Tres Palacios Creek Tidal Total Maximum Daily Load Implementation Plan Status Report

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Abbreviations

Abbreviation	**Meaning**
ATS	Akritas-Theil-Sen
cfu	cfu
EPA	Environmental Protection Agency
I-Plan	Implementation Plan
mL	milliliters
MPN	most probable number
MS4	municipal separate storm sewer system
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
SWCD	Soil and Water Conservation District
SWQM	Surface Water Quality Monitoring
TCEQ	Texas Commission on Environmental Quality
TIAER	Texas Institute for Applied Environmental Research
TMDL	Texas Parks and Wildlife Department
TPWD	Total Maximum Daily Load
TWRI	Texas Water Resources Institute

Abbreviation	Meaning
USDA	United States Department of Agriculture
WPP	WPP

Introduction

The Tidal Segment of Tres Palacios Creek (Segment 1501; Figure 1) was identified as impaired for primary contact recreation in the 2006 edition of the *Texas Water Quality Inventory and 303(d) List* due to high levels of fecal indicator bacteria (TCEQ 2007). Since the initial listing, the segment has remained on subsequent editions of the report (now called the *Texas Water Quality Inventory and 303(d) List*). In 2015, A Total Maximum Daily Load (TMDL) project was initiated through a contract between the Texas Commission on Environmental Quality (TCEQ) and the Texas Water Resources Institute (TWRI) with the Texas Institute for Applied Environmental Research (TIAER) as a subaward recipient to TWRI. Through this project TWRI worked with TCEQ, TIAER, and numerous local stakeholders to develop a TMDL, TMDL Implementation Plan (I-Plan), and Watershed Protection Plan (WPP). The purpose of these plans was to (1) meet requirements for impaired water bodies under the Clean Water Act, (2) identify potential sources of fecal indicator bacteria to the water body, (3) identify current fecal indicator bacteria loadings and the load reductions needed to meet water quality standards, and (4) develop and identify management measures and resources required to obtain the loading reductions required for the achievement of water quality requirements. The TMDL and I-Plan for Tres Palacios Tidal were adopted by the commission in January 2018 (TCEQ 2018; TWRI 2018). Stakeholders and agencies that contributed to the development of these plans include:

- City of El Campo City Manager's Office and Public Works Departments
- Matagorda County Judge
- Matagorda County Soil and Water Conservation District (SWCD)
- Palacios Chamber of Commerce
- Texas A&M AgriLife Extension Service
- Texas Sea Grant
- TIAER
- Texas Parks and Wildlife Department (TPWD)
- Texas State Soil and Water Conservation Board (TSSWCB)
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
- Wharton County Judge
- Wharton County SWCD
- Local landowners and residents

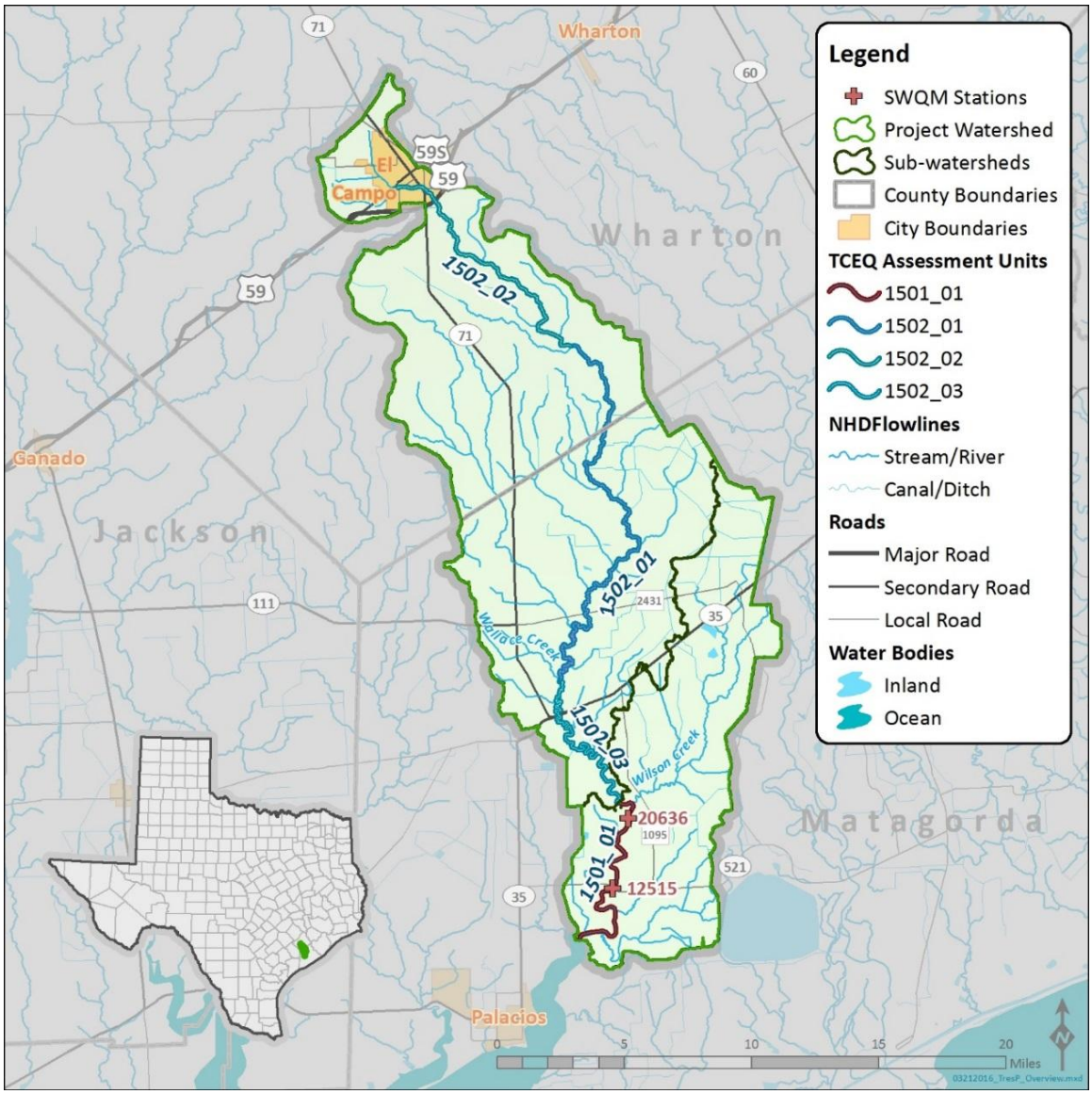

Figure 1. Overview map of the Tres Palacios Creek watershed. Figure from *Technical Support Document for Total Maximum Daily Load for Indicator Bacteria in Tres Palacios Creek Tidal* (Painter et al. 2017).

The water quality planning process for Tres Palacios Tidal identified that in order to meet water quality standards [35 colony forming units (cfu) per 100 milliliters (mL)] Enterococcus loads needed to be reduced by 3.34×10^{14} cfu per year (Schramm et al. 2017; TWRI 2018)[1]. Stakeholders identified and prioritized for implementation a set of management measures that would reduce fecal indicator bacteria loads from a range of different sources. Management measures identified as the most feasible and likely to reduce fecal indicator bacteria loading included:

[1]Different lab-based bacteria enumeration methods provide different units for counts of bacteria, primarily cfu or most probable number (MPN). This report uses cfu for consistency but considers the terms interchangeable.

1. Development and implementation of conservation plans in priority areas of the watershed
2. Removal and management of feral hogs
3. Identification, prioritization, and remediation of on-site sewage facilities (OSSFs)
4. Reduction of illicit dumping and proper disposal of animal carcasses
5. Planning and management for urban stormwater
6. Installation of urban best management practices
7. Development and implementation of pet waste programs
8. Planning and implementation of wastewater reuse
9. Infrastructure maintenance and replacement

The purpose of this report is to provide an update on implementation progress after approximately 5 years of implementation. TWRI works with TCEQ and stakeholders to collect information on implementation activities. TWRI also developed an I-Plan and WPP evaluation form distributed to stakeholders to evaluate feedback and desire for future activities.

Implementation Status

Management Measure 1: Development and Implementation of Conservation Plans

The primary goal of this management measure was to establish additional agricultural acreage under conservation practices and conservation plans. To accomplish this a combination of educational programs and additional local staff were desired to help agricultural producers develop and implement conservation plans that reduce the impact of operations on water quality. Milestones for this management measure included the development and implementation of 9 conservation practices annually (45 total), and annual extension and outreach workshops.

Table 1. Implementation of conservation plans and practices from calendar years 2018 through 2023. Note, that the reporting metric changed from conservation plans to practices and acres implemented in 2020.

Calendar Year	Status
2018	47 conservation plans created, 37 plans with implementation covering 11,317 acres
2019	38 conservations plans created (acres unreported)
2020	107 conservation practices implemented covering 9,109 acres
2021	118 conservation practices implemented covering 11,197 acres
2022	154 conservation practices implemented covering 14,315 acres
2023	41 conservation practices implemented covering 16,645 acres

Since 2018, over 430 conservation practices were implemented in watershed, totaling 62,583 acres (Table 1). The number of implemented conservation practices and acres are higher than indicated here because practices were not reported for 2018 or 2019. Further, this data does not

account for any voluntarily implemented practices that do not leverage USDA NRCS cost-share funding.

Management Measure 2: Removal and Management of Feral Hogs

The goal of this management measure was to (the extent possible) manage feral hog populations in the watershed through trapping and other means. From 2019 through 2021, the Matagorda County Extension Agent secured funding to acquire feral hog traps that could be loaned to country residents and agricultural producers. Over two years, over 10,606 feral hogs were reported removed via the trap loaner program. There is no ongoing reporting for feral hogs in the watershed, however the trap loaner program is ongoing in Matagorda County. In 2023, Wharton County secured a $20,000 Texas Feral Hog Abatement Grant that will begin to be implemented in 2024. The I-Plan had an initial goal for the reduction of the existing feral hog population by approximately 1,000 feral hogs per year.

Management Measure 3: Identification, Prioritization, and Remediation of OSSFs

There are approximately 1,490 OSSFs within the watershed and most are located on soils classified as “very-limited” for OSSF capacity and infiltration. Failure of OSSFs, especially near waterbodies, can lead to the direct loading via overland transport of fecal indicator bacteria and associated pathogens. The I-Plan set out a goal for the replacement or repair of 30 OSSFs over 5 years.

Tracking repair or replaced systems within the watershed proved difficult because the permit and reporting system was not set up to provide information. However, TWRI secured funds for an OSSF repair/replacement project through a 319 Clean Water Act grant from the TCEQ and the Environmental Protection Agency (EPA). Over the source of the project, three OSSF workshops were provided and eight OSSFs were repaired or replaced in the Tres Palacios Oaks subdivision adjacent to Tres Palacios Tidal. Seven of these systems were under 200 yards from the edge of the river and the other system was 457 yards from the river.

Management Measure 4: Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses

There were no reported activities for this management measure.

Management Measure 5: Planning and Management for Urban Stormwater

The goal of this management measure was to initiate stormwater management planning and strategies that are anticipated as part of MS4 Phase II requirements. As part of this goal, in 2020 the City of El Campo adopted an ordinance establishing methods of pollutant control for the municipal separate storm sewer system (MS4) that are in accordance with Texas Pollutant Discharge Elimination System (TPDES) permit requirements for small MS4s.

Management Measure 6: Installation of Urban Best Management Practices

The purpose of this management measure is to install the best urban management practices possible throughout the watershed. Management of potential urban sources of bacteria can be addressed with a number of different BMPs. At the time of I-Plan development, the City of El Campo prioritized development of a large stormwater detention project that ultimately was not developed due to funding and other constraints. However, TWRI and the City of El Campo collaborated to develop stormwater education and outreach materials (door hangers, mail inserts, and bookmarks) and signage. These materials were funded through a 319 grant project from TCEQ and EPA.

Management Measure 7: Development and Implementation of Pet Waste Programs

There are approximately 6,370 household pets in the Tres Palacios watershed (TWRI 2018). Runoff can transport waste and pathogens associated with pet waste to surface water bodies. Implementation of management measure 7 was intended to decrease loading associated with household pets through education and provided pet waste stations in public locations. The City of El Campo worked with TWRI to secure 319 grant funding that allowed the purchase and installation of five pet waste stations in Legacy Park.

Management Measure 8: Planning and Implementation of Wastewater Reuse

There were no reported activities for this management measure.

Management Measure 9: Infrastructure Maintenance and Replacement

There are three wastewater treatment facilities in the Tres Palacios watershed that are permitted for fecal indicator bacteria in their discharge (Painter et al. 2017). All three facilities are typically well under their permitted limit (126 cfu/100 mL *Escherichia coli*, Painter et al. 2017). Additionally, sanitary sewer overflows (SSOs) occur relatively infrequently and are considered a minor and periodic contributor to fecal indicator bacteria loading in the watershed (TWRI 2018). However, infrastructure maintenance and replacement are critical for ensuring that wastewater collection systems operate as designed and minimize the potential for periodic releases to surface waters. Through this management measure, responsible entities undertake infrastructure maintenance and replacement activities to ensure proper functioning of collection and treatment systems.

We were not able to obtain information from the Markham Municipal Utility District or the Midfield WWTF regarding infrastructure maintenance or replacement activities. The City of El Campo has been proactive in collection system inspections by conducting annual smoke testing of the sewer collection system to identify faulty connections, cross connections, and areas of inflow and infiltration that can overwhelm the collection system or cause direct discharges. Over

two miles of sanitary sewer line have been replaced in El Campo and a $1.3 million WWTF upgrade has been completed.

Education and Outreach

Water quality education and outreach programs are often part of more than one management measure, so we have summarized delivery of education and outreach programming separately (Table 2). Since 2018, ten water quality education and outreach programs have been delivered. In addition to these programs, county extension agents offer an annual CEU (continuing education unit) workshop in both Wharton and Matagorda counties that targets agricultural producers in the watershed. These all-day events typically include at least one hour on a water quality related topic relevant to agricultural producers.

Table 2. Water quality related education and outreach programs delivered in the Tres Palacios watershed.

Program	Delivery Date	Management Measure
Feral Hog Management Seminar	December 2023	2
Lone Star Healthy Streams	October 2021	1, 2
Riparian Stream and Ecosystem Program	March 2018	1, 2
Riparian Stream and Ecosystem Program	October 2024	1, 2
Texas Well Owner's Network	November 2019	3
Texas Well Owner's Network	September 2024	3
OSSF Owners Workshop	December 2018	3
OSSF Owners Workshop (2nd delivery)	December 2018	3
OSSF Owners Workshop (3rd delivery)	January 2021	3
Healthy Lawns Healthy Waters	August 2020	6

Changes in Water Quality

The *2022 Texas Surface Water Quality Standards* define the water quality criterion for primary contact recreation 1 in saltwater as a geometric mean of 35 (Enterococci) per 100 mL with a single sample criterion of 130 per 100 mL (TCEQ 2022). Since the impairment listing of Tres Palacios Tidal in the 2006 *Texas Water Quality Inventory and 303(d) List*, the reported assessment values have steadily declined from 238 cfu/100 mL in 2006 to 34 cfu/100 mL in the draft 2024 *Texas Water Quality Inventory and 303(d) List* (Table 3). Figure 2 also shows the steady decline in the 7-year rolling geometric mean for routine collected enterococcus in Tres Palacios Tidal.

Table 3. Assessment values for Tres Palacios Tidal since the initial listing in the 2006 *Texas Water Quality Inventory and 303(d) List.*

Reporting year	Assessment period	Number of samples (n)	Assessment value (cfu/100mL)
2006	December 1, 1999 - November 30, 2004	32	238
2008	December 1, 1999 - November 30, 2006	50	150
2010	December 1, 2001 - November 30, 2008	63	106
2012	December 1, 2003 - November 30, 2010	65	79
2014	December 1, 2005 - November 30, 2012	64	67
2016	December 1, 2007 - November 30, 2014	53	61
2018	December 1, 2009 - November 30, 2016	42	66
2020	December 1, 2011 - November 30, 2018	28	40
2022	December 1, 2013 - November 30, 2020	19	36
2024	December 1, 2015 - November 30, 2022	20	34

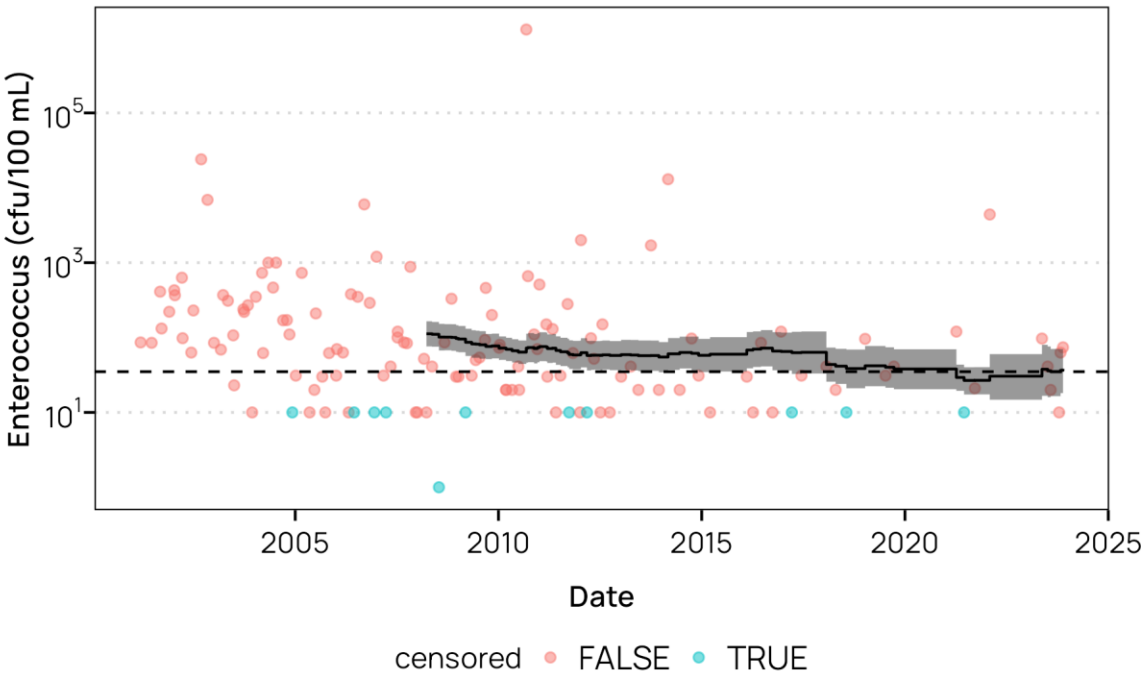

Figure 2. Enterococcus concentration over time at Tres Palacios Creek Tidal. Data points are routine samples (monitoring type code *RT*) collected at TCEQ SWQM stations 12515 and 20636. The solid line indicates the 7-year rolling geometric mean with 90% confidence intervals indicated by the shaded area. Data point color indicates if the reported laboratory value was below the detection limit (censored values).

To assess if there was a trend in average (geometric mean) enterococcus bacteria concentration (correlation between enterococcus and time in years) we computed the Akritas-Theil-Sen (ATS) slope and intercept using log-transformed data. The ATS estimator is a non-parametric approach for computing slope and intercepts of temporal data with censored data (Akritas et al. 1995; Helsel 2011). Kendall's Tau (τ) is a nonparametric correlation coefficient measure that can be applied to censored data. Specifically, τ detects monotonic (increasing or decreasing) relationships between two variables (in this case, log-transformed enterococcus and time).

The fitted trend line (Figure 3) is calculated as:

$$y = e^{199.9401} \times e^{-0.0973 \times x}$$

where y is estimated geometric mean concentration and x is the date converted to decimal year. This equates to an approximate 9.27% per year reduction in the geometric mean Enterococcus concentration (a one unit change in year equals a nine percent reduction in Enterococcus from the previous year). The correlation coefficent (τ=-0.22, p-value < 0.001) also provides strong evidence that the slope or observed monotonic decrease is significantly different than zero.

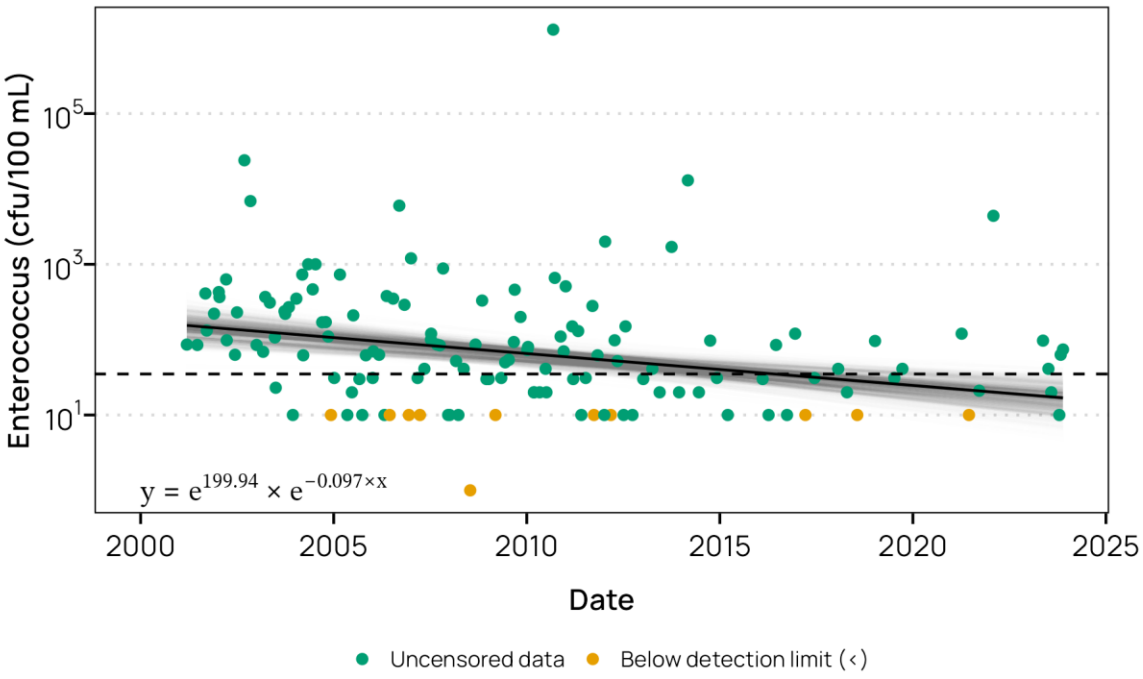

Figure 3. The Akritas-Thiel-Sen slope ($\hat{\beta}$ = -0.0973) for trend with censored data (solid black line) indicates a decrease in Enterococcus geometric means over time. Kendall's Tau (τ=-0.22, p-value < 0.001) provides strong evidence that the slope is not equal to zero.

Since there is a strong relationship between streamflow and Enterococcus concentration, it is worth exploring flow-adjusted trends. This approach first fits a smooth function between log(streamflow) and log(Enterococcus) concentration. The ATS estimated slope and intercept and τ are then calculated using the residuals of the smooth function (Helsel 2011; Helsel et al. 2020). By fitting the estimator to the smoothing function residuals, the estimator results are adjusted for variations in Enterococcus caused by changes in streamflow alone.

The streamflow adjusted trend line (Figure 4) is calculated as:

$$y = 154.5723 - 0.07693 \times x$$

where y is the residual between streamflow and Enterococcus concentration, and x is the decimal date. The slope equates to approximately a 7.4% reduction per year. This suggests that nearly 2% of the change in concentration was influenced by streamflow alone. We still have strong evidence the remaining decrease was significantly different from zero (τ=-0.16, p-value = 0.005)

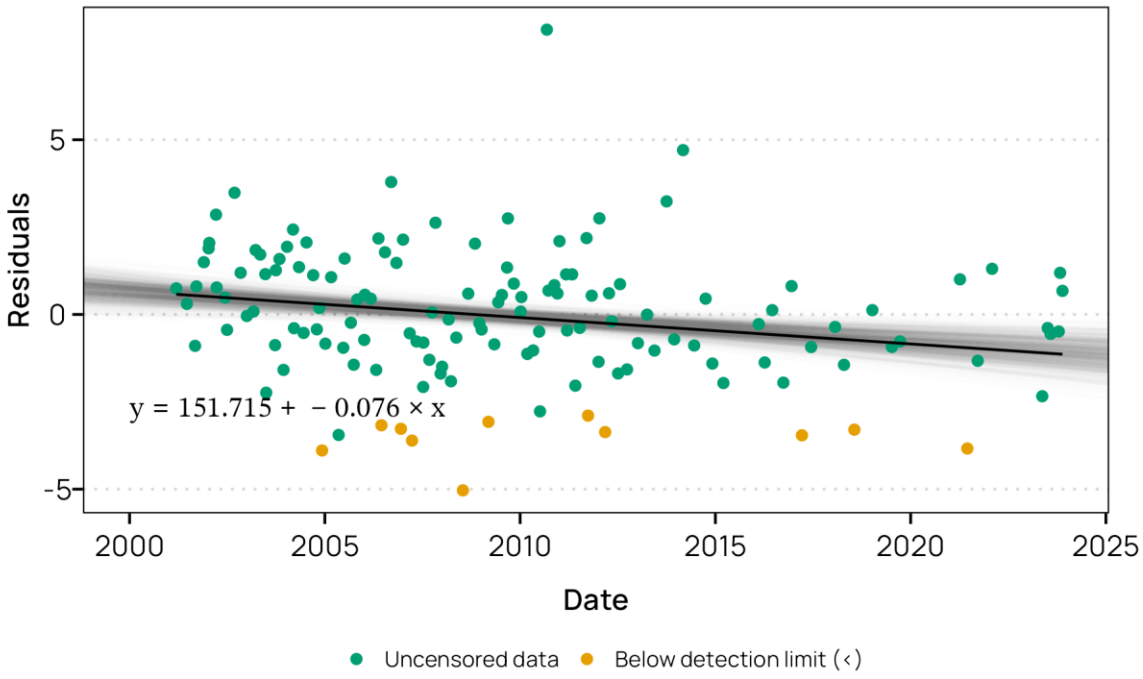

Figure 4. The flow-adjusted Akritas-Thiel-Sen slope ($\hat{\beta}$ = -0.07693) for trend with censored data (solid black line) indicates a decrease in Enterococcus geometric means over time. Kendall's Tau (τ=-0.16, p-value = 0.005) provides strong evidence that the slope is not equal to zero.

Stakeholder Questionnaire

A project evaluation was distributed to stakeholders in September 2024 to gauge perceptions of water quality, effectiveness of planning and implementation, and future planning and education need (Table 4). The evaluation was distributed and conducted using the Qualtrics platform. We received a total of 33 responses.

Table 4. Project evaluation questionnaire.

Question	Response Options
How familiar are you with water quality levels in Tres Palacios Creek?	○ Not familiar at all ○ Slightly familiar ○ Moderately familiar ○ Very familiar ○ Extremely familiar
How would you rate the current water quality in Tres Palacios Creek?	○ Terrible ○ Poor ○ Fair ○ Good ○ Excellent

Question	Response Options
Finish this sentence: "Compared to 10 years ago, the water quality in Tres Palacios Creek has ____."	○ Gotten worse ○ Stayed the same ○ Improved
How familiar are you with the watershed protection planning documents developed for Tres Palacios Creek? The watershed plan documents include a Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan) and Watershed Protection Plan adopted in 2018.	○ Not familiar at all ○ Slightly familiar ○ Moderately familiar ○ Very familiar ○ Extremely familiar
Do you feel that the watershed planning documents need to be updated?	○ Definitely yes ○ Probably yet ○ Probably not ○ Definitely not
What education and outreach topics would be most impactful for water quality improvement in the Tres Palacios Creek? Choose as many answers as you like.	○ Conservation practices for landowners ○ Feral hog management ○ Turf and garden management ○ Septic system maintenance ○ K-12 (Youth) natural resources education ○ Stormwater management (management of rainwater runoff from surfaces like rooftops, driveways, streets, etc.) ○ Something else: (Tell us below)
In the Tres Palacios Creek Watershed, how effective would the following communication channels be for delivering education and outreach materials?	○ Not at all effective ○ Slightly effective ○ Moderately effective ○ Very effective ○ Extremely effective

Perceived Water Quality

We found that respondents had generally moderate perceptions of water quality in Tres Palacios Creek. Respondents showed a wide distribution of perceived familiarity with water quality in Tres Palacios Creek (Figure 5A). Half of respondents rated current water quality as *poor* (50%, Figure 5B), while 46.2% rated water quality as *good* or *fair*. Most respondents (64%) felt water quality has *improved* or *stayed the same* compared to 10 years (Figure 5C).

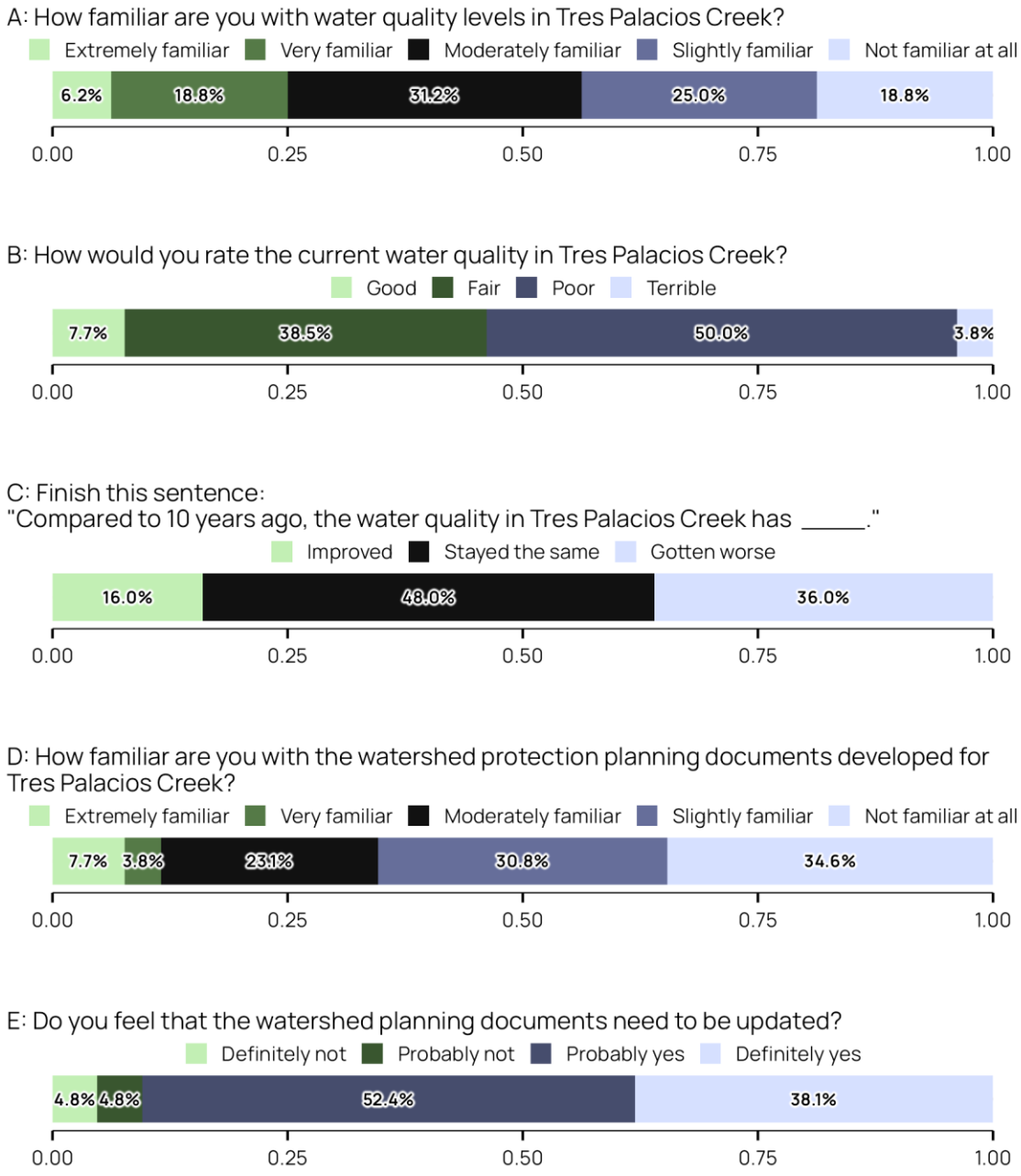

Figure 5. Distribution of responses to project evaluation questions.

Watershed Planning, Education, and Communication

Most respondents had some level of familiarity with the watershed planning documents (TMDL I-Plan or WPP) developed for Tres Palacios Creek with only 34.6% indicating they were *not familiar at all* with the documents (Figure 5D). A large majority (90.5%) indicated that there is a need to update the planning documents (Figure 5E).

Figure 6 shows the frequency that respondents chose education and outreach topics that they felt were most impactful on water quality. Over half of respondents chose septic system maintenance (54.5%) and conservation practices for landowners (51.5%). Other topics raised by respondents included issues on wastewater plant treatment, livestock grazing and feedlot practices, and pet waste management. One respondent mentioned that the waterbody is called Tres Palacios *River* instead of *Creek*. Although the TCEQ refers to the waterbody officially as Tres Palacios Creek, other sources such as the National Hydrography Database do refer to the water body as *River*. Future planning and outreach efforts should consider updating the water body name.

Figure 7 shows the distribution of perceived effectiveness of different education and outreach methods. In-person programs received the highest frequency of *"extremely"* or *"very effective"* ratings. Social media received a similar frequency of *"extremely"* or *"very effective"* ratings but also received the highest proportion of *"not at all effective"* ratings, indicating that respondents are opinionated and split on the effectiveness of social media. The remaining education and outreach methods were generally seen as *"moderately"* or "s*lightly effective*".

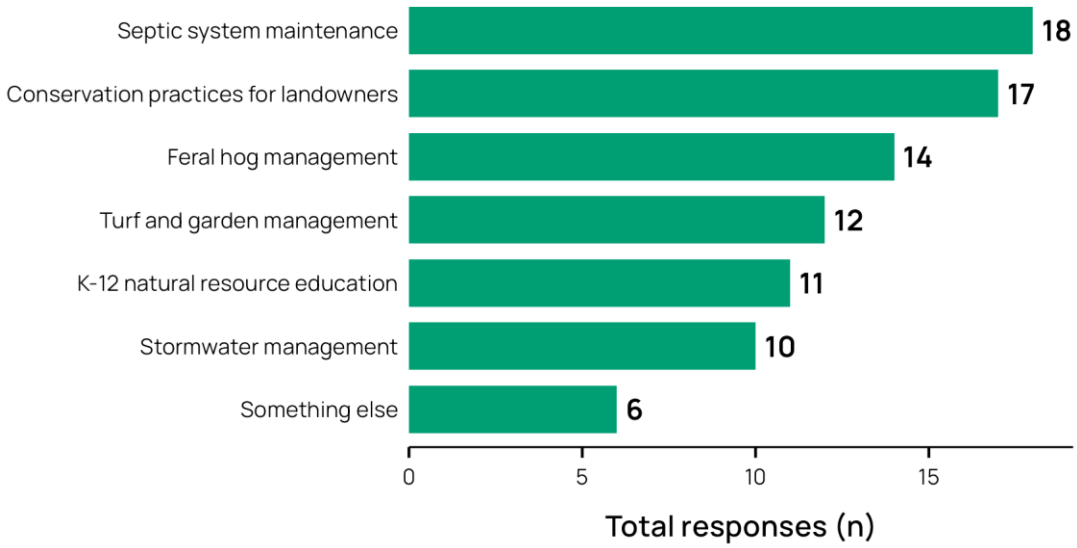

Figure 6. Frequency of responses for most impactful education and outreach topics.

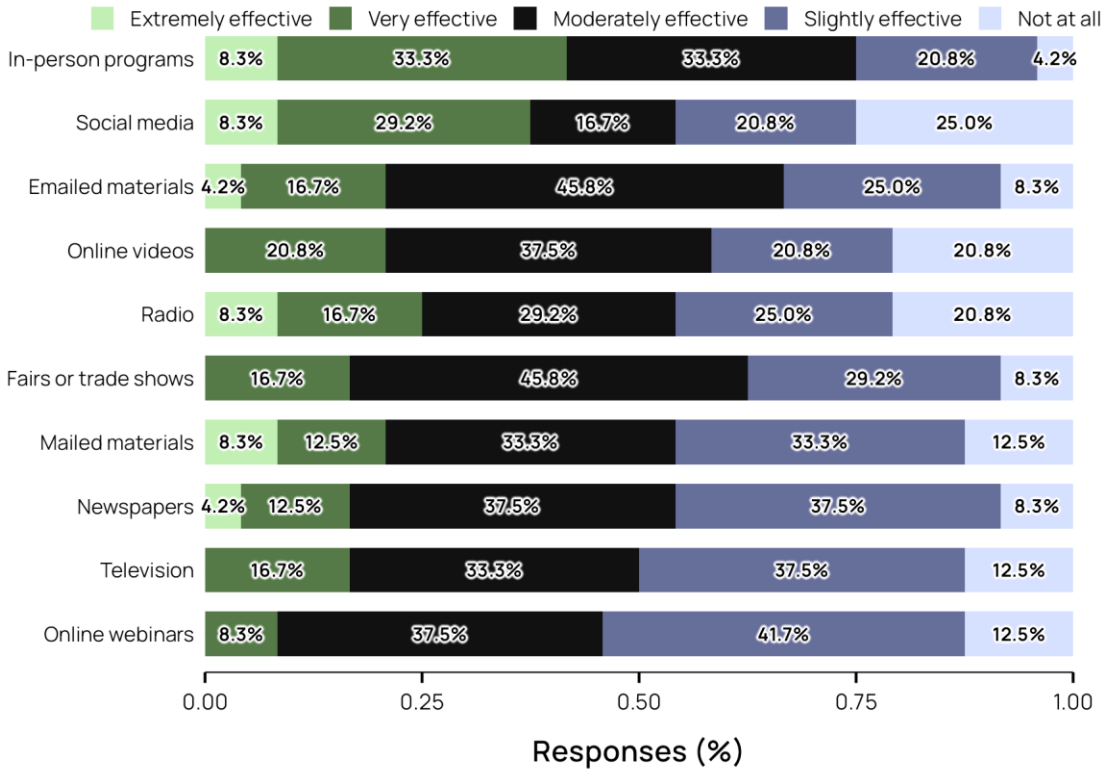

Figure 7. Perceived effectiveness of different education and outreach communication methods.

Discussion

Since the initial impairment listing in 2006, Tres Palacios has seen steady improvements in geometric mean indicator bacteria concentrations. Decreases in 7-year geometric means and statistically significant declining trends provide evidence that stakeholder efforts to reduce various sources of elevated indicator bacteria have been effective.

Substantial effort has gone into enrolling agricultural producers in conservation plans and implementing water quality protection practices across the watershed. Additionally, extensive local efforts have assisted landowners with feral hog control activities, although this effort has slowed somewhat due to changes in local staffing and priorities. Future planning may identify strategies that better sustain both removal activities and the tracking of progress indicators.

Efforts to repair and replace OSSFs in the watershed have been limited; however, one program successfully replaced failing systems near the impaired area, which likely contributed direct load

reductions to the Tres Palacios. Identifying and securing adequate local matching funds has been a significant challenge in expanding OSSF repair and replacement programs.

Progress has also been made in urbanized areas with the installation of pet waste stations, educational signage, and continued investment in wastewater infrastructure. Wastewater reuse and illicit dumping management, however, did not see any progress. Neither of these measures was expected to achieve substantial reductions in indicator bacteria loading. Wastewater reuse depended on substantial funding that was ultimately not secured by the City of El Campo. Tracking progress and enforcing reductions in illicit dumping required a responsible local party, a commitment that watershed groups have not been able to secure.

Based on stakeholder feedback, there is desire for an update in the Tres Palacios I-Plan and/or the Tres Palacios WPP. In addition, additional focus on septic system maintenance and agricultural conservation practice education and outreach materials are needed. Stakeholders generally felt in-person programs are the most effective approach for delivering education and outreach materials.

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