins 20, 21, and 30

Goal: Reduce the amount of pet waste and excess fertilizer that may wash into water bodies during rainfall and irrigation runoff events by providing educational and physical resources to increase stakeholder awareness of water quality and health issues caused by excessive pet waste and poor lawn maintenance. Effectively manage *E. coli* loading from 10% of the estimated dog population, or 2,037 dogs.

Description: Expand education and outreach regarding the need to properly dispose of pet waste and properly apply fertilizers in the watersheds. Install and maintain pet waste stations and signage in public areas to facilitate increased collection and proper pet waste disposal.

Implementation strategy

Participants	Recommendations	Period	Capital costs
Texas A&M AgriLife Extension, NRA, watershed coordinator	Educational programming for homeowners	2023–2032	$9,000 ($3,000/ program)
Cities, counties, homeowners, homeowner associations	Provide needed maintenance supplies for pet waste stations: estimated 25 stations	2023–2032	$500/station: $12,500 total
Cities, counties, AgriLife Extension, Texas Water Resources Institute, HOAs	Develop and provide educational resources to residents	2023–2032	N/A

Estimated load reduction

Estimated *E. coli* load reductions and potential nutrient reductions resulting from pet waste management measure are reliant on changes in people's behavior and are therefore uncertain. Assuming 20% of targeted individuals respond by properly disposing of pet waste, annual load reductions are:

	Managed dog waste	*E. coli* (cfu/year)	Nitrogen (lbs/year)	Phosphorus (lbs/year)
Petronila Creek	387	2.23×10^{14}	202	47
San Fernando Creek	1,650	9.49×10^{14}	862	199

Effectiveness	High: Collecting and properly disposing dog waste is a direct method to immediately prevent *E. coli* from entering water bodies.
Certainty	Low: Some pet owners in the watersheds likely already collect and properly dispose of dog waste. Those who do not properly dispose of pet waste may be difficult to reach or convince. The number of additional people that will properly dispose of pet waste is difficult to anticipate.
Commitment	Moderate: Some parks currently have pet waste stations installed; however, maintenance is sometimes less frequent than it needs to be. Meanwhile, little encouragement for owners to pick up after their pets occurs.
Needs	Low: Increasing maintenance on existing pet waste stations could occur. Landscapers can easily add this to their list of items when mowing parks if resources are provided.

Colony forming units, cfu; homeowners association, HOA; Nueces River Authority, NRA; pound, lb

Neighborhood stormwater pond in Kingsville. Photo by Lucas Gregory.

Management Measure 5 – Implement and Expand Surface Stormwater Runoff Management

Stormwater runoff is a potentially large *E. coli* source influencing water bodies, especially near urban centers like Alice and Kingsville, which are rapidly developing and have high percentages of impervious cover. The objective of this management measure is to work with local entities to increase green stormwater infrastructure to reduce runoff during storm events that can carry bacteria and nutrients into creeks. Runoff also increases turbidity and can carry metals and hydrocarbons to water bodies, further harming biological activity.

Significant local activity is underway to manage stormwater to reduce flooding potential. While water quality is not the focus of these efforts, significant opportunity exists to combine flooding and water quality management. Efforts of many parties contributing to this WPP are underway to accomplish this goal, and they will continue. The WPP can and should complement these activities. Actions that can address both flooding and water quality include BMPs implemented at the demonstration, property, subdivision, or regional scale. The watershed coordinator will work to encourage these activities as appropriate and as funding permits (Table 25). Urban stormwater BMPs reduce or delay runoff generated by impervious or highly compacted surfaces such as roofs, roads, and parking lots. Potential BMPs include but are not limited to rain gardens, rain barrels/cisterns, green roofs, permeable pavement, bioretention, constructed wetlands, swales, and tree box filters. These BMPs vary in ability to reduce stormwater runoff quantity and improve runoff quality based on design and location. Furthermore, volume reductions from BMPs can reduce stormwater entering local sewage collection systems through I&I. Well-placed and well-designed stormwater BMPs can substantially decrease and delay runoff and reduce bacteria and nutrient loading. Further implementation of these practices should be encouraged through ordinance development that encourage improved practice use requirements for new development where feasible. Addressing runoff concerns during development can reduce the burden of cost for corrective actions after development.

Stakeholders expressed an interest in identifying areas for riparian restoration and constructed wetlands to help with bacteria and nutrient load reduction. Candidate implementation locations have already been identified and others will be identified as funding allows. Local interest and resource contributions should be capitalized on while available.

The second objective is to deliver education programs in the watersheds that increase awareness regarding the impacts of stormwater on water quality and riparian areas. This can include installation of demonstration sites (constructed wetlands, green infrastructure practices, etc.), training for city/county/drainage district officials, flyers, and other outreach materials.

Table 25. Management measure 5: Urban stormwater management.

<table>
<tr><th colspan="4">Pollutant source: Urban stormwater runoff</th></tr>
<tr><td colspan="4">Problem: Fecal bacteria loading from stormwater runoff in developed and urbanized areas</td></tr>
<tr><td colspan="4">Objectives:
• Educate residents and decision makers about stormwater BMPs.
• Identify and install stormwater BMPs at all scales feasible: demonstration, property, subdivision, region including identification of appropriate sites and costs.
• Influence future stormwater manage decisions, requirements, and implementation</td></tr>
<tr><td colspan="4">Critical Areas: In and near urbanized areas in the San Fernando and Petronila creeks watersheds</td></tr>
<tr><td colspan="4">Goal: Reduce E. coli loading associated with urban stormwater runoff through implementation of stormwater BMPs as appropriate and to increase local officials and residents’ awareness of stormwater pollution and management.</td></tr>
<tr><td colspan="4">Description: Promote stormwater management BMP projects through education, demonstration and leveraging of other resources. Coordinate with decision makers and property owners.</td></tr>
<tr><th colspan="4">Implementation strategy</th></tr>
<tr><th>Participants</th><th>Recommendations</th><th>Period</th><th>Capital costs</th></tr>
<tr><td>Cities, property, owners, contractors</td><td>Identify and install stormwater BMPs as funding becomes available</td><td>2023–2032</td><td>$40,000–95,000/acre (rough estimate)</td></tr>
<tr><td>Texas A&M AgriLife Extension, Texas Water Resources Institute, watershed coordinator, Clean Coast Texas</td><td>Deliver education and outreach (riparian and stream ecosystem education workshop or others as appropriate) to landowners and decision makers; encourage stormwater management requirements for future development</td><td>2023–2032</td><td>N/A</td></tr>
<tr><th colspan="4">Estimated load reduction</th></tr>
<tr><td colspan="4">Installation of stormwater BMPs that reduce runoff or treat bacteria will result in direct reductions in bacteria loadings in the watersheds. Potential load reductions were not calculated because the location, type, and sizes of projects installed will determine the potential load reductions. Nutrient reductions are also commonly realized with many stormwater BMPs but are not estimated as noted with bacteria.</td></tr>
<tr><td>Effectiveness</td><td colspan="3">Moderate to high: BMP effectiveness for reducing bacteria loading is dependent on design, site selection, and maintenance of the BMP.</td></tr>
<tr><td>Certainty</td><td colspan="3">Moderate: BMP installation requires sustained commitment from local governments. Recent grant funding acquired will help plan and implement specific projects to reduce local flooding, which can also have a positive water quality impact if properly designed.</td></tr>
<tr><td>Commitment</td><td colspan="3">Moderate: Flood reduction is a high priority for local cities/counties/drainage districts, but financial needs are significant.</td></tr>
<tr><td>Needs</td><td colspan="3">High: Stormwater management is costly and financial assistance needs are significant yet largely unknown. Information regarding stormwater management alternatives is needed to increase awareness of potential water quality management benefits.</td></tr>
</table>

Best management practice, BMP

WWTF raceway. Photo courtesy of NRA.

WWTF clarifier. Photo courtesy of NRA.

Management Measure 6 – Upgrade and Repair WWTFs and Reduce SSOs and Unauthorized Discharges

Aging WWTF infrastructure is a major concern for stakeholders and a significant potential contributor of bacteria and nutrients in the watersheds. NRA is working to establish management agreements for some WWTFs. Under these agreements, NRA will operate the WWTFs and perform necessary infrastructure repairs and upgrades to the treatment units and wastewater collection networks as funding allows (Table 26).

The TCEQ SSO Initiative is a voluntary program that initiates efforts to address SSOs. These events are often due to aging collection systems and may be the result of I&I issues during storm events caused by line breaks and blockages.

NRA has expressed interest in generating SSO initiatives at several WWTFs as they take on facility management. Activities in SSO initiatives vary but commonly include line inspections and testing, routine repairs and replacements, and education and outreach.

Fats, oils, grease, non-flushables, and many other substances should not be disposed of through household drains. These items can cause material build up and create blockages in collection systems, which lead to system damage and repairs. Several educational programs on proper disposal of fats, oils and grease are available through AgriLife Extension and NRA. Education material distribution and providing online videos on the San Fernando and Petronila Creeks WPP website will help encourage and inform homeowners of how to properly dispose of fats, oils, grease, and non-flushables.

Table 26. Management measure 6: Reduce sanitary sewer overflows and unauthorized discharges.

<table>
<tr><th colspan="5">Pollutant source: Municipal SSOs or unauthorized discharges</th></tr>
<tr><td colspan="5">Problem: Fecal bacteria loading from SSO events and malfunctioning sewage infrastructure</td></tr>
<tr><td colspan="5">Objectives:
• Reduce unauthorized discharges and SSOs.
• Replace and repair sewage infrastructure as needed.
• Educate residents and homeowners on the need for infrastructure maintenance and what types of waste can be put in the sewer system.</td></tr>
<tr><td colspan="5">Critical Areas: Urbanized areas in subbasins 20, 21, and 30</td></tr>
<tr><td colspan="5">Goal: Work with entities operating WWTFs to continue and expand inspection efforts. Identify problematic areas and repair or replace problematic infrastructure to reduce I&I issues and minimize WWTF overload occurrences.</td></tr>
<tr><td colspan="5">Description: Identify potential locations within municipal sewer systems where I&I occurs using available strategies (e.g., smoke tests, camera inspections). Prioritize system repairs or replacements based on system impacts (largest impact areas addressed first). Complete repairs or replacements to reduce future I&I issues and WWTF overloading.</td></tr>
<tr><th colspan="5">Implementation strategy</th></tr>
<tr><th colspan="2">Participants</th><th>Recommendations</th><th>Period</th><th>Capital costs</th></tr>
<tr><td colspan="2">NRA, responsible entities</td><td>Repair and upgrade aging infrastructure at WWTFs within the watersheds</td><td>2023–2032</td><td>$41.5 million (NRA estimate)</td></tr>
<tr><td colspan="2">NRA, cities, watershed coordinator</td><td>Identify potential resources and develop programs to aid WWTFs replacement of sewage pipes</td><td>2023–2032</td><td>N/A, TBD</td></tr>
<tr><td colspan="2">Cities, Texas A&M AgriLife Extension, watershed coordinator</td><td>Develop and deliver education material to residents and property owners</td><td>2023–2033</td><td>N/A</td></tr>
<tr><th colspan="5">Estimated load reduction</th></tr>
<tr><td colspan="5">Reduction of SSOs and discharges associated with I&I will result in direct reductions in bacteria loads. However, because the response to education efforts and resource acquisition to complete system repairs is uncertain, load reductions were not calculated.</td></tr>
<tr><td>Effectiveness</td><td colspan="4">Moderate to high: Although infrequent, reduction in SSOs and unauthorized discharges will result in direct reductions to bacteria loading during the highest flow events.</td></tr>
<tr><td>Certainty</td><td colspan="4">Moderate to low: Costs associated with sewer pipe replacement and treatment plant upgrades are expensive to homeowners and municipalities.</td></tr>
<tr><td>Commitment</td><td colspan="4">Moderate: Municipal public works have incentive to resolve I&I issues to meet discharge requirements. However, limited funding hinders sewage line replacement.</td></tr>
<tr><td>Needs</td><td colspan="4">High: Financial needs are significant.</td></tr>
</table>

Inflow and infiltration, I&I; Nueces River Authority, NRA; sanitary sewer overflow, SSO; wastewater treatment facility, WWTF

Table 27. Management measure 7: Reduce illicit dumping.

<table>
<tr><th colspan="4">Pollutant source: Illicit and illegal dumping</th></tr>
<tr><td colspan="4">Problem: Illicit and illegal dumping of trash and animal carcasses in and along waterways</td></tr>
<tr><td colspan="4">Objectives:
• Promote and expand education and outreach efforts in the watershed
• Provide additional disposal locations across the watershed</td></tr>
<tr><td colspan="4">Critical Areas: Entirety of San Fernando and Petronila creeks watersheds, with a focus on bridge crossing and public access areas</td></tr>
<tr><td colspan="4">Goal: Increase awareness of and access to proper disposal techniques and reduce illicit dumping of waste and animal carcasses in or near water bodies throughout the watersheds.</td></tr>
<tr><td colspan="4">Description: Education and outreach materials will be developed and delivered to residents throughout the watersheds on the proper disposal of waste materials. Work to secure resources to provide additional waste disposal locations across the watersheds.</td></tr>
<tr><th colspan="4">Implementation strategy</th></tr>
<tr><th>Participants</th><th>Recommendations</th><th>Period</th><th>Capital costs</th></tr>
<tr><td>Counties, watershed coordinator</td><td>Organize hazardous waste collection events</td><td>2023–2032</td><td>TBD</td></tr>
<tr><td>Counties, NRA, watershed coordinator</td><td>Develop and deliver educational and outreach materials to residents</td><td>2023–2032</td><td>$21,000 (estimate)</td></tr>
<tr><th colspan="4">Estimated load reduction</th></tr>
<tr><td colspan="4">Load reductions are likely minimal from this management measure and are not quantified.</td></tr>
<tr><td>Effectiveness</td><td colspan="3">Low: Preventing illicit dumping, especially animal carcasses, is likely to reduce bacteria loads by some amount, although this loading is likely limited to areas with public access.</td></tr>
<tr><td>Certainty</td><td colspan="3">Low: Anticipating changes in resident behavior due to education and outreach is difficult at best. Reaching residents that illegally dump is likely difficult.</td></tr>
<tr><td>Commitment</td><td colspan="3">Moderate: Many stakeholders indicate illicit dumping occurs; however, enforcement is difficult. Addressing the issue is not a high priority and resource availability is low.</td></tr>
<tr><td>Needs</td><td colspan="3">Moderate: Financial resources are required to develop and distribute educational materials and provide additional waste collection events/facilities.</td></tr>
</table>

Management Measure 7 – Reduce Illicit Dumping

Stakeholders indicate and photo evidence suggests that large-scale illicit dumping is a problem throughout the watersheds. Dumping activities typically occur at or near bridge crossings and access roads near riparian habitats. Items deposited often include animal carcasses, tires, home appliances and household trash (Figure 32). The scope of the problem has not been fully quantified, but it is a contributor to the degradation of water and environmental quality. While much of the known trash dumped is not a direct bacteria contributor, it undoubtedly invites additional trash dumping and creates other pollution concerns for habitat, soil, and water. Development and delivery of educational and outreach materials that focus on the proper disposal of carcasses and other trash should reduce the negative impacts resulting from illicit dumping (Table 27).

Hosting hazardous waste collection events (including agricultural waste) annually in the watersheds can reduce improper waste disposal. Stream clean-up events and outreach materials will be scheduled and distributed to help improve current dump sites and raise public awareness regarding dumping. Stakeholders are interested in providing additional trash disposal locations across the watersheds; however, funding and management needs must be met to implement this activity.

Illicit dumping site near Baffin Bay.

Management Recommendation Summary

Most recommended management strategies will improve fecal bacteria retention on the landscape and allow natural bacteria die-off to occur while several will remove bacteria from the watersheds. This will directly and indirectly reduce the quantity of viable bacteria reaching the creeks during runoff events. Keeping this in mind, the quantity of feasible management practices recommended are estimated to yield significantly larger bacteria reductions across the watersheds than are necessary to meet instream water quality.

Chapter 7
Education and Outreach

Texas Watershed Stewardattendees in Kingsville. Photo by Michael Kuitu.

An essential element to WPP implementation is effective education and outreach. Long-term commitments from citizens and landowners are necessary to achieve comprehensive improvements in the San Fernando and Petronila creeks watersheds. The education and outreach component of implementation will focus on keeping the public, landowners, and agency personnel informed of project activities, provide information about appropriate management practices, and assist in identifying and forming partnerships to implement WPP components.

Watershed Coordinator

The role of the watershed coordinator is to lead efforts to establish and maintain the working partnerships with stakeholders. Establishing a watershed coordinator role is an important step towards successful WPP implementation. The watershed coordinator will be tasked with maintaining stakeholder support for years to come, identifying and securing funds to implement the WPP, tracking success of implementation, and working to implement adaptive strategies. A full-time watershed coordinator position in or near the watersheds is recommended to effectively support WPP implementation.

Public Meetings

During WPP development, stakeholder engagement was critical. Public meetings to develop the WPP began in February 2021with local stakeholders. In total, 14 meetings were held to discuss plan development, including general stakeholder meetings and specialized workgroup meetings.

Throughout the process, local stakeholders participated in public meetings, individual meetings, phone calls, and video meetings associated with WPP development. Stakeholders were present from all four counties within the watersheds and represented agriculture, agency, coastal, conservation, and urban groups. Groups and entities involved in the planning process include the Baffin Bay Stakeholder Group, city personnel, Coastal Bend Bay & Estuaries Program (CBBEP), county officials, Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi (HRI), King Ranch Inc., NRA, NRCS, SWCDs, TCEQ, TSSWCB, Texas Sea Grant, and the Texas Department of Transportation.

Future Stakeholder Engagement

Watershed stakeholders will continue to be engaged throughout the WPP implementation process. The watershed coordinator will facilitate engagement by continuing to coordinate, organize, and host periodic public meetings and educational events and by seeking out and meeting with stakeholder groups to identify and secure implementation funds. The Baffin Bay Stakeholder Group is an existing group concerned with Baffin Bay and its water quality. Many members of this group participated in meetings to develop the WPP and will remain engaged in implementation. The watershed coordinator will also provide content to maintain and update a project website, track WPP implementation progress, and participate in local events to promote watershed awareness and stewardship. News articles, newsletters, and the project website will be primary tools used to communicate with watershed stakeholders on a regular basis. Content will be developed to periodically update readers on implementation progress, provide information on new implementation opportunities, and inform them of available technical or financial assistance and information regarding the WPP effort.

Education Programs

Delivering applicable and desired educational programming is a critical part of the WPP implementation process. Multiple programs providing information on potential pollutant sources and feasible management strategies will be delivered in and near the watersheds and will be advertised to watershed stakeholders. These programs will be coordinated with the efforts of other entities operating in and near the watersheds. An approximate program delivery schedule is provided in the management measures described in Chapter 6. As implementation and data collection continues, the adaptive management process will be used to modify this schedule and respective educational needs as appropriate. Potential programs that can meet educational needs are described in subsequent sections.

Texas Watershed Stewards

The Texas Watershed Stewards program is a free educational workshop presented by AgriLife Extension and TSSWCB. It is designed to help watershed stakeholders improve and protect their water resources by getting involved in local watershed protection and management activities. The program is tailored to address the specific water quality issues within the San Fernando and Petronila creeks watersheds.

Texas Well Owners Network

Private water wells provide a source of water to many Texas residents. The Texas Well Owners Network Program delivered by AgriLife Extension provides needed education and outreach that focuses on private drinking water wells and the impacts on human health and the environment that can be mitigated by using proper management practices. This includes a brief session on proper operation and maintenance of OSSFs because they are commonly used near private drinking water wells. Well screenings are conducted through this program and provide useful water test information to well owners that aids them in better managing their water supplies.

Riparian and Stream Ecosystem Education Training

Healthy watersheds and good water quality are synonymous with well-managed riparian and stream ecosystems. Delivering the Riparian and Stream Ecosystem Education Program will increase stakeholder awareness, understanding, and knowledge about the nature and function of riparian zones. The program will highlight the benefits of riparian zones and BMPs that can be implemented to protect them while minimizing NPS pollution. Through this program, riparian landowners will be connected with local technical and financial resources to improve management opportunities and promote healthy watersheds and riparian areas on their land.

OSSF Operation and Maintenance Workshop

A training program that focuses on OSSF rules, regulations, operation, and maintenance needs will be delivered in one or more locations in the watersheds. This training consists of education and outreach practices to promote the proper OSSF management and garners support for efforts to further identify and address failing OSSFs through inspections and remedial actions. AgriLife Extension provides the needed expertise to deliver this training. Additionally, an online training module that provides an overview of septic systems, how they operate, and what maintenance is required to sustain proper functionality and extend system life will be made available to anyone interested through the partnership website.

Healthy Lawns Healthy Waters Workshop

The Healthy Lawns and Healthy Waters Program aims to improve and protect surface water quality by enhancing awareness, knowledge, and implementation of residential landscape BMPs. This program is most beneficial in urbanized portions of the watersheds and can teach homeowners how to care for their lawns appropriately to reduce the risk of NPS pollution entering San Fernando and Petronila creeks and ultimately Baffin Bay.

Urban Riparian and Stream Restoration Workshop

The Urban Riparian and Stream Restoration workshop is available for delivery in the watersheds. Although the watersheds are predominantly rural, urban stormwater influences on stream health and quality exist. This program discusses natural restoration techniques and the unique stressors faced by urban streams.

Lone Star Healthy Streams Workshop

The watershed coordinator will coordinate with AgriLife Extension personnel to deliver the Lone Star Healthy Streams curriculum. This program provides information regarding management practices that can be implemented to reduce potentially adverse water quality impacts resulting from cattle, feral hogs, and horses. For livestock, content focuses on improving grazing land management and presents practices that can reduce NPS pollution. The feral hog program differs in that it largely discusses population control options. This statewide program promotes BMP adoption that is proven to effectively reduce bacterial contamination of streams. This program provides educational support for developing CPs and WQMPs by illustrating the benefits of many practices included in those plans.

Wildlife Management Workshops

Periodic wildlife management workshops are warranted to provide information on management strategies and available resources to those interested. The watershed coordinator will work with AgriLife Extension wildlife specialists, TPWD, and others as appropriate to plan and secure funding to deliver workshops in and near the San Fernando and Petronila creeks watersheds. Wildlife management workshops will be advertised through newsletters, news releases, the project website, and other avenues as appropriate.

Public Meetings

Periodic public stakeholder meetings will achieve several WPP implementation goals. Public meetings will provide a platform for the watershed coordinator and project personnel to provide WPP implementation information including implementation progress, near-term implementation goals and projects, information on how to sign-up or participate in active implementation programs, appropriate contact information for specific implementation programs, and other information as appropriate. These meetings will keep stakeholders engaged in the WPP process and provide a platform to discuss adaptive management to keep the WPP relevant to watershed and water quality needs. This will be accomplished by reviewing implementation goals and milestones and actively discussing how watershed needs can be better served. Feedback will be incorporated into WPP addendums as appropriate.

Newsletters and News Releases

Watershed newsletters will be developed and sent directly to actively engaged stakeholders at least annually or more often if warranted. News releases will be developed and distributed through the mass media outlets in the area to highlight significant happenings related to WPP implementation and to continue raising public awareness and support for watershed protection. These means will be used to inform stakeholders of implementation programs, eligibility requirements, and when and where to sign up for specific programs. Lastly, public meetings and other WPP-related activities will be advertised through these outlets.

Events and Opportunities

Entities working in and around the watersheds routinely host educational events that are relevant to the watersheds and their stakeholders. These entities include the AgriLife Extension, CBBEP, HRI, King Ranch Inc., NRA, and Texas Sea Grant. Programs provided will be advertised to watershed stakeholders to increase information transfer.

Baffin Bay Stakeholder Group

The Baffin Bay Stakeholder Group is jointly facilitated by CBBEP and HRI to better understand the water quality issues in Baffin Bay and develop collaborative solutions to address those issues. This group meets routinely and provides a great platform to discuss WPP implementation needs and progress along with future adaptations to the plan.

Clean Rivers Program Annual Meeting

Each year, NRA hosts an annual Clean Rivers Program (CRP) stakeholder meeting. This meeting covers their entire river basin and includes San Fernando, Petronila, and Los Olmos creeks and Baffin Bay. Discussions in these meetings focus on water quality and quantity issues across the basin and other issues of concern. These are good meetings for high level issues and concerns and an excellent location to bring up localized water resource concerns.

Nueces Delta Preserve Programs

Although outside the watersheds, the Nueces Delta Preserve operated by CBBEP provides hands-on learning experiences related to coastal water resources. A variety of programming opportunities are available throughout the year and upon special request. Specific information about these opportunities is available online at: https://www.nuecesdeltapreserve.org/.

Chapter 8 Plan Implementation

Grain sorghum ready for harvest in the watershed . Photo by Lucas Gregory.

Implementing the WPP is a multi-year commitment that will require active participation from various stakeholders and local entities for a planned 10-year period. Implementing management measures described in Chapter 6 will require significant financial and technical assistance supported by continued education and outreach. The first step to successful implementation is to create a reasonable implementation schedule with interim goals and estimated costs. All management strategies in the WPP are voluntary but have received stakeholder support, which increases the likelihood that they will be implemented.

A complete list of management measures and goals, responsible parties, and estimated costs is included in Table 28. Implementation goals are included incrementally to reflect anticipated implementation time frames. In specific cases, funding acquisition, personnel hiring, or program initiation may delay implementation progress. This approach provides incremental implementation targets that can be used as gages to measure implementation progress. If sufficient progress is not made, adjustments will ensue to increase implementation and meet established goals. Adaptive management may also be used to adjust the planned approach if the original strategy is no longer feasible or other measures have proven more effective.

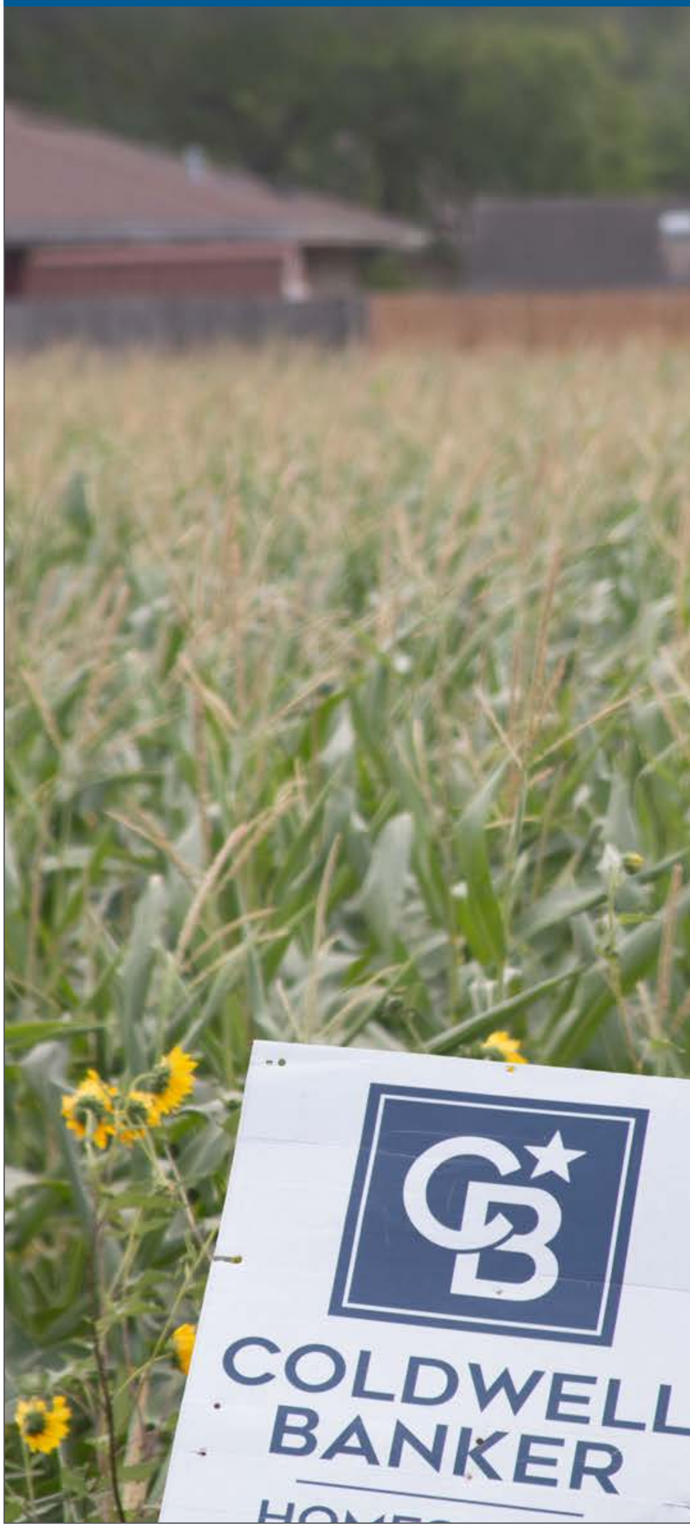
Table 28. Implementation schedule.

Management measure	Responsible party	Estimated unit cost	Number implemented in time frame (year 1–3)	Number implemented in time frame (year 4–6)	Number implemented in time frame (year 7–10)	Estimated total cost
Cattle and other livestock						
Develop funding to hire WQMP technician	TSSWCB, SWCDs, watershed coordinator	$75,000/ year	1			$750,000
Develop, implement, and provide financial assistance for CPs and WQMPs	Producers, landowners, NRCS, TSSWCB, SWCDs, watershed coordinator	$15,000/ plan	90	130	180	$6,000,000
Deliver education and outreach programs and workshops to landowners	Texas A&M AgriLife Extension, NRCS, TSSWCB, watershed coordinator	N/A	1	1	1	N/A
Feral hog management						
Voluntarily construct fencing around deer feeders to prevent feral hog access	Landowner, managers, lessees	$300/ feeder	As many as possible			N/A
Voluntarily trap/ remove/shoot feral hogs to reduce numbers	Landowner, managers, lessees	N/A	3,264 hogs/year			N/A
Develop and implement wildlife management plans and practices	Landowners, producers, TPWD, watershed coordinator	N/A	As many as possible			N/A
Deliver feral hog education workshops	AgriLife Extension, TPWD, watershed coordinator	$3,000 each	1	1	1	$9,000
OSSF management						
Identify, inspect, and repair or replace OSSFs as funding allows	Individuals, counties, contractors	$8,000–$12,000/ system	20	30	50	$800,000–$1,200,000
OSSF education, outreach and training program for installers, service providers and homeowners	NRA, AgriLife Extension, counties, watershed coordinator	$3,500	1	1	1	$10,500

Management measure	Responsible party	Estimated unit cost	Number implemented in time frame (year 1–3)	Number implemented in time frame (year 4–6)	Number implemented in time frame (year 7–10)	Estimated total cost
Develop and deliver materials (postcards, handouts, etc.) to educate homeowners	watershed coordinator, Voices of the Colonias	$2 each	20,000 mailouts over course of implementation			$40,000
Pet waste management						
Pet waste station establishment and maintenance	Cities, HOAs, counties, watershed coordinator,	$500/ station	5	10	10	$12,500
Pet waste education materials	NRA, cities, HOAs, counties, watershed coordinator	$3,000	1	1	1	$9,000
Urban stormwater management						
Identify and install stormwater BMPs	Cities, CBBEP, watershed coordinator, CCT	$4,000–$100,000/ acre	As many as possible			N/A
Deliver education and outreach programs	NRA, watershed coordinator, CCT, AgriLife Extension	N/A	1	0	1	N/A
WWTFs infrastructure repair and replace						
Repair/upgrade wastewater treatment infrastructure at smaller WWTFs	NRA, WWTFs, cities	$3,000,000–$4,000,000/ site	As identified/needed/funding available			2021 estimate of $41,500,000 or more
Deliver education and outreach programs	NRA	N/A	1	1	1	N/A
Reduce illicit dumping						
Hazardous waste collection events	Cities, counties, NRA, watershed coordinator	$35,000–$60,000/ event	3	3	3	$315,000–$540,000
Deliver education and outreach programs	Cities, counties, NRA, AgriLife Extension	$7,000	1	1	1	$21,000

Best management practice, BMP; Clean Coast Texas, CCT; Coastal Bend Bays & Estuaries Program, CBBEP; conservation plan, CP; homeowners association, HOA; Natural Resources Conservation Service, NRCS; Nueces River Authority, NRA; on-site sewage facility; soil and water conservation district, SWCD; Texas Parks and Wildlife Department, TPWD; Texas State Soil and Water Conservation Board, TSSWCB; wastewater treatment facility, WWTF; water quality management plan, WQMP

Chapter 9
Implementation Resources



Future working land conversion in the watershed. Photo by Lucas Gregory.

This chapter identifies potential technical and financial assistance sources available to implement management measures in the San Fernando and Petronila creeks watersheds. Grant funding will be a substantial source of implementation funding given the type and variety of needs identified. Funding support for a local watershed coordinator to guide WPP implementation and facilitate long-term success of the plan is also critical and will be sought through grant opportunities.

Technical Assistance

Designing, planning, and implementing many management recommendations in the plan will require technical expertise. In these cases, appropriate technical support will be sought. Funding required to secure needed expertise will be included as appropriate in requests for specific projects. Potential technical assistance sources for each management measure are listed below (Table 29).

Livestock Management

Technical assistance to develop and implement practices to improve livestock management is available from TSSWCB, local SWCDs, and local NRCS personnel. Interested producers must request planning assistance and these agencies will work with the producer to define operation-specific management goals and objectives and develop a management plan that prescribes effective practices that will achieve stated goals while also improving water quality.

Feral Hog Management

Watershed stakeholders can benefit from technical assistance regarding feral hog control approaches, options, best practices, and regulations. AgriLife Extension and TPWD can provide educational resources through local programs and public events. Online resources regarding feral hog trap and transport regulations, trap construction and design, and trapping techniques are also available at: http://feralhogs.tamu.edu/.

OSSF Management

Identifying failing OSSFs requires trained personnel and available time. County designated representatives or septic service providers can provide expertise and help identify

Table 29. Summary of potential sources of technical assistance.

Management Measure (MM)	Technical Assistance
MM 1: Develop and implement water quality management plan (WQMPs) or conservation plans (CPs)	Natural Resources Conservation Service (NRCS); Texas State Soil and Water Conservation Board (TSSWCB); local soil and water conservation districts (SWCDs)
MM 2: Feral hog management	Texas A&M AgriLife Extension; NRCS; Texas Parks and Wildlife Department (TPWD); TSSWCB
MM 3: On-site sewage facilities	Designed technicians from counties, AgriLife Extension, Clean Coast Texas (CCT)
MM 4: Lawn and landscape maintenance	Cities, AgriLife Extension, Nueces River Authority (NRA), Texas Sea Grant, CCT
MM 5: Green stormwater infrastructure	Coastal Bend Bay & Estuaries Program (CBBEP), AgriLife Extension, NRA, Texas Sea Grant, CCT
MM 6: Wastewater treatment facility (WWTFs)	NRA, WWTFs
MM 7: Reduce illicit dumping	AgriLife Extension, NRA, CBBEP, cities and counties

Coastal Bend Bay & Estuaries Program, CBBEP; Clean Coast Texas, CCT; conservation plans, CPs; management measure, MM; Natural Resources Conservation Service, NRCS; Nueces River Authority, NRA; soil and water conservation district, SWCD; Texas Parks and Wildlife Department, TPWD; Texas State Soil and Water Conservation Board, TSSWCB; water quality management plans, WQMPs

systems in need of repairs or replacement. Technical support is also needed to help secure funding for large scale programs to repair or replace failing OSSFs. Education and outreach content for OSSF owners is also technical in nature and requires trained personnel. AgriLife Extension personnel can provide these educational resources.

Pet Waste

Limited technical assistance is available to directly address pet waste. City public works departments, homeowner associations, and other entities as appropriate will be relied upon to identify viable sites for pet waste stations. These entities may also be able to provide operation and maintenance of collection sites. Educational materials can be provided to cities through AgriLife Extension, NRA, and Texas Sea Grant.

Urban Stormwater Infrastructure

Urban stormwater infrastructure and stormwater management efforts can benefit from technical assistance provided through education programs, BMP demonstrations, and public or privately funded projects. Practice demonstrations provide physical teaching tools and allow decision makers to see how practices look and function. This is especially useful for encouraging green stormwater infrastructure in areas where traditional practices are common. NRA, CBBEP, and Texas Sea Grant will coordinate with city and county officials to develop and implement demonstration sites and full-scale projects as needed. Technical assistance with education and outreach programming is available through AgriLife Extension, NRA, and CBBEP. An additional resource is the *Guidance for Sustainable Stormwater Drainage on the Texas Coast,* published by the Clean Coast Texas (CCT) program in April 2021 (CCT 2021), which provides communities with information on how to implement development strategies that reduce NPS pollution resulting from land development. Structural projects may need engineering designs and should be integrated into the costs of the projects. In the city of Kingsville, a drainage master plan was developed with funding from the U.S. Housing and Urban Development Community Development Block Grant. An engineering firm was awarded the contract in 2018 and subsequently worked with the community through public meetings to identify flood problem areas and mitigation solutions.

WWTF Infrastructure Repair or Replace

WWTFs have the potential to be large contributors of bacteria and nutrient loading in a watershed. This is especially true if facilities have antiquated or failing components needing repair or replacement. Addressing these issues in the San Fernando and Petronila creeks watersheds will take a coordinated effort by local governments and NRA to ensure adequate funding is secured. Education and outreach assistance is available through NRA.

Reduce Illicit Dumping

Efforts to reduce illicit dumping will focus on education and outreach in conjunction with hazardous waste collection events throughout the watersheds. AgriLife Extension and NRA will provide technical assistance with education and outreach efforts. County law enforcement and TPWD game wardens are the primary source for enforcement and monitoring activities associated with illicit dumping. NRA, CBBEP, and Texas Sea Grant will continue efforts to secure funding support for cleanups and trash collection locations.

Technical Resource Descriptions

Texas A&M AgriLife Extension

AgriLife Extension is a statewide outreach education agency with offices in every county of the state. AgriLife Extension provides a network of professional educators, volunteers, and local county extension agents. AgriLife Extension will be consulted to develop and deliver education programs, workshops, and materials as needed.

Engineering Firms

Private firms provide consulting, engineering, and design services. The technical expertise provided by firms may be required for urban BMP design or wastewater infrastructure projects. Extensive work has been conducted by the Texas General Land Office through their CCT program to develop manuals and recommended strategies that can be incorporated into engineering designs. The CCT program can be leveraged by engineering firms to ensure future plans are aligned with the goals and regulatory guidelines of partnering organizations. Funding for services will be identified and written into project budgets as required.

County or City Designated Representatives

OSSF construction or replacement in Duval, Jim Wells, Kleberg, and Nueces counties requires a permit on file with local authorized agents. Permits must be applied for through a TCEQ-licensed professional installer. The county or city's designated representative is responsible for approving or denying permits. Site evaluations must be done by a TCEQ-licensed site and soil evaluator, licensed maintenance provider, or licensed professional installer.

Natural Resources Conservation Service

NRCS provides conservation planning and technical assistance to private landowners. For decades, private landowners have voluntarily worked with NRCS personnel to prevent erosion, improve water quality, and promote sustainable agriculture. Assistance is available to help landowners maintain and improve private lands, implement improved land management technologies, protect water quality and quantity, improve wildlife and fish habitat, and enhance recreational opportunities. Local NRCS centers are located in Benavides, Alice, Kingsville, and Robstown.

Nueces River Authority

NRA provides valuable assistance in all or parts of 22 counties located in the Nueces River Basin, the San Antonio-Nueces Coastal Basin, the Nueces-Rio Grande Coastal Basin, and the adjacent bays and estuaries in South Texas. NRA provides routine water quality monitoring data to the state's database, conducts education outreach using custom made models, conducts riparian assessments/removal of invasive species, and provides WWTF operation expertise. NRA will be a primary source of water quality data and environmental technical assistance across the watersheds.

Soil and Water Conservation Boards

A SWCD, like a county or school district, is a subdivision of the state government. SWCDs are administered by a board of five directors who are elected by their fellow landowners. There are 216 individual SWCDs organized in Texas. It is through this conservation partnership that local SWCDs can furnish technical assistance to farmers and ranchers for the preparation of a complete soil and water CP to meet each land unit's specific capabilities and needs. The local SWCDs include Agua Poquita SWCD (Duval County), Nueces SWCD, Kleberg-Kenedy SWCD, and Jim Wells County SWCD.

Texas Commission on Environmental Quality

TCEQ offers a variety of programming and personnel resources that can provide technical support for WPP Implementation. TCEQ's SSO Initiative is a voluntary program for permitted WWTFs and municipalities. Through the initiative, an SSO plan is developed outlining the causes of SSOs, mitigative and corrective actions, and a timeline for implementation. Assistance for SSO planning and participation in the SSO Initiative is available through the TCEQ regional office (Region 14, Corpus Christi; Region 16, Laredo) and the TCEQ Small Business and Environmental Assistance Division.

TCEQ regional offices also provide resources and expertise for environmental monitoring activities, investigating compliance at permitted facilities and responding to complaints, developing enforcement actions for violations, and performing environmental education and technical assistance for communities as needed. Regional offices also respond to environmental emergencies (disasters, spills, etc.) and evaluate public exposure to hazardous materials.

Texas Parks and Wildlife Department

TPWD's Private Land Services is a program to provide landowners with practical information on ways to manage wildlife resources that are consistent with other land use goals, to ensure plant and animal diversity, to provide aesthetic and economic benefits and to conserve soil, water, and related natural resources. TPWD offers assistance in developing property-specific wildlife habitat management plans and can aid in tracking the expected water quality improvements. Additionally, TPWD offers a habitat management workshop through their regional biologists. To participate, landowners may request assistance by contacting the TPWD district serving their county.

Texas State Soil and Water Conservation Board

TSSWCB supports the operation of local SWCDs and leads the WQMP program by providing technical assistance for developing management and conservation plans at no charge to agricultural producers. A visit with the local SWCD offices is the first step for operators to begin the plan development process.

Clean Coast Texas

CCT is a website and technical information repository developed by the Texas General Land Office and members of the Texas Coastal Nonpoint Source Pollution Program that aims to address the negative impacts of urban development in Gulf Coast communities. Technical manuals are available on subjects such as sustainable stormwater, low-impact development, and green infrastructure. Elected officials, builders, engineers, and homeowners are encouraged to use the free resources provided. The CCT program may be used as a reference for development and implementation of regulatory or incentivized stormwater management strategies to be adopted at the local government and organizational level.

Harte Research Institute for Gulf of Mexico Studies

HRI created a regional effort called the Regional Resilience Partnership. Their overall mission is to mitigate disaster risk and increase community resilience in the Texas Coastal Bend. With funding from the U.S. Economic Development Administration, the group is building an open-source GIS platform called GeoRED. The platform will integrate datasets of physical structures with layers representative of hazards so that the public may better assess risks in counties along the Texas coast.

Financial Resources Descriptions

Successful WPP implementation will require substantial fiscal resources. Diverse funding sources will be sought to meet these needs. Resources will be leveraged where possible to extend the impacts of acquired and contributed implementation funds.

Grant funds will be relied upon to initiate implementation efforts. Existing state and federal programs will also be expanded or leveraged with acquired funding to further implementation impacts. Grant funds are not a sustainable source of financial assistance but are necessary to assist in WPP implementation. Other sources of funding will be used, and creative funding approaches will be sought where appropriate. Sources of funding that are applicable to this WPP will be sought as appropriate and are described in this chapter.

Federal Sources

Clean Water Act §319(h) Nonpoint Source Grant Program

EPA provides grant funding to Texas to implement projects that reduce NPS pollution through the §319(h) Nonpoint Source Grant Program. These grants are administered by TCEQ and TSSWCB. WPPs that satisfy the nine key elements of successful watershed-based plans are eligible for funding through this program. To be eligible for funding, implementation measures must be included in the accepted WPP and meet other program rules. Some commonly funded items include but are not limited to:

- development and delivery of education programs;
- water quality monitoring;
- OSSF repairs and replacements;
- BMP installation and demonstrations; and
- water body cleanup events.

Further information can be found at: https://www.tceq.texas.gov/waterquality/nonpoint-source/grants/grant-pgm.html and https://www.tsswcb.texas.gov/programs/texas-nonpoint-source-management-program.

Conservation Stewardship Program

The Conservation Stewardship Program (CSP) is a voluntary conservation program administered by NRCS that encourages producers to address resource concerns in a comprehensive manner by undertaking additional conservation activities and improving, maintaining, and managing existing conservation activities. The program is available for private agricultural lands including cropland, grassland, prairie land, improved pasture, and rangeland. CSP encourages landowners and stewards to improve conservation activities on their land by installing and adopting additional conservation practices including but not limited to prescribed grazing, nutrient management planning, precision nutrient application, manure application, and integrated pest management.

Program information can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/.

Conservation Reserve Program

The Conservation Reserve Program is a voluntary program for agricultural landowners administered by the USDA Farm Service Agency. Individuals may receive annual rental payments to establish long-term, resource-conserving covers on environmentally sensitive land. The goal of the program is to reduce runoff and sedimentation to protect and improve lakes, rivers, ponds, and streams. Financial assistance covering up to 50% of the costs to establish approved conservation practices, enrollment payments, and performance payments are available through the program.

Information on the program is available at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index.

Environmental Quality Incentives Program (EQIP)

NRCS operates EQIP, which is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of 10 years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and provides opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and nonindustrial private forestland. Individuals engaged in livestock or agricultural production on eligible land are permitted to participate in EQIP. Practices selected address natural resource concerns and are subject to NRCS technical standards adapted for local conditions. They also must be approved by the local SWCD. Local work groups are formed to provide recommendations to NRCS that advise the agency on allocations of EQIP county-based funds and identify local resource concerns. Watershed stakeholders are strongly encouraged to participate in their local work group to promote the objectives of this WPP with the resource concerns and conservation priorities of EQIP.

Information regarding EQIP can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

National Water Quality Initiative

The National Water Quality Initiative is administered by NRCS and is a partnership between NRCS, state water quality agencies, and EPA to identify and address priority impaired water bodies through voluntary conservation. Conservation systems include practices to promote soil health and reduce erosion and nutrient runoff.

Further information is available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/?cid=stelprdb1047761.

Regional Conservation Partnership Program

The Regional Conservation Partnership Program (RCPP) is a comprehensive and flexible program that uses partnerships to stretch and multiply conservation investments and reach conservation goals on a regional or watershed scale. Through RCPP and NRCS, state, local, and regional partners coordinate resources to help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved.

Information regarding RCPP can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/rcpp/.

Rural Development Water and Environmental Programs

USDA Rural Development provides grants and low interest loans to rural communities for potable water and wastewater system construction, repair, or rehabilitation. Funding options include:

- Rural repair and rehabilitation loans and grants: provide assistance to make repairs to low-income homeowners' housing to improve or remove health and safety hazards
- Technical assistance and training grants for rural waste systems: provide grants to nonprofit organizations that offer technical assistance and training for water delivery and waste disposal
- Water and waste disposal direct loans and grants: assist in developing water and waste disposal systems in rural communities with populations less than 10,000 individuals.

More information about the USDA Rural Development program can be found at: https://www.rd.usda.gov/programs-services/water-environmental-programs.

Urban Water Small Grants Program

The objective of the Urban Waters Small Grants Program, administered by EPA, is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. In particular, the Urban Waters Small Grants Program seeks to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of local urban waterways.

More information about the Urban Waters Small Grants Program can be found at: https://www.epa.gov/urbanwaters/urban-waters-small-grants.

Community Development Block Grants

Grants are available through the U.S. Housing and Urban Development program. The city of Kingsville has been awarded a community development block grant to address urban runoff and stormwater management. The city was able to use the funds to develop a drainage master plan that will be implemented soon through contracting with an engineering firm.

More information about the Community Development Block Grants Program can be found at: https://www.hud.gov/program_offices/comm_planning/cdbg.

State Sources

Clean Rivers Program

TCEQ administers Texas CRP, a state fee-funded program that provides surface water quality monitoring, assessment, and public outreach. Allocations are made to 15 partner agencies (primarily river authorities) throughout the state to assist in routine monitoring efforts, special studies, and outreach efforts. NRA is the partner for the San Fernando and Petronila creeks watersheds. The program supports water quality monitoring and annual water quality assessments and engages stakeholders in addressing water quality concerns in both creeks and the larger Baffin Bay watershed.

More information about the NRA CRP is available at: https://nracleanriversprogram.org/.

Clean Water State Revolving Fund

The Clean Water State Revolving Fund, authorized through the CWA and administered by the Texas Water Development Board (TWDB), provides low-interest loans to local governments and service providers for infrastructure projects that include stormwater BMPs, WWTFs, and collection systems. The loans can spread project costs over a repayment period of up to 20 years. Repayments are cycled back into the fund and used to pay for additional projects. Through 2020, the program has committed approximately $10 billion for projects across Texas.

More information on Clean Water State Revolving Fund is available at: http://www.twdb.texas.gov/financial/programs/CWSRF/.

Landowner Incentive Program

TPWD administers the Landowner Incentive Program (LIP) for private landowners to implement conservation practices that benefit healthy aquatic and terrestrial ecosystems and create, restore, protect, or enhance habitat for rare or at-risk species. The program provides financial assistance but does require the landowner to contribute through labor, materials, or other means.

Further information about this program is available at: https://tpwd.texas.gov/landwater/land/private/lip/.

Supplemental Environmental Projects

The Supplemental Environmental Program (SEP) program, administered by TCEQ, directs fines, fees, and penalties for environmental violations toward environmentally beneficial uses. Through this program, a respondent in an enforcement matter can choose to invest penalty dollars to improve the environment, rather than paying into the Texas General Revenue Fund. Program dollars may be directed to OSSF repair, trash clean up, and wildlife habitat restoration or improvement, among other things. Program dollars may be directed to entities for single, one-time projects that require special approval from TCEQ or directed entities (such as Resource Conservation and Development Councils) with pre-approved "umbrella" projects.

Further information about SEP is available at: https://www.tceq.texas.gov/compliance/enforcement/sep/sep-main.

Texas Farm and Ranch Lands Conservation Program

The Texas Farm and Ranch Lands Conservation Program was established and is administered by TPWD to conserve high value working lands to protect water, fish, wildlife, and agricultural production that are at risk of future development. The program's goal is to educate citizens on land resource stewardship and establish conservation easements to reduce land fragmentation and loss of agricultural production.

Program information is available from TPWD at: https://tpwd.texas.gov/landwater/land/private/farm-and-ranch/.

Other Sources

Private foundations, nonprofit organizations, land trusts, and individuals can potentially assist with implementing some aspects of the WPP. Funding eligibility requirements for each program should be reviewed before applying to ensure applicability. Some groups that may be able to provide funding include but are not limited to:

- Cynthia and George Mitchell Foundation: provides grants for water and land conservation programs to support sustainable protection and conservation of Texas' land and water resources
- Dixon Water Foundation: provides grants to nonprofit organizations to assist in improving/maintaining watershed health through sustainable land management
- Meadows Foundation: provides grants to nonprofit organizations, agencies and universities engaged in protecting water quality and promoting land conservation practices to maintain water quality and water availability on private lands
- Partnerships with local industry in the watersheds could also provide in-kind donations or additional funding for implementation projects
- Texas Agricultural Land Trust: funding provided by the trust assists in establishing conservation easements for enrolled lands

Chapter 10
Measuring Success

Nueces River Authority conducting water quality monitoring on Petronila Creek at FM 892. Sam Sugarek, Nueces River Authority.

Implementing this WPP requires coordination with many stakeholders over the next 10 years. Implementation will focus on addressing readily manageable bacteria sources in the watersheds to achieve water quality targets. This plan identified substantial financial resources, technical assistance, and education required to achieve these targets. Management measures identified in this WPP are voluntary but supported at the recommended levels by watershed stakeholders.

Measuring WPP implementation impacts on water quality is a critical process. Planned water quality monitoring at critical locations will provide data needed to document progress toward water quality goals. While improvements in water quality are the preferred measure of success, documenting implementation accomplishments can also be used. Combining water quality data and implementation accomplishments helps facilitate adaptive management by illustrating which recommended measures are working and which measures need modification.

Water Quality Targets

An established water quality goal defines the target for future water quality and allows the needed bacteria load reductions to be defined. The stakeholder-selected water quality goal in San Fernando and Petronila creeks is the existing primary contact recreation standard for *E. coli* of 126 cfu/100 mL and enterococcus of 35 cfu/100 mL in the tidal segment (Table 30). If there are revisions or adoption of new water quality standards, such as for nutrients, these targets may be revised or amended as appropriate.

Additional Data Collection Needs

Continued water quality monitoring in the San Fernando and Petronila creeks watersheds is necessary to track water quality changes resulting from WPP implementation. Currently, NRA conducts quarterly water quality monitoring at five monitoring stations in the watersheds. This continues data collection at monitoring stations used in state water quality assessment and is critical for future evaluations and should be continued. Additionally, stations 13033 and 13096 were used in LDC analysis to determine needed load reductions to meet the water quality targets listed above. Continued data collection over time is imperative for changes in bacteria loading to be evaluated.

Table 30. The water quality targets for impaired water bodies in the San Fernando and Petronila creeks watersheds.

Station(s)	Segment	Current concentration*	5 years after implementation*	10 years after implementation*
13090	2203_01	44.9	40.0	≤35
13094	2204_01	419.4	272.5	≤126
13096	2204_02	592.5	359.3	≤126
20806	2204_02	28.8	≤126	≤126
13033	2492A_01	303.6	214.8	≤126

*Geometric mean in units of most probable numbers of *E. coli* (enterococcus in tidal segment, 2203_01) per 100 milliliters of water

The current monitoring site distribution and data collection frequency across the watersheds limit potential to observe subtle water quality changes that result from WPP implementation. Defining localized water quality impacts from specific WPP implementation activities will require focused water quality monitoring efforts, which can only be planned once specific WPP implementation activities and locations are known. Focused monitoring plans will require funding support and will be used to assess implementation effectiveness. Targeted water quality monitoring could include paired watershed studies, multiple watershed studies, or edge-of-field runoff analysis where different land use or management measures have been implemented. Data derived from this monitoring could demonstrate the applicability of different BMPs within the watersheds. Targeted monitoring may also include more intensive sampling in other stream segments to identify potential pollutant sources.

Additional data collection is also warranted outside the watersheds' boundaries to better understand the influences of WPP implementation on water quality in Baffin Bay. Expanded Los Olmos Creek monitoring is needed to further understand its influence on Baffin Bay water quality. Continued routine and special project monitoring should be prioritized in Baffin Bay and Los Olmos Creek.

Through the adaptive management process and WPP updates, future water quality monitoring needs will be evaluated and adjusted as necessary. This could include adding new sites to address new concerns or areas of interest in the watersheds.

Data Review

Watershed stakeholders are responsible for evaluating WPP implementation impacts on instream water quality. Stakeholders will use TCEQ's statewide biennial water quality assessment approach, which uses a moving 7-year geometric mean of bacteria data collected through the state's CRP, as a primary means of gauging implementation success. This assessment is published in the *Texas Integrated Report and 303(d) List* and is available online at https://www.tceq.texas.gov/waterquality/assessment/305_303.html. It is noted that a 2-year lag occurs in data reporting and assessment; therefore the *2024* or *2026 Texas Integrated Report* will likely be the first to include water quality data collected during WPP implementation.

Identifying water quality improvements from WPP implementation is challenging if only relying on the 7-year data window used for the *Texas Integrated Report.* Therefore, another method to evaluate water quality improvements is using the geometric mean of the most recent 3 years of water quality data identified within TCEQ's Surface Water Quality Monitoring Information System. To support data assessment as needed, trend analysis and other appropriate statistical analyses will be used. Regardless of method used, water quality changes resulting from WPP implementation will be difficult to determine and may be overshadowed by activity in the watersheds that negatively influences water quality. As such, data review will not be relied on exclusively to evaluate WPP effectiveness. Data will be summarized and reported to watershed stakeholders at least annually through stakeholder meetings and NRA's annual CRP meeting.

The watershed coordinator will be responsible for tracking implementation targets and water quality in the watersheds. Implementation progress and water quality will be evaluated to describe the success of WPP implementation to that point. Should implementation targets or water quality lag significantly, adaptive management efforts will be initiated to reevaluate management recommendations and targets included in the WPP.

Interim Measurable Milestones

WPP implementation will occur over a 10-year timeframe. Milestones can be useful in evaluating incremental implementation progress of management measures described in the WPP. Milestones outline a clear process for progression throughout implementation. Interim measurable milestones for management measures and education and outreach are addressed in Table 28. Responsible parties and estimated costs (where available) are included in the schedule. In some cases, funding acquisition, personnel hiring, or program initiation may delay the start of some items. This approach provides incremental targets to measure progress throughout WPP implementation. Adaptive management may be used where necessary to reorganize or prioritize varying implementation aspects to achieve overarching water quality goals.

Adaptive Management

Watersheds are dynamic by nature, with countless variables governing landscape processes; therefore, uncertainty is expected and the WPP was developed with this in mind. As WPP implementation progresses, it is necessary to track water quality over time and make needed adjustments to the implementation strategy. Including an adaptive management approach in the WPP provides flexibility that enables such adjustments.

Adaptive management is the ongoing process of accumulating knowledge regarding impairment causes and water quality response as implementation efforts progress and adjusting management efforts as needed. As implementation activities are instituted, water quality is tracked to assess impacts. This information can be used to guide adjustments to future implementation activities. This ongoing, cyclical implementation and evaluation process can focus project efforts and optimize its impacts. Watersheds where impairments are dominated by NPS pollutants are good candidates for adaptive management. Progress toward achieving established water quality targets will also be used to evaluate the need for adaptive management. An annual implementation progress and water quality trends review will be presented to stakeholders during meetings. Due to numerous factors that can influence water quality and the time lag that often appears between implementation efforts and resulting water quality improvements, sufficient time should be allowed for implementation to occur before triggering adaptive management. In addition to water quality targets, if satisfactory progress toward achieving milestones is determined to be infeasible due to funding, implementation scope, or other reasons that would prevent implementation, adaptive management provides an opportunity to revisit and revise the implementation strategy. If stakeholders determine inadequate progress toward water quality improvement or milestones is being made, efforts will be made to increase BMP adoption and adjust strategies or focus areas as appropriate.

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Appendix A: Potential Load Calculations

Estimates for potential loads are based on the best available data (e.g., local, state, and federal databases, scientific research) and local stakeholder input (e.g., local livestock stocking practices, wildlife densities). Potential loading rates assume a worst-case scenario and are primarily used to calculate where management measures should be implemented first to maximize effectiveness and estimate potential load reductions.

Livestock

Calculating potential bacteria loads from livestock requires animal population estimates for the watersheds. USDA provides recommended livestock stocking rates by county based on livestock census data. These estimates were used to estimate an initial livestock population as a basis to present to stakeholders in the watersheds. Using stakeholder feedback, stocking rates for different counties were adjusted as shown in Table 31. Animal numbers fluctuate annually based on local conditions; however, this approach provides a baseline to estimate potential loadings. Challenges using this approach to estimate livestock numbers include the reliance on land cover maps and the difficulty in identifying pasture and rangeland. These maps do not differentiate between land that is used for hay production versus grazed pasture. Furthermore, identifying actual stocking rates used by individual landowners is impossible. Therefore, reliance on local stakeholders was critical to properly estimating cattle populations.

Cattle

Cattle are the dominant livestock species in the watersheds and were assessed separately from other livestock. Cattle estimates were compared to NASS population estimates for watershed counties to determine if generated estimates compared to USDA stocking rate-based estimates. Using these inputs, there are an estimated 29,544 cattle animal units (AnU) in the San Fernando Creek watershed and 8,670 cattle AnU in the Petronila Creek watershed for a combined total of 38,214 cattle AnU across both watersheds. The two methods differed by 21 animals across the watersheds.

Table 31. U.S. Department of Agriculture-recommended cattle stocking rates by county measured in acres/animal unit (ac/AnU).

County	Pasture/grassland	Light brush	Medium brush	Heavy brush	Medium/heavy combined
Duval	7	18	27	34	30.5
Jim Wells	10	15	20	25	22.5
Nueces	5	15	23	28	25.5
Kleberg	17	21	n/a	32	32

Using the cattle population estimates generated, potential E. coli loading across the watersheds and for individual subbasins was estimated with GIS analysis. The annual load from cattle was calculated as:

$$PAL_{cattle} = AnU \times FC_{cattle} \times \ Conversion \times 365 \frac{days}{year}$$

Where:

PAL_{cattle} = Potential annual *E. coli* loading attributed to cattle

AnU = Animal Units of cattle (~1,000 lbs of cattle)

FC_{cattle} = Fecal coliform rate of cattle; 8.55×10^9 cfu fecal coliform/AnU/day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential annual loading across all subbasins due to cattle is 1.58×10^{14} cfu *E. coli*/year in the San Fernando Creek watershed and 4.69×10^{13} cfu *E. coli*/year in the Petronila Creek watershed.

Other Livestock

NASS reported number for goats, sheep, and horses were used for these species and were scaled down to the combined watershed area in appropriate land covers using GIS. Potential *E. coli* loading for individual subbasins was estimated using these estimates. The annual load from other livestock was calculated as:

$$PAL_{OL} = [(AnU \times FC_{goat}) + (AnU \times FC_{horse}) + (AnU \times FC_{sheep})] \times Conversion \times 365\,\frac{days}{year}$$

Where:

PAL_{OL} = Potential annual *E. coli* loading attributed to other livestock

AnU = Animal Units conversion (~1,000 lbs of live animal weight)

FC_{goat} = Fecal coliform loading rate of cattle; 4.32×10^{9} cfu fecal coliform/AnU/day (Wagner and Moench 2009)

FC_{horse} = Fecal coliform loading rate of cattle; 3.64×10^{8} cfu fecal coliform/AnU/day (Wagner and Moench 2009)

FC_{sheep} = Fecal coliform loading rate of cattle; 5.8×10^{10} cfu fecal coliform/AnU/day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential annual loading across all subbasins due to other livestock is 1.82×10^{14} cfu *E. coli*/year in the San Fernando Creek watershed and 5.74×10^{13} cfu *E. coli*/year in the Petronila Creek watershed.

Feral Hogs

Feral hog populations were estimated using an estimated population density of one feral hog/39.4 ac of suitable habitat. The density estimate was based on statewide estimates described in Timmons et al. (2012) then adjusted based on stakeholder feedback within each watershed. GIS analysis was used to estimate watershed-wide and subbasins feral hog populations. Based on this analysis, an estimated 17,826 feral hogs exist within the San Fernando Creek watershed and 3,933 feral hogs within the Petronila Creek watershed. Like other population estimates, these numbers provide general estimates that change based on actual conditions. Furthermore, feral hogs roam across large areas that might be larger than individual subbasins; however, these estimates provide guidance on where to focus control efforts based on suitable habitats. Using the feral hog population estimates, the potential *E. coli* loading across the watersheds and for individual subbasins was estimated. The annual load from feral hogs was calculated as:

$$PAL_{fh} = N_{fh} \times AnUC \times FC_{fh} \times Conversion \times 365\,\frac{days}{year}$$

Where:

PAL_{fh} = Potential annual *E. coli* loading attributed to feral hogs

N_{fh} = Number of feral hogs

$AnUC$ = Animal unit conversion; 0.125 AnU/feral hog (Wagner and Moench 2009)

FC_{fh} = Fecal coliform loading rate of feral hogs; 1.21×10^{9} cfu fecal coliform/AnU/day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential annual loading across all subbasins due to feral hogs is 1.66×10^{12} cfu *E. coli*/year in the San Fernando Creek watershed and 1.01×10^{12} cfu *E. coli*/year in the Petronila Creek watershed.

Domestic Pets

Dog estimates were generated using an estimated population density of 0.614 dogs per household applied to weighted U.S. Census block household data (AVMA 2018). In the San Fernando Creek watershed, there are an estimated 16,507 dogs. In the Petronila Creek watershed, there are an estimated 3,875 dogs. It was assumed that approximately 40% of dog owners do not pick up dog waste (Swann 1999). Based on these assumptions, there are an estimated 6,603 dogs in the San Fernando Creek watershed and 1,550 dogs in the Petronila Creek watershed whose owners do not pick up after them. Using the resulting dog population estimate, the annual load due to dogs was estimated as:

$$PAL_d = N_d \times FC_d \times Conversion \times 365\,\frac{days}{year}$$

Where:

PAL_d = Potential annual *E. coli* loading attributed to dogs

N_d = Number of dogs that owners do not pick up after

FC_d = Fecal coliform loading rate of dogs; 5.00×10^9 cfu fecal coliform/dog/day (EPA 2001)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

Therefore, the estimated potential annual loading attributed to dogs is 5.12×10^{13} cfu *E. coli*/year in the San Fernando Creek watershed and 1.07×10^{13} cfu *E. coli*/year in the Petronila Creek watershed.

OSSFs

Using the watershed OSSF estimates and distribution, potential *E. coli* loading for individual subbasins was estimated. Methods to estimate OSSF locations and numbers are described in Chapter 4 of this WPP. The annual load from OSSFs was calculated as:

$$PAL_{ossf} = N_{ossf} \times N_{hh} \times Production \times Failure\ Rate \times FC_s \times Conversion \times 365\,\frac{days}{year}$$

Where:

PAL_{ossf}= Potential annual *E. coli* loading attributed to OSSFs

N_{ossf}= Number of OSSFs

N_{hh} = Average number of people/household (2.05)

Production = Assumed sewage discharge rate; 70 gallons/person/day (Borel et al. 2015)

Failure Rate = Assumed failure rate; 15% (Reed, Stowe & Yanke 2001)

FC_s = Fecal coliform concentration in sewage; 1.0×10^6 cfu/100 mL (EPA 2001)

Conversion = Conversion rate from fecal coliform to *E. coli;* 126/200 (Wagner and Moench 2009) and mL to gallon (3785.4 mL/gallon)

The estimated potential annual loading across all subbasins due to OSSFs is 1.45×10^{12} cfu *E. coli*/year in the San Fernando Creek watershed and 1.10×10^{12} cfu *E. coli*/year in the Petronila Creek watershed.

WWTFs

Potential loadings from WWTFs were calculated for all permitted dischargers with a bacteria monitoring requirement. Potential loads were calculated as the sum of the maximum permitted discharges of all WWTFs multiplied by the maximum permitted *E. coli* concentration:

$$PAL_{wwtf} = Discharge \times Concentration_{max} \times Conversion \times 365\ days/year$$

Where:

PAL_{wwtf} = Potential annual *E. coli* loading due to WWTF discharges

Discharge = Maximum permitted daily discharge

$Concentration_{max}$ = Maximum average permitted concentration of *E. coli* in wastewater discharge (126 cfu/100 mL)

Conversion = Unit conversion (3785.4 mL/gallon)

The estimated potential annual loading across all subbasins due to WWTF discharges are 4.71×10^{10} cfu *E. coli*/year in the San Fernando Creek watershed and 2.65×10^{9} *E. coli*/year in the Petronila Creek watershed.

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Appendix B: Load Reduction Calculations

Livestock

E. coli loading reductions resulting from implementation of CPs and WQMPs (plans) involves potential reductions from various livestock. Cattle are the dominant livestock in the watersheds and were assumed to be the species managed through livestock-focused management.

According to NASS data and stakeholder input, there are an estimated 29,544 AnU of cattle in the San Fernando Creek watershed and 8,670 AnU of cattle in the Petronila Creek watershed for a combined total of 38,214 AnU of cattle across both watersheds (see Appendix A). This information was used to estimate the number of cattle per operation. In the Petronila Creek watershed, 53 AnU/operation were assumed, and 30 AnU/operation were estimated in the San Fernando Creek watershed. These are the presumed number of cattle managed by each plan.

The agriculture work group estimated that 200 producers per watershed will be willing to implement management plans if assistance is provided. However, not all of these will primarily address livestock. NASS also reports average farm/ranch size and the number of farms/ranches by county. Averaged across the four counties that make up the watersheds, average farm/ranch size is 686.5 ac. Using this size and the percentage of suitable grazing acres compared to total agricultural acres across the watersheds (Table 2), the anticipated number of plans that will primarily address livestock loading in each watershed was estimated (Table 32).

Table 32. Data for estimating grazing focused plans.

Watershed	Suitable grazing acres[1]	Total grazing plus cropped acres[1]	Percent of acres for grazing	Presumed number of plans with grazing focus (out of 200 total)
Petronila Creek	112,237	399,783	28%	56
San Fernando Creek	660,557	743,396	89%	178

[1] Acres reported in Table 2 from the 2017 National Land Cover Database land cover layer

In reality, each plan will vary in size and number of actual AnU addressed based on the specifics of the managed property and the current climatic conditions.

To estimate expected *E. coli* reductions, median BMP efficacy values reported in literature were used (Table 33). BMPs were selected based on agriculture work group member feedback. Because actual BMPs implemented in each plan are unknown, an overall median efficacy value of 0.62 (62%) was used to estimate load reductions. The proximity of implemented BMPs to water bodies also influences the effectiveness at reducing loads reaching the creeks. A proximity factor of 0.05 (5%) is used for BMPs in upland areas and 0.25 used in riparian areas. Because there is uncertainty in specific BMPs and the locations where plans are implemented, an average proximity factor of 0.15 was used.

Table 33. Best management practice load reduction median effectiveness values.

Management practice	*E. coli*	Nitrogen	Phosphorus
Exclusionary fencing[1]	62%[1]	33%[4]	49%[7]
Prescribed grazing[2]	54%[2]	55%[5]	41%[8]
Watering facility[3]	73%[3]	5%[6]	57%[9]

[1] Brenner et al. 1996; Cook 1998; Hagedorn et al. 1999; Line 2002; Line 2003; Lombardo et al. 2000; Meals 2001; Meals 2004; Peterson et al. 2011
[2] Tate et al. 2004; EPA 2010
[3] Byers et al. 2005; Hagedorn et al. 1999; Sheffield et al. 1997
[4] Line et al. 2000
[5] Chesapeake Bay Program 2017; Olness et al. 1980; Tuppad et al. 2010
[6] Byers et al. 2005; Chesapeake Bay Program 2017
[7] Flores-Lopez et al. 2010; Kay et al. 2009; Line et al. 2000, 2016; Sharpley et al. 2009
[8] Chesapeake Bay Program 2017; Olness et al. 1980; Sharpley et al. 2009; Tuppad et al. 2010
[9] Byers et al. 2005; Kay et al. 2009; Sheffield et al. 1997

Total potential *E. coli* load reductions from plans were calculated with the following equation:

$$LR_{cattle} = N_{plans} \times \frac{AnU}{Plan} \times FC_{cattle} \times Conversion \times 365\frac{days}{year} \times BMP\ Efficacy \times Proximity\ Factor$$

Where:

LR_{cattle} = Potential annual load reduction of *E. coli*

N_{plans} = Number of WQMPs and CPs, 200 are proposed in each watershed for this WPP

AnU/Plan = Animal Units of cattle (~1,000 lbs of cattle) per management plan

FC_{cattle} = Fecal coliform loading rate of cattle; 8.55×10^9 cfu fecal coliform/AnU/day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

Efficacy = Median BMP efficacy value; 0.62

Proximity Factor = Percentage-based factor based on the assumed proximity of the management measure to the water body; 0.15

Using the above-described inputs, estimated annual potential *E. coli* load reductions by managing cattle through plans (San Fernando Creek watershed [178 plans] and Petronila Creek watershed [56 plans]) total 8.15×10^{13} cfu in Petronila Creek and 1.50×10^{14} cfu in San Fernando Creek. Additionally, nutrient reductions can also be anticipated with each plan through some of the same practices used to reduce bacteria loading (Table 33). Using the same assumptions as above, potential nutrient load reductions expected from cattle management practices were estimated with:

Number of Plans × *cattle/Plan* × *Pounds of Nutrient/Animal/day* × *Median Effectiveness* × *Proximity Factor*

Based on the above assumptions and equations, the total potential nitrogen load reduction from implementation of CPs is estimated at 16,633 lbs of nitrogen and 8,763 lbs of phosphorus/year in the Petronila Creek watershed. In the San Fernando Creek watershed, total potential load reductions are estimated at 30,610 lbs of nitrogen/year and 16,128 lbs of phosphorus/year.

Feral Hogs

Loading reductions for feral hogs assume that existing feral hog populations can be reduced and maintained by a certain amount on an annual basis. Removal of a feral hog from the watersheds is assumed to completely remove the potential bacteria load generated by that feral hog. Therefore, the total potential load reduction is calculated as the population reduction in feral hogs achieved in the watersheds. Based on GIS analysis, 3,933 feral hogs were estimated to exist across the San Fernando Creek watershed and 17,826 across the Petronila Creek watershed (see Appendix A for details). The established goal is to reduce and maintain the feral hog population 15% below current population estimates, thus resulting in a 15% reduction in potential loading that is attributable to feral hogs. Load reductions were calculated based on the following:

$$LR_{fh} = N_{fh} \times FC_{fh} \times Conversion \times Proximity\ Factor\ \times 365\frac{days}{year}$$

Where:

LR_{fh} = Potential annual load reduction of *E. coli* attributed to feral hog removal

N_{fh} = Number of feral hogs removed

FC_{fh} = Fecal coliform loading rate of feral hogs; 1.00×10^{10} cfu fecal coliform/AnU/day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

Proximity Factor = 0.25

The estimated potential annual loading across the San Fernando and Petronila creeks watersheds, based on reducing and maintaining the population by 15% (2,674 feral hogs in the San Fernando Creek watershed and 590 in the Petronila Creek watershed), is 9.28 × 1013 and 2.05 × 1013 cfu E. coli annually, respectively. Nutrient reductions are also anticipated for each feral hog removed. NRCS (2009) estimates nitrogen and phosphorus production from swine at 0.14 and 0.05 lbs/day respectively.

Using these values and the equation below, annual load reductions 3,769 lbs of nitrogen/year and 1,346 lbs of phosphorus/year can be removed from the Petronila Creek watershed. In the San Fernando Creek watershed, these annual reductions are 17,080 and 6,100 lbs of nitrogen and phosphorus respectively.

Removed feral hogs × Pounds of Nutrient/Animal/Day × 0.125 (AnU/feral hog) × 365 days

Domestic Pets

The San Fernando Creek watershed contains approximately 16,507 dogs, and the Petronila Creek watershed contains approximately 3,875 dogs. Load reductions assume that approximately 10% of pet owners that do not currently dispose of pet waste will respond to the management measure efforts (Swann 1999). Therefore, the goal is to increase the number of pet owners who dispose of pet waste by 660 and 155 pet owners in the San Fernando and Petronila creeks watersheds, respectively. The resulting reductions are calculated by:

$$LR_d = N_d \times FC_d \times Conversion \times Effectiveness\ Factor \times 365\frac{days}{year}$$

Where:

LR_d = Potential annual load reduction of *E. coli* attributed to proper dog waste disposal

N_d = Number of additional dog owners disposing of pet waste (10% of total dogs)

FC_d = Fecal coliform loading rate of dogs; 5.0×10^9 cfu fecal coliform/dog/day (EPA 2001)

Effectiveness Factor = 0.5

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential load reduction attributed to dog waste management in the San Fernando Creek watershed is 9.49×10^{14} cfu *E. coli* annually and 2.23×10^{14} cfu *E. coli* annually in the Petronila Creek watershed. Additionally, nutrient reductions are anticipated from proper dog waste management. Schuster and Grismer (2004) report daily nitrogen and phosphorus production of 1.3 grams (g)/dog and 0.3 g/dog respectively. Using this information and the equation below, in the Petronila Creek watershed an estimated 202.3 lbs of nitrogen/year and 46.7 lbs of phosphorus/year are expected to be removed. In the San Fernando Creek watershed, expected reductions for nitrogen and phosphorus are 861.6 and 198.8 lbs/year respectively.

Dogs in watershed × percent of dogs managed × g of nitrogen/day × lbs/g × Practice Efficiency

Where:

lbs/g = 0.0022

OSSFs

OSSFs are common in the San Fernando and Petronila creeks watersheds, with an estimated 9,087 systems across both watersheds. OSSF failures are factors of system age, soil suitability, system design, and maintenance. For this area of the state, a 15% failure rate is assumed (Reed, Stowe & Yanke 2001). Load reductions from repairing or replacing failing OSSFs are calculated based on the number of assumed failing OSSFs replaced. The following equation was used to calculate potential load reductions:

$$LR_{ossf} = N_{ossf} \times N_{hh} \times Production \times FC_s \times Conversions \times\ 365\frac{days}{year}$$

Where:

LR_{ossf}= Potential annual load reduction of *E. coli* attributed to OSSF repair/replacement

N_{ossf}= Number of OSSFs repaired/replaced

N_{hh} = 2.89 = Average number of people/household (four county average; USCB 2021)

Production = Assumed sewage discharge rate; 70 gallon/person/day (Borel et al. 2012)

FC_s = Fecal coliform concentration in sewage; 1.0×10^7 cfu/100 mL (EPA 2001)

Conversions = Conversion rate of 126/200 from fecal coliform to *E. coli* (Wagner and Moench 2009) and mL to gallon (3785.4 mL/gallon)

Proximity Factor = 0.5 for very limited; 0.1 for not limited soil suitability (76% of OSSFs presumed in very limited soils; 24% presumed in not limited soils)

In the San Fernando and Petronila creeks watersheds, it is assumed that 40 and 60 OSSFs, respectively, will be repaired or replaced. This results in a potential reduction of 4.52×10^{14} cfu *E. coli* annually in the San Fernando Creek watershed and 6.78×10^{14} cfu *E. coli* annually in the Petronila Creek watershed. Additionally, nutrient reductions are anticipated for every OSSF replaced.

$$\text{Number of OSSFs replaced} \times \text{average people/household} \times \text{mg of nutrient/L} \\ \times \text{gallons of sewage produced/person/day} \times \text{lbs/mg} \times \text{L/gallon} \times \text{365 days/year}$$

Using the assumption (Table 34) and equation above, annual nutrient reductions for the watersheds are estimated at 1,477.6 lbs of nitrogen and 369.4 lbs of phosphorus reduced in Petronila Creek and 985.1 lbs of nitrogen and 246.3 lbs of phosphorus reduced from San Fernando Creek.

Table 34. On-site sewage facility septage constituent assumptions.

Assumptions	
People/household	2.89 (USCB 2021)
Milligrams of nitrogen/liter of septage	40 mg/L (Davis and Cornwell 1991)
Milligrams of phosphorus/liter of septage	10 mg/L (Davis and Cornwell 1991)
Gallons of septage/person/day	70
Pounds/milligram	2.2×10^{-6}
Liters/gallon	3.79

Liter, L; milligram, mg

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Appendix C: Watershed Protection Plan Elements and Review Checklist

EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* describes the nine elements critical for achieving improvements in water quality that must by sufficiently included in a WPP for it to be eligible for implementation funding through the CWA Section 319(h) funds. These elements do not preclude additional information from being included in the WPP. This appendix briefly describes the nine elements and references the chapters and sections that fulfill each element.

A: Identification of Causes and Sources of Impairment

Identify the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan). Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed. Information can be based on a watershed inventory or extrapolated from a subwatershed inventory, aerial photos, GIS data, or other sources.

B: Estimated Load Reductions

Estimate the load reductions expected for the management measures proposed as part of the watershed plan.

C: Proposed Management Measures

Describe the management measures that will need to be implemented to achieve the estimated load reductions and identification (using a map or description) of the critical areas in which those measures will be needed to implement the plan. Proposed management measures are defined as including BMPs and measures needed to institutionalize changes. A critical area should be determined for each combination of source BMP.

D: Technical and Financial Assistance Needs

Estimate the amounts of technical and financial assistance needed, associated costs and/or the sources and authorities that will be relied upon to implement this plan. Authorities include the specific state or local legislation that allows, prohibits, or requires an activity.

E: Information, Education and Public Participation Component

Information/education components will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the appropriate nonpoint source pollution management measures.

F: Implementation Schedule

Schedule implementing the nonpoint source pollution management measures identified in the plan that is reasonably expeditious.

G: Milestones

Provide a description of interim, measurable milestones for determining whether nonpoint source pollution management measures or other control actions are being implemented. Milestones should be tied to the progress of the plan to determine if it is moving in the right direction.

H: Load Reduction Evaluation Criteria

Determine a set of criteria that can be used to determine whether loading reductions are being achieved over time and if substantial progress is being made toward attaining water quality standards. If not, it is also the criteria for determining if the watershed-based plan needs to be revised. The criteria for the plan needing revision should be based on the milestones and water quality changes.

I: Monitoring Component

Include a monitoring component to evaluate the effectiveness of the implementation efforts over time that is measured against the evaluation criteria. The monitoring component should include required project-specific needs, the evaluation criteria, and local monitoring efforts. It should also be tied to the state water quality monitoring efforts.

Name of water body	San Fernando and Petronila creeks watersheds
Assessment units	2203_01, 2204A_01, 2204B_01, 2204_01, 2204_02, 2492A_01
Impairments addressed	Bacteria and nutrient concerns
Concerns addressed	Impaired fish community, nitrate, total phosphorus

Element	Report Section(s)
Element A: Identification of Causes and Sources	
1. Sources identified, described, and mapped	Chapters 3, 4, and 5, Appendix A
2. Subbasins sources	Chapter 5
3. Data sources are accurate and verifiable	Chapter 5, Appendix A
4. Data gaps identified	Appendix A
Element B: Expected Load Reductions	
1. Load reductions achieve environmental goal	Chapter 5, Appendix B
2. Load reductions linked to sources	Chapter 5
3. Model complexity is appropriate	Appendix B
4. Basis of effectiveness estimates explained	Chapter 6 Tables 20–27, Appendix B
5. Methods and data cited and verifiable	Appendix B
Element C: Management Measures Identified	
1. Specific management measures are identified	Chapter 6
2. Priority areas	Chapter 6
3. Measure selection rationale documented	Chapter 6
4. Technically sound	Chapter 6
Element D: Technical and Financial Assistance	
1. Estimate of technical assistance	Chapter 9
2. Estimate of financial assistance	Chapter 9
Element E: Education/Outreach	
1. Public education/information	Chapter 7
2. All relevant stakeholders are identified in outreach process	Chapter 7
3. Stakeholder outreach	Chapter 7
4. Public participation in plan development	Chapter 7
5. Emphasis on achieving water quality standards	Chapter 7
6. Operation and maintenance of BMPs	Chapter 8 Table 28
Element F: Implementation schedule	
1. Includes completion dates	Chapter 8 Table 28
2. Schedule is appropriate	Chapter 8 Table 28

Element	Report Section(s)
Element G: Milestones	
1. Milestones are measurable and attainable	Chapter 8 Table 28, Chapter 10
2. Milestones include completion dates	Chapter 8 Table 28, Chapter 10
3. Progress evaluation and course correction	Chapter 8 Table 28, Chapter 10
4. Milestones linked to schedule	Chapter 8 Table 28, Chapter 10
Element H: Load Reduction Criteria	
1. Criteria are measurable and quantifiable	Chapter 6 Tables 20–27
2. Criteria measure progress toward load reduction goal	Chapter 6 Tables 20–27
3. Data and models identified	Chapter 6 Tables 20–27, Appendix B
4. Target achievement dates for reduction	Chapter 10
5. Review of progress toward goals	Chapter 10
6. Criteria for revision	Chapter 10
7. Adaptive management	Chapter 10
Element I: Monitoring	
1. Description of how monitoring is used to evaluate implementation	Chapter 10
2. Monitoring measures evaluation criteria	Chapter 10
3. Routine reporting of progress and methods	Chapter 10
4. Parameters are appropriate	Chapter 10
5. Number of sites is adequate	Chapter 10
6. Frequency of sampling is adequate	Chapter 10
7. Monitoring tied to QAPP	Chapter 10
8. Can link implementation to improved water quality	Chapter 10

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