Mission and Aransas Rivers Implementation Plan Status Report

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Table of Contents

Table of Contents 2

Table of Figures 2

Table of Tables 3

Abbreviations 4

Introduction 5

Implementation Status 7

Management Measure 1: Develop and Implement Conservation Plans in Priority Areas of the Watershed 7

Management Measure 2: Explore Feasibility of Altering Tax Exemption Requirements for Small Acreage Landowners 8

Management Measure 3: Promote the Management of Feral Hogs and Control Their Population 9

Management Measure 4: Promote the Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses 9

Management Measure 5: Identify OSSFs, Prioritize OSSF Problem Areas, and Systematically Work to Bring Failing OSSF Systems into Compliance 9

Management Measure 6: Promote the Improved Quality and Management of Urban Stormwater 10

Management Measure 7: Coordinate Efforts to Reduce Unauthorized Discharges 10

Management Measure 8: Reduce WWTF Contributions by Meeting Half of the Permitted Bacteria Limit 11

Management Measure 9: Coordinate and Expand Existing Water Quality Monitoring in the Watershed 12

Control Action 1: Improve Monitoring of WWTF Effluent to Ensure Permit Compliance 13

Control Action 2: Improve and Upgrade WWTFs 13

Education and Outreach 13

Changes in Water Quality 14

Plan Evaluation 20

Perceived Water Quality 21

Watershed Planning, Education, and Communication 24

Discussion 24

References 24

Table of Figures

Figure 1. Overview map of the Mission and Aransas rivers watershed. 6

Figure 2. Number of reported SSO events in the watersheds from 2016 through 2020. 11

Figure 3. Annual averages (geometric means) of reported daily mean fecal indicator bacteria concentrations from WWTF discharge monitoring reports. Data was obtained from the EPA Enforcement and Compliance History Online database. 12

Figure 4. Enterococcus concentration over time at Mission River Tidal. Data points are routine samples (monitoring type code *RT*) collected at TCEQ SWQM station 12943. 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). 15

Figure 5. Enterococcus concentration over time at Aransas River Tidal. Data points are routine samples (monitoring type code *RT*) collected at TCEQ SWQM stations 12947 and 12948. 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). 16

Figure 6. The Akritas-Thiel-Sen slope (β = -0.017) for trend with censored data indicates minimal change in Enterococcus geometric means over time in Mission River Tidal. Kendall’s Tau (τ=-0.067, p-value = 0.30) indicates no evidence that slope is not equal to zero. The solid black line show the relationship between the geometric mean and date and the light grey lines are bootstrap resamples to depict the uncertainty around the geometric mean estimate. 17

Figure 7. The Akritas-Thiel-Sen slope (β = -0.0973) for trend with censored data indicates a decrease in Enterococcus geometric means over time in Aransas River Tidal. Kendall’s Tau (τ=-0.22, p-value < 0.001) provides strong evidence that the slope is not equal to zero. The solid black line show the relationship between the geometric mean and date and the light grey lines are bootstrap resamples to depict the uncertainty around the geometric mean estimate. 18

Figure 8. The flow-adjusted Akritas-Thiel-Sen slope (solid black line, β = -0.003, light grey lines are results from 1,000 bootstrap resamples to depict estimates of uncertainty) for trend with censored data indicates Enterococcus geometric means have not changed over time in Mission River Tidal. Kendall’s Tau (τ=-0.012, p-value = 0.86) does not provide evidence that the slope is significantly different than zero. 19

Figure 9. The flow-adjusted Akritas-Thiel-Sen slope (solid black line, β = -0.07, light grey lines are results from 1,000 bootstrap resamples to depict estimates of uncertainty) for trend with censored data (solid black line) indicates a decrease in Enterococcus geometric means over time in Aransas River Tidal. Kendall’s Tau (τ=-0.16, p-value = 0.004) provides strong evidence that the slope is significantly different than zero. 20

Figure 10. Distribution of responses to project evaluation questions. 22

Figure 11. Response rates for most impactful education and outreach topics. 23

Figure 12. Perceived effectiveness of different education and outreach communication methods. 23

Table of Tables

Table 1. Implementation of conservation plans and practices in the Mission River watershed from calendar years 2018 through 2023. Note, that the reporting metric changed from conservation plans to practices and acres implemented in 2020. 8

Table 2. Implementation of conservation plans and practices in the Aransas River watershed from calendar years 2018 through 2023. Note, that the reporting metric changed from conservation plans to practices and acres implemented in 2020. 8

Table 3. Water quality related education and outreach programs delivered in the Mission and Aransas watershed. 13
Table 4. Assessment values for Mission River Tidal since the initial listing in the 2006*Texas Water Quality Inventory and 303(d) List.* 14
Table 5. Assessment values for Aransas River Tidal since the initial listing in the 2006*Texas Water Quality Inventory and 303(d) List.* 14
Table 6. Project evaluation questionnaire. 21

Abbreviations

Abbreviation	**Meaning**
ATS	Akritas-Theil-Sen
AU	Assessment Unit
CEU	Continuing Education Unit
cfu	cfu
EPA	Environmental Protection Agency
H-GAC	Houston-Galveston Area Council
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
SSO	sanitary sewer overflow
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	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
USDA	United States Department of Agriculture
WWTF	Wastewater Treatment Facility

Introduction

The Tidal Segments of the Mission River (Segment 2001) and Aransas River (Segment 2003; Figure 1) were identified as impaired for primary contact recreation in the 2004 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 segments have remained on subsequent editions of the report (now called the *Texas Water Quality Inventory and 303(d) List*). In 2013, 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 and TMDL Implementation Plan (I-Plan). The purpose of the TMDL and I-Plan were 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 the tidal segments of the Mission and Aransas rivers were adopted by the commission in May 2016 (TCEQ 2016a; TCEQ 2016b). Additional indicator bacteria TMDLs were developed for the Aransas River Above Tidal (Assessment Unit [AU] 2004_02) and Poesta Creek (AU 2004B_02) in the Aransas River watershed in 2017 (Schramm 2017) and for Poesta Creek (AU 2004B_01) in 2023 (Jain and Schramm 2023). Stakeholders and agencies that contributed to the development of these plans include:

- Texas A&M AgriLife Extension
- Texas A&M AgriLife Research
- Texas Parks and Wildlife Department
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
- Texas State Soil and Water Conservation Board (TSSWCB)
- Bee Soil and Water Conservation District #344
- Goliad Soil and Water Conservation District # 352
- San Patricio Soil and Water Conservation District # 324
- Copano Bay Soil and Water Conservation District #329
- Coastal Bend Bays and Estuaries Program
- Nueces River Authority

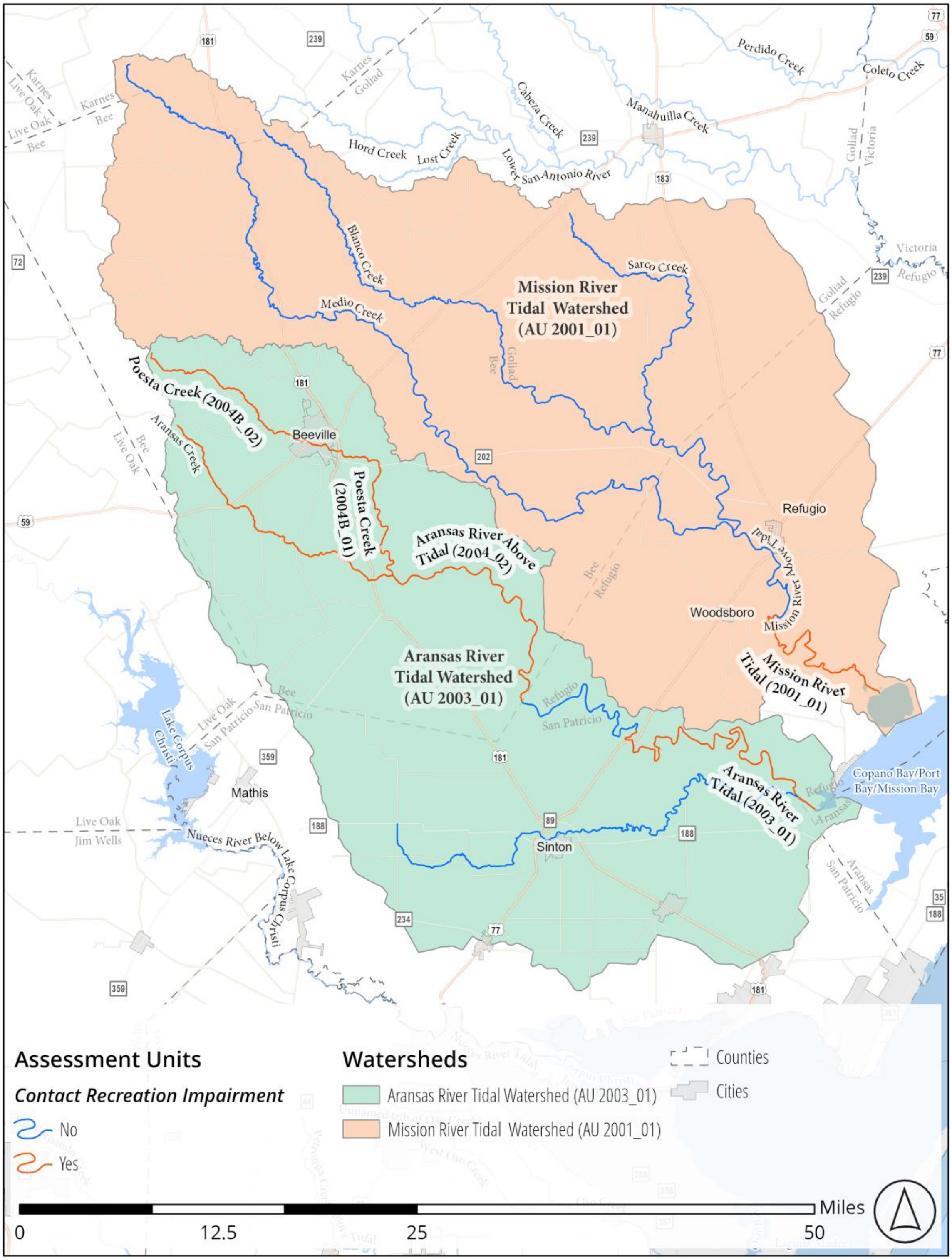

Figure 1. Overview map of the Mission and Aransas rivers watershed.

The TMDL identified that the Mission River required a 91% reduction in Enterococcus under high flow conditions, 48% reduction under mid-range flows, and a 27% reduction under low flows in order to meet water quality standards (35 colony forming units [cfu] per 100 milliliters [mL] Enterococcus, Painter et al. 2013). The Aransas River required a 98% reduction under high flow conditions, a 1% reduction under mid-range flows, and 0% reduction under low flows (Painter et al. 2013) [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. Develop and Implement Conservation Plans in Priority Areas of the Watershed
2. Explore Feasibility of Altering Tax Exemption Requirements for Small Acreage Landowners
3. Promote the Management of Feral Hogs and Control Their Populations
4. Promote the Reduction of Illicit Dumping and Proper Disposal of Animal Carcasses
5. Identify On-Site Sewage Facilities (OSSFs), Prioritize OSSF Problem Areas, and Systematically Work to Bring Failing OSSF Systems into Compliance
6. Promote the Improved Quality and Management of Urban Stormwater
7. Coordinate Efforts to Reduce Unauthorized Discharges
8. Reduce Wastewater Treatment Facility (WWTF) Contributions by Meeting Half of the Permitted Bacteria Limit
9. Coordinate and Expand Existing Water Quality Monitoring in the Watershed

The I-Plan also included two control actions:

1. Improve Monitoring of WWTF Effluent to Ensure Permit Compliance
2. Improve and Upgrade WWTFs

The purpose of this report is to provide an update on implementation progress after approximately 8 years of implementation. TWRI works with TCEQ and stakeholders to collect information on implementation activities. TWRI also developed an I-Plan evaluation form distributed to stakeholders to evaluate feedback and desire for future activities.

Implementation Status

Management Measure 1: Develop and Implement Conservation Plans in Priority Areas of the Watershed

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:

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[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.

- 64 additional conservation plans in the Aransas River watershed over 5 years
- 49 additional conservation plans in the Mission River watershed over 5 years
- 6 education and outreach programs promoting best management practices

Since 2018, over 292 conservation practices were implemented in Mission River watershed, totaling 118,782 acres (Table 1). 385 conservation practices were implemented in the Aransas River watershed, totaling 38,130 acres (Table 2). 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.

Table 1. Implementation of conservation plans and practices in the Mission River watershed 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	81 conservation plans
2019	54 conservation plans
2020	143 conservation practices implemented covering 92,289 acres
2021	77 conservation practices implemented covering 15,683 acres
2022	40 conservation practices implemented covering 5,641 acres
2023	32 conservation practices implemented covering 5,169 acres

Table 2. Implementation of conservation plans and practices in the Aransas River watershed 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	122 conservation plans
2019	53 conservation plans
2020	185 conservation practices implemented covering 14,259 acres
2021	133 conservation practices implemented covering 15,683 acres
2022	23 conservation practices implemented covering 2,219 acres
2023	44 conservation practices implemented covering 5,970 acres

Management Measure 2: Explore Feasibility of Altering Tax Exemption Requirements for Small Acreage Landowners

The purpose of Management Measure 2 was to reduce livestock overstocking on small acreage land parcels by altering property tax exemption requirements. Small acreage landowners that apply for agricultural tax exemptions must stock their land to meet the tax requirement, often at a stocking rate above the land's carrying capacity. An alternative to the agricultural exemption is the wildlife tax valuation that allows landowners to minimize tax burden by through wildlife management practices instead of traditional agricultural practices. Components of this management measure include working with local taxing authorities to discuss alternative tax exemptions and proposals for changes to components such as stocking rate requirements. Stakeholders have not reported any progress on this management measure. However, components of some education and outreach programs delivered in the watershed discuss the wildlife tax valuation process with landowners (see the Education and Outreach section).

Management Measure 3: Promote the Management of Feral Hogs and Control Their Population

The goal of this management measure was to (the extent possible) manage feral hog populations in the watersheds through trapping and other means. The I-Plan had an initial goal for the reduction of the removal of 5,960 feral hogs from the Mission River watershed and 4,785 feral hogs from the Aransas River watershed over 5 years.

Tracking feral hog removal has been difficult, attempts such as the Feral Hog Tracker mobile and web app have been discontinued. The Goliad County Wildlife Management Association implemented a feral hog trap loaner program and reported that over 1,200 feral hogs were removed with the program in calendar year 2021. NRCS, TSSWCB, USDA Animal and Plant Health and Inspection Service, and the Texas A&M AgriLife Natural Resources Institute began a pilot Feral Swine Control Project in Bee and San Patricio counties. The purpose of the project is to provide landowners with access to smart traps, directed control activities, and education and outreach.

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

Management Measure 4 intended to target illicit waste disposal from portable housing and recreational vehicles, trash and other household waste dumped at bridge crossings, and improper animal carcasses disposal by hunters. The goal was to develop grant proposals to fund educational programs, enforcement and other strategies to reduce illicit dumping. To date, no external funds have been leveraged for this management measure. Goliad County has begun holding two annual household waste collection events to help reduce illicit dumping.

Management Measure 5: Identify OSSFs, Prioritize OSSF Problem Areas, and Systematically Work to Bring Failing OSSF Systems into Compliance

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 57 OSSFs in the Mission River watershed over 5 years and 365 OSSFs in the Aransas River watershed over 5 years. There was a goal to develop and submit proposals to fund OSSF assistance/incentive and/or education programs as well as a tracking system for OSSFs. Stakeholders have not reported any progress on this management measure.

Management Measure 6: Promote the Improved Quality and Management of Urban Stormwater

In the Mission River and Aransas River watersheds, there are no large Phase I or small Phase II Municipal Separate Storm Sewer System (MS4) stormwater permits; therefore, urban stormwater is not regulated in the TMDL watersheds. The long-term goal of this management measure is to decrease nonpoint source pollution from stormwater runoff in urban areas in the TMDL watersheds, through the adoption of structural and non-structural urban BMPs and to raise awareness among local residents about how urban stormwater impacts local water quality. The milestones for this management measure include securing funds for stormwater education, development of comprehensive stormwater assessments, delivery of education and planning activities, and urban stormwater BMP installation. TWRI and H-GAC collaborated on a project funded by 319 funds to expand delivery of H-GAC's Coastal Communities education resources to area cities. The Meadows Center and Texas General Land Office have also developed the Clean Coast Texas Collaborative project designed to provide coastal communities throughout the entire Texas coastal zone with technical resources on nonpoint source best practices (https://cleancoast.texas.gov/).

Management Measure 7: Coordinate Efforts to Reduce Unauthorized Discharges

The purpose of this management measure is to reduce and prevent unauthorized discharges of wastewater from treatment facilities and collection systems through service, management, repair, and replacement of infrastructure. To facilitate the accomplishment of this management measure, Certificates of Convenience & Necessity permit holders intended to track unauthorized discharges through GIS database development and develop annual plans for prioritizing system improvements and repairs. Stakeholders have not reported any progress on this management measures. Based on the limited data available, there are no major changes in the number of sanitary sewer overflow (SSO) discharges occurring in the watershed (Figure 2).

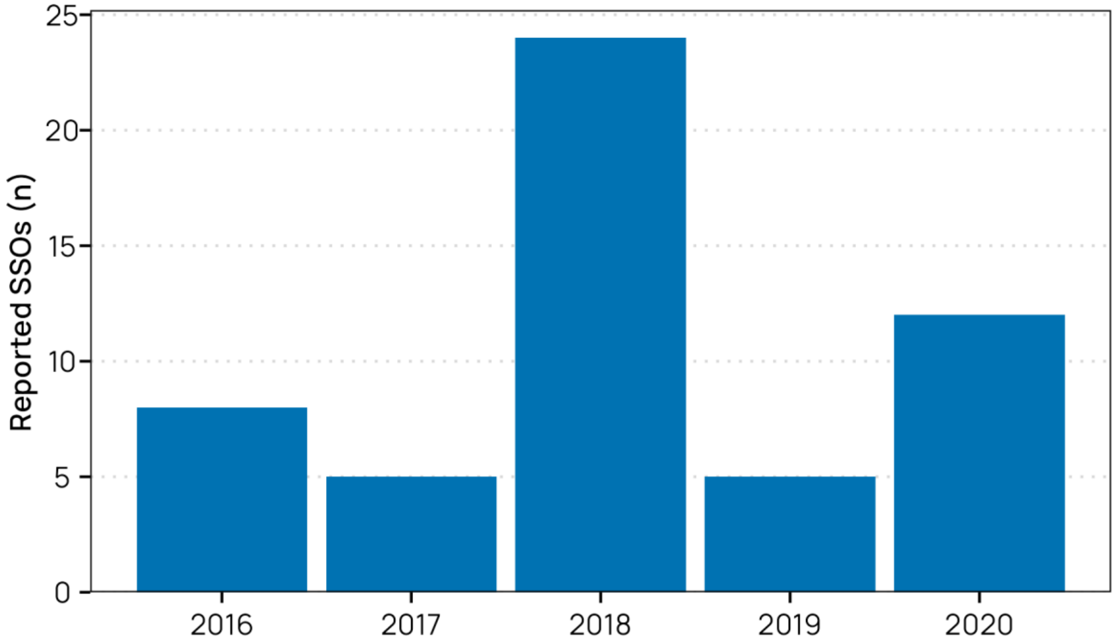

Figure 2. Number of reported SSO events in the watersheds from 2016 through 2020.

Management Measure 8: Reduce WWTF Contributions by Meeting Half of the Permitted Bacteria Limit

In order to minimize WWTF contributions to bacteria loadings, participating WWTFs voluntarily adopted target discharge bacteria concentrations at half the typically permitted indicator bacteria discharge limit (126 MPN/100 mL for *E. coli* and 35 MPN/100 mL for Enterococcus). For the twelve WWTFs in the watershed, the annual averages for daily mean fecal indicator bacteria concentration generally remain well below the 126 cfu/100 mL limit for *E. coli* and 35 cfu/100 mL limit for Enterococcus (Figure 3). The St. Paul WSC WWTF had routine exceedances of *E. coli* from 2014 through 2016 that have been resolved. More recently the City of Sinton Main WWTF reported exceedances of Enterococci concentrations from 2021 through 2023. For the remaining WWTFs, discharge concentrations are typically near or below 10 cfu/100 mL *E. coli* or 5 cfu/100 mL Enterococcus.

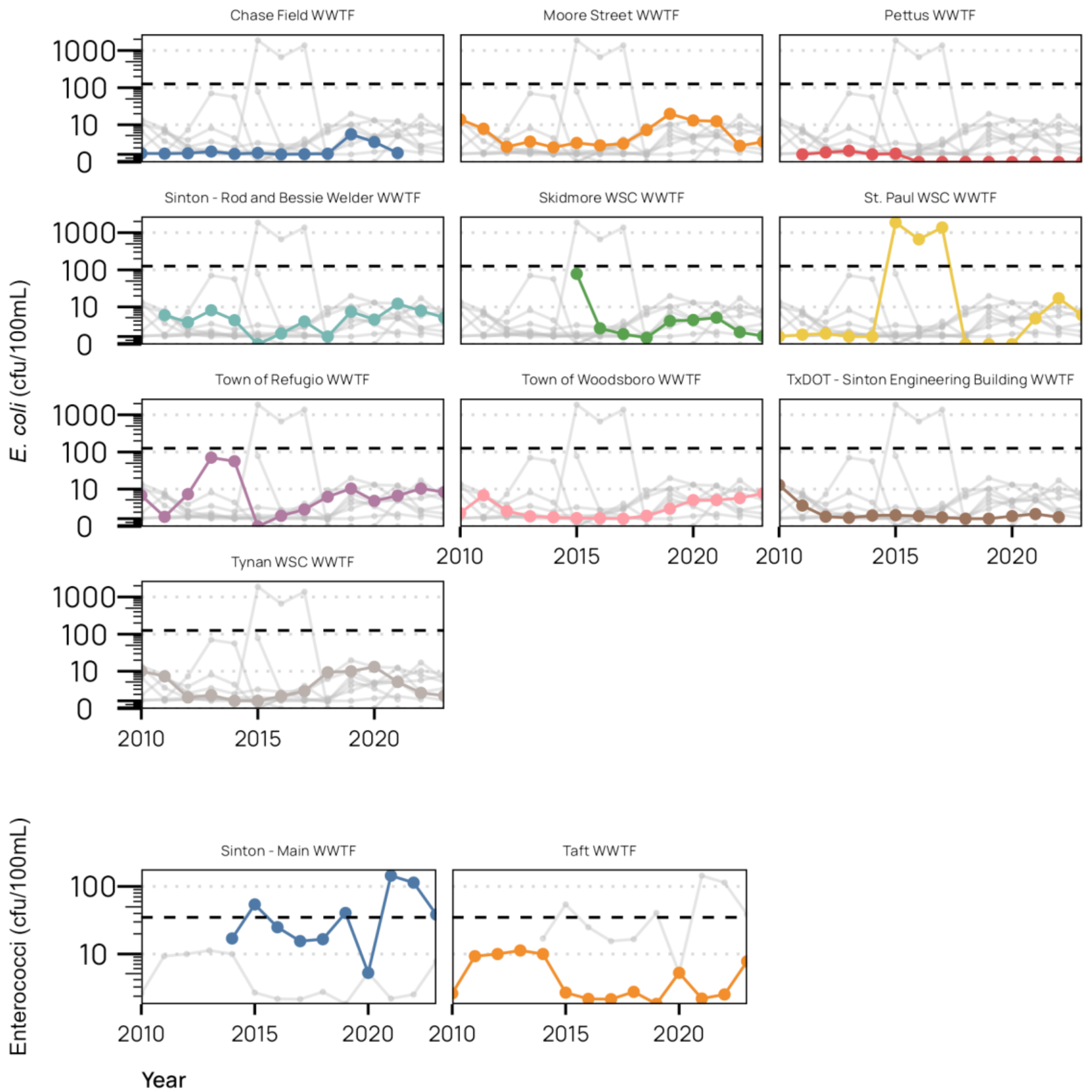

Figure 3. Annual averages (geometric means) of reported daily mean fecal indicator bacteria concentrations from WWTF discharge monitoring reports. Data was obtained from the EPA Enforcement and Compliance History Online database.

Management Measure 9: Coordinate and Expand Existing Water Quality Monitoring in the Watershed

One of the primary goals of the stakeholder group was the expansion of water quality monitoring throughout the watershed. When TMDL stakeholder meetings first began, quarterly monitoring at the tidal segments of each river were the only data points available. Nueces River Authority is the Clean Rivers Program Partner for the watershed and has expanded quarterly routine monitoring to upstream segments. TWRI received funding in 2018 to conduct monthly monitoring at two additional sites on Aransas River Tidal and one site on Mission River Tidal in addition to the existing quarterly monitoring conducted by Nueces River Authority. This supplemental monitoring is ongoing through funds provided by TCEQ's TMDL program.

Control Action 1: Improve Monitoring of WWTF Effluent to Ensure Permit Compliance

At the time of TMDL development 10 of the 12 WWTFs in the watershed had monitoring requirements for fecal indicator bacteria in their wastewater permits. The purpose of this control action was the inclusion of monitoring requirements for all permitted WWTFs in the watershed. Currently, all WWTFs in the watershed have monitoring provisions included in their TPDES wastewater permit.

Control Action 2: Improve and Upgrade WWTFs

The purpose of this management measure is to update WWTFs that are not currently treating their effluent to the lowest bacteria levels possible, so that bacteria treatment is optimized for each facility, as appropriate. Further, those WWTFs in the TMDL watersheds that currently treat bacteria to acceptable levels may need to improve/upgrade their treatment process to accommodate population growth and to more efficiently treat effluent and reduce periodic exceedances.

In 2021, the City of Beeville approved a $7.5 million bond to fund renovations and expansions on the Moore Street and Chase Field WWTFs. Construction activities began in May 2021 and anticipated to be completed in 2024. No other updates have been provided by stakeholders.

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 3). Since 2018, nine 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 each county 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 3. Water quality related education and outreach programs delivered in the Mission and Aransas watershed.

Program	Delivery Date	Management Measure
Texas Wildlife Association Small Acreage Workshop	2021 (three workshops)	1, 2
TWRI Riparian Education Workshop	2018	1, 3
AgriLife Extension Texas Watershed Stewards	2018	General watershed education
Texas Well Owners Network	2018, 2019	5
Lone Star Healthy Streams	2019	1, 3
Livestock management education mailers	2023	1

Changes in Water Quality

Table 4. Assessment values for Mission River 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	20	98
2008	December 1, 1999 - November 30, 2006	28	67
2010	December 1, 2001 - November 30, 2008	28	68
2012	December 1, 2003 - November 30, 2010	28	67
2014	December 1, 2005 - November 30, 2012	28	71
2016	December 1, 2007 - November 30, 2014	29	69
2018	December 1, 2009 - November 30, 2016	28	74
2020	December 1, 2011 - November 30, 2018	28	42
2022	December 1, 2013 - November 30, 2020	28	58
2024	December 1, 2015 - November 30, 2022	34	92

Table 5. Assessment values for Aransas River 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	15	182
2008	December 1, 1999 - November 30, 2006	23	115
2010	December 1, 2001 - November 30, 2008	28	66
2012	December 1, 2003 - November 30, 2010	46	60
2014	December 1, 2005 - November 30, 2012	49	64
2016	December 1, 2007 - November 30, 2014	61	91
2018	December 1, 2009 - November 30, 2016	49	84
2020	December 1, 2011 - November 30, 2018	29	45
2022	December 1, 2013 - November 30, 2020	36	50
2024	December 1, 2015 - November 30, 2022	48	69

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 Mission River Tidal and Aransas River Tidal in the 2004 *Texas Water Quality Inventory and 303(d) List*, the reported assessment values show substantial fluctuation (Table 4; 5). Figures 4 and 5 also show the fluctuations in the 7-year rolling geometric mean for routine enterococcus samples collected in in Mission River Tidal and Aransas River Tidal.

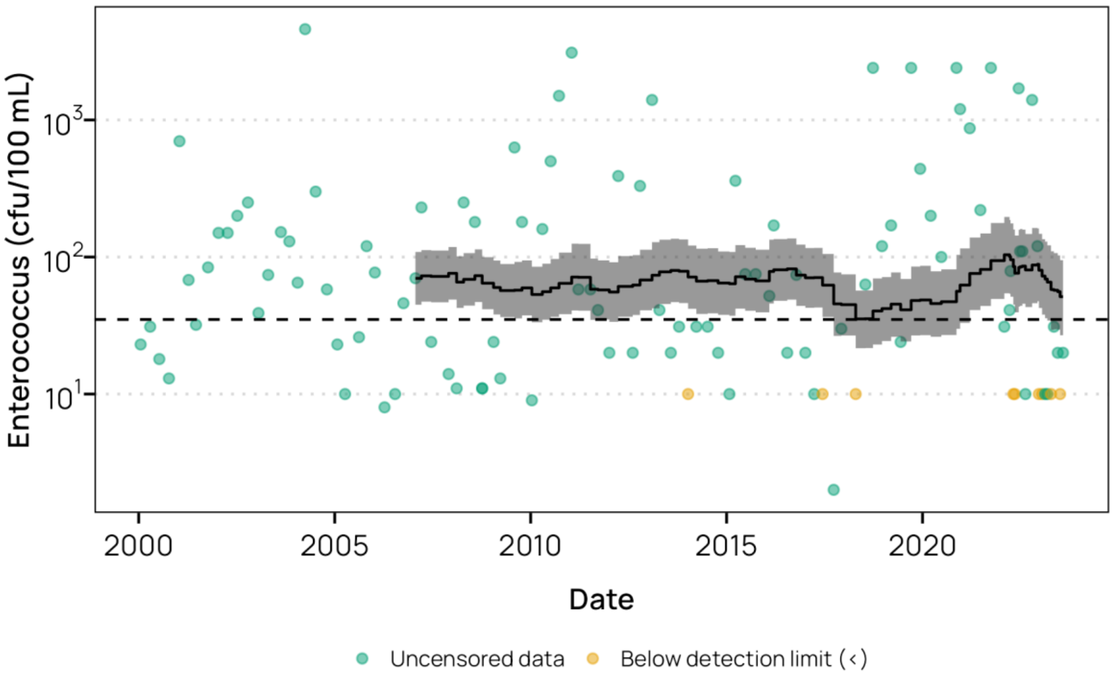

Figure 4. Enterococcus concentration over time at Mission River Tidal. Data points are routine samples (monitoring type code *RT*) collected at TCEQ SWQM station 12943. The solid line indicates the 7-year rolling geometric mean with 90% confidence intervals indicated by the shaded area. Data point color indicates if the reported laboratory value was below the detection limit (censored values).

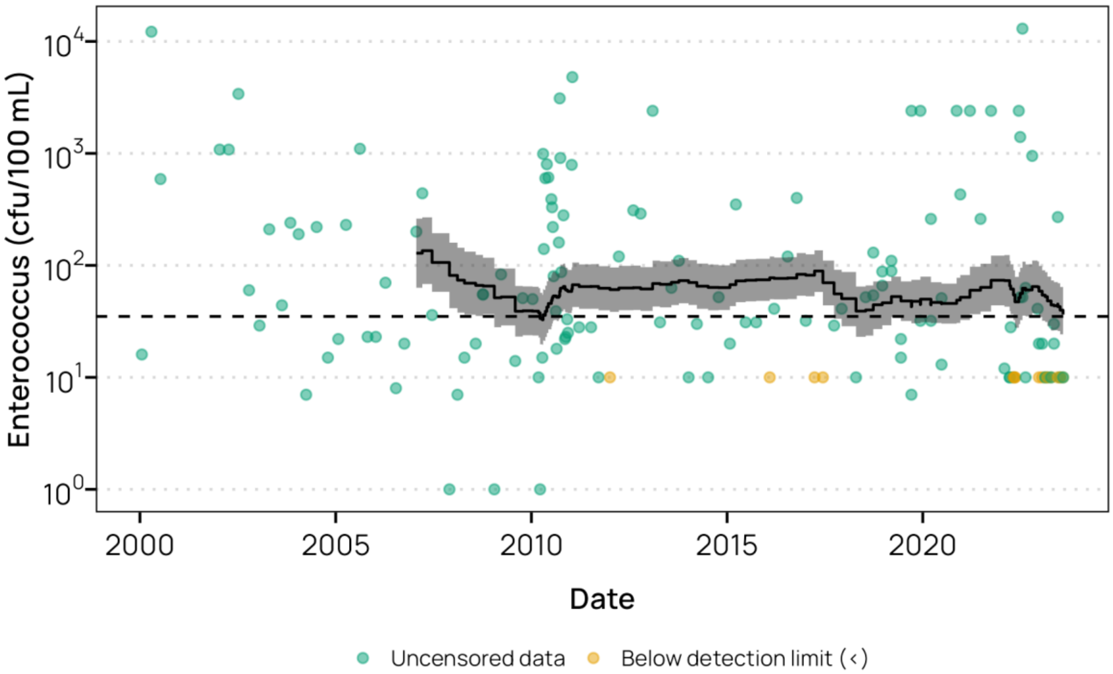

Figure 5. Enterococcus concentration over time at Aransas River Tidal. Data points are routine samples (monitoring type code *RT*) collected at TCEQ SWQM stations 12947 and 12948. The solid line indicates the 7-year rolling geometric mean with 90% confidence intervals indicated by the shaded area. Data 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).

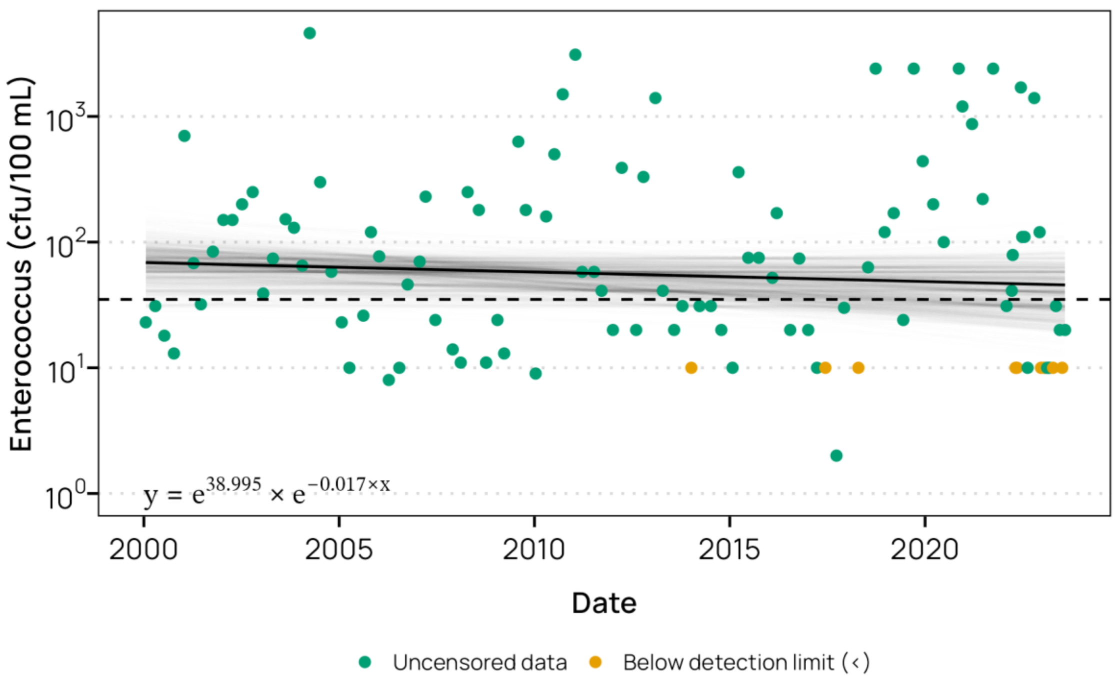

Figure 6. The Akritas-Thiel-Sen slope ($\hat{\beta}$ = -0.017) for trend with censored data indicates minimal change in Enterococcus geometric means over time in Mission River Tidal. Kendall's Tau (τ=-0.067, p-value = 0.30) indicates no evidence that slope is not equal to zero. The solid black line show the relationship between the geometric mean and date and the light grey lines are bootstrap resamples to depict the uncertainty around the geometric mean estimate.

For Mission River Tidal, the fitted trend line (Figure 6) is calculated as:

$$y = e^{38.995} \times e^{-0.017 \times x}$$

where y is estimated geometric mean concentration and x is the date converted to decimal year. This equates to an approximate 1.69% per year reduction in the geometric mean Enterococcus concentration (a one-unit change in year equals a 1.69 percent reduction in Enterococcus from the previous year). The correlation coefficient (τ=-0.067, p-value = 0.30) indicates we don't have evidence that the slope or observed monotonic decrease is significantly different than zero.

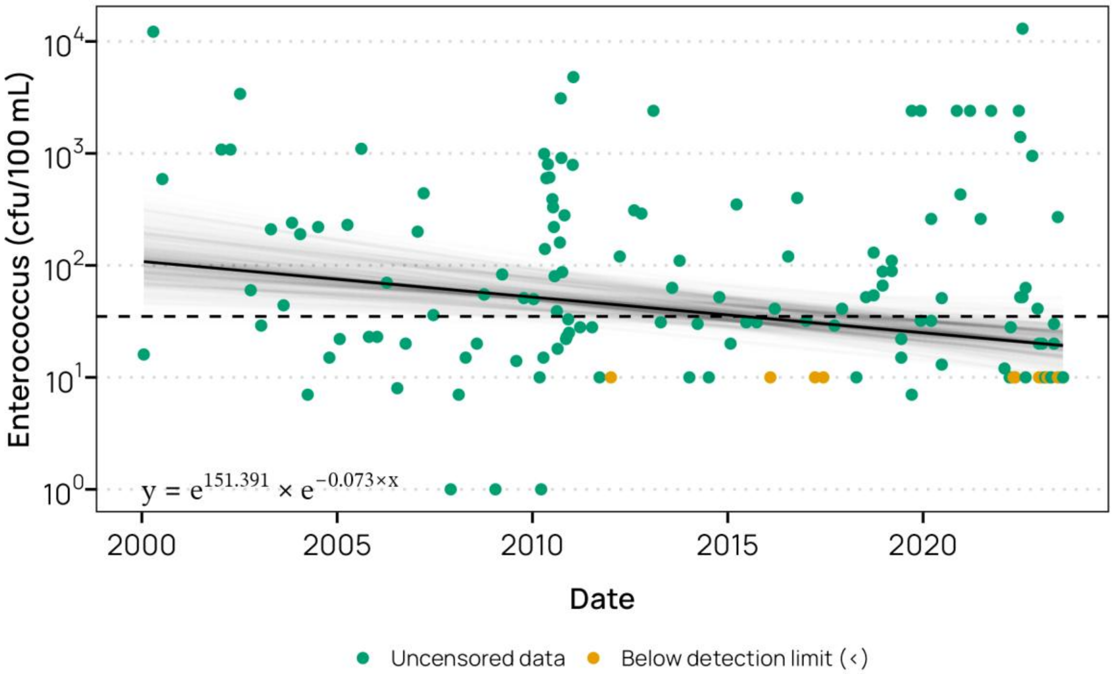

Figure 7. The Akritas-Thiel-Sen slope ($\hat{\beta}$ = -0.0973) for trend with censored data indicates a decrease in Enterococcus geometric means over time in Aransas River Tidal. Kendall's Tau (τ=-0.22, p-value < 0.001) provides strong evidence that the slope is not equal to zero. The solid black line show the relationship between the geometric mean and date and the light grey lines are bootstrap resamples to depict the uncertainty around the geometric mean estimate.

For Aransas River Tidal, the fitted trend line (Figure 7) is calculated as:

$$y = e^{151.391} \times e^{-0.073 \times x}$$

This equates to an approximate 7.04% per year reduction in the geometric mean Enterococcus concentration (a one-unit change in year equals a seven percent reduction in Enterococcus from the previous year). The correlation coefficient (τ=-0.174, p-value = 0.002) provides strong evidence that the slope or observed monotonic decrease is significantly different than 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.

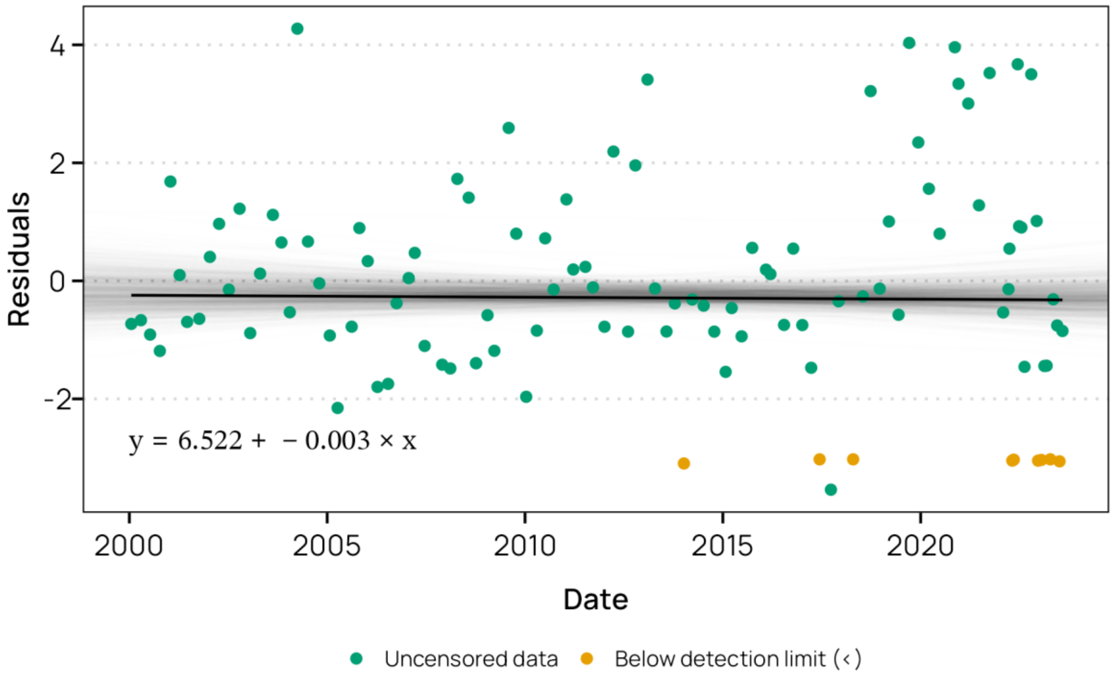

Figure 8. The flow-adjusted Akritas-Thiel-Sen slope (solid black line, $\hat{\beta}$ = -0.003, light grey lines are results from 1,000 bootstrap resamples to depict estimates of uncertainty) for trend with censored data indicates Enterococcus geometric means have not changed over time in Mission River Tidal. Kendall's Tau (τ=-0.012, p-value = 0.86) does not provide evidence that the slope is significantly different than zero.

The streamflow adjusted trend line for Mission River Tidal (Figure 8) is calculated as:

$$y = 6.522 - 0.003 \times x$$

where y is the residual between streamflow and Enterococcus concentration, and x is the decimal date. The slope equates to approximately a 0.29% reduction per year and there is not strong evidence the the change in bacteria concentration was significantly different from zero (τ=-0.012, p-value = 0.86)

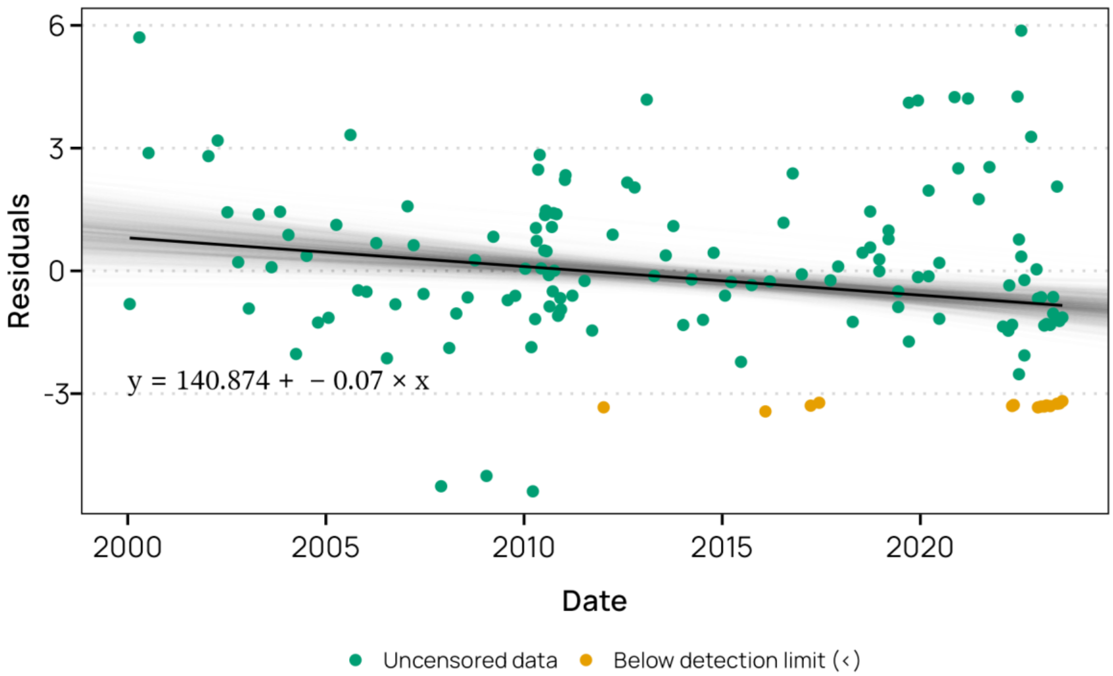

Figure 9. The flow-adjusted Akritas-Thiel-Sen slope (solid black line, $\hat{\beta}$ = -0.07, light grey lines are results from 1,000 bootstrap resamples to depict estimates of uncertainty) for trend with censored data (solid black line) indicates a decrease in Enterococcus geometric means over time in Aransas River Tidal. Kendall's Tau (τ=-0.16, p-value = 0.004) provides strong evidence that the slope is significantly different than zero.

The streamflow adjusted trend line for Aransas River Tidal (Figure 9) is calculated as:

$$y = 140.87 - 0.07 \times x$$

which equates to approximately 6.7% reduction in flow-adjusted Enterococcus per year, suggesting only 0.34% of the overall change in bacteria is influenced by changes in flow. The correlation coefficient (τ=-0.16, p-value = 0.004) provides strong evidence that the observed trend is significantly different than zero.

Plan Evaluation

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 6). The evaluation was distributed and conducted using the Qualtrics platform. We received a total of 7 responses.

Table 6. Project evaluation questionnaire.

Question	Response Options
How familiar are you with water quality levels in the Mission and Aransas Rivers and their tributaries?	○ Not familiar at all ○ Slightly familiar ○ Moderately familiar ○ Very familiar ○ Extremely familiar
How would you rate the current water quality in the Mission and Aransas Rivers and their tributaries?	○ Terrible ○ Poor ○ Fair ○ Good ○ Excellent
Finish this sentence: "Compared to 10 years ago, the water quality in the Mission and Aransas Rivers and their tributaries has ____."	○ Gotten worse ○ Stayed the same ○ Improved
How familiar are you with the watershed protection planning documents developed for the Mission and Aransas Rivers and their tributaries? The watershed plan documents include a Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan) adopted in 2016 and Watershed Protection Plan adopted in 2021.	○ 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 Mission and Aransas Rivers and their tributaries? 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 Mission and Aransas Rivers Watersheds, 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

The majority of our respondents were at least moderately familiar with the water quality in the Mission and Aransas Rivers watersheds (Figure 10A). Most respondents also indicated that water quality was at least *"fair"* or *"good"* (Figure 10B). Three quarters of the respondents felt that water quality has remained the same in the project watersheds over the last 10 years (Figure 10C).

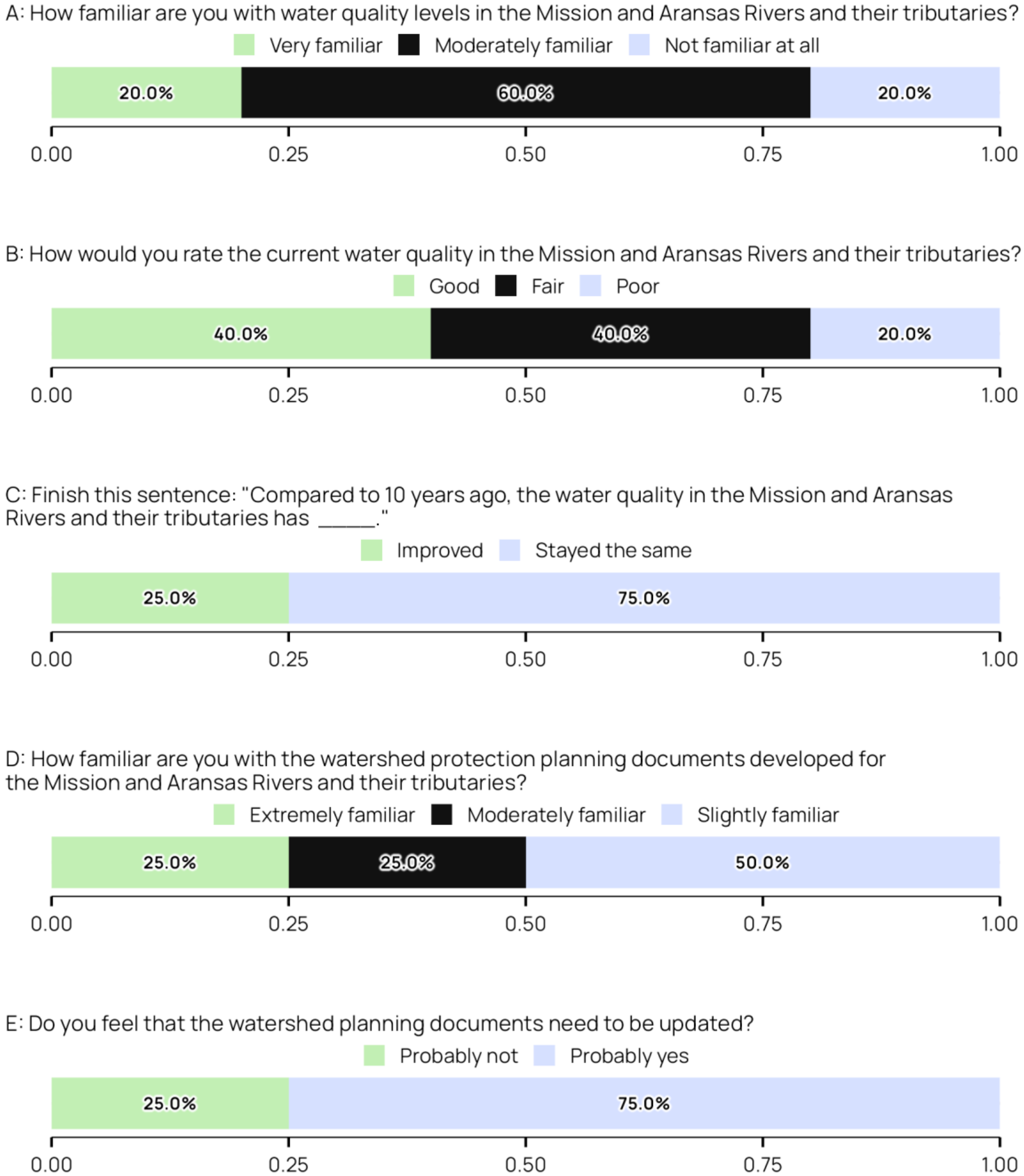

Figure 10. Distribution of responses to project evaluation questions.

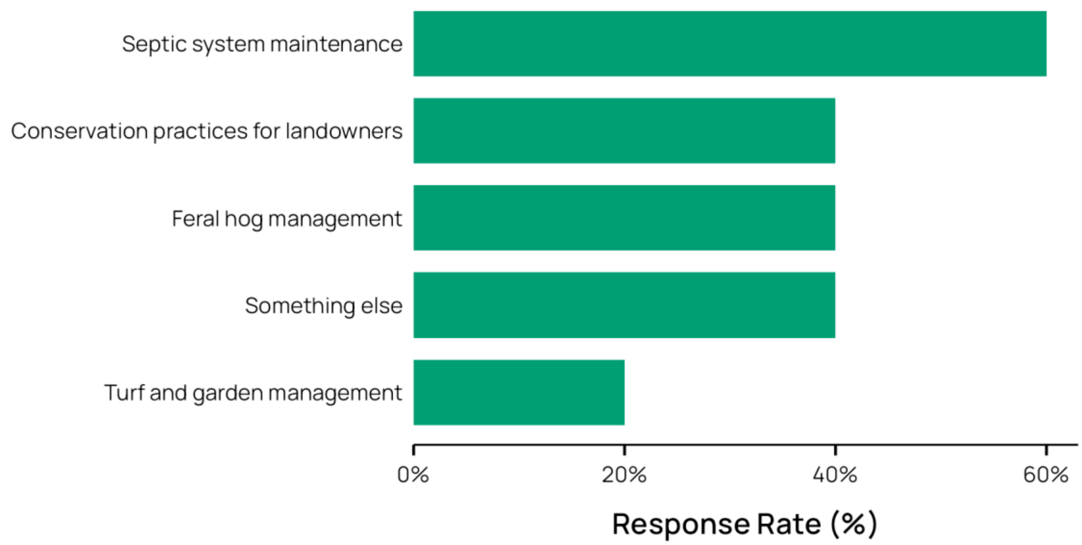

Figure 11. Response rates for most impactful education and outreach topics.

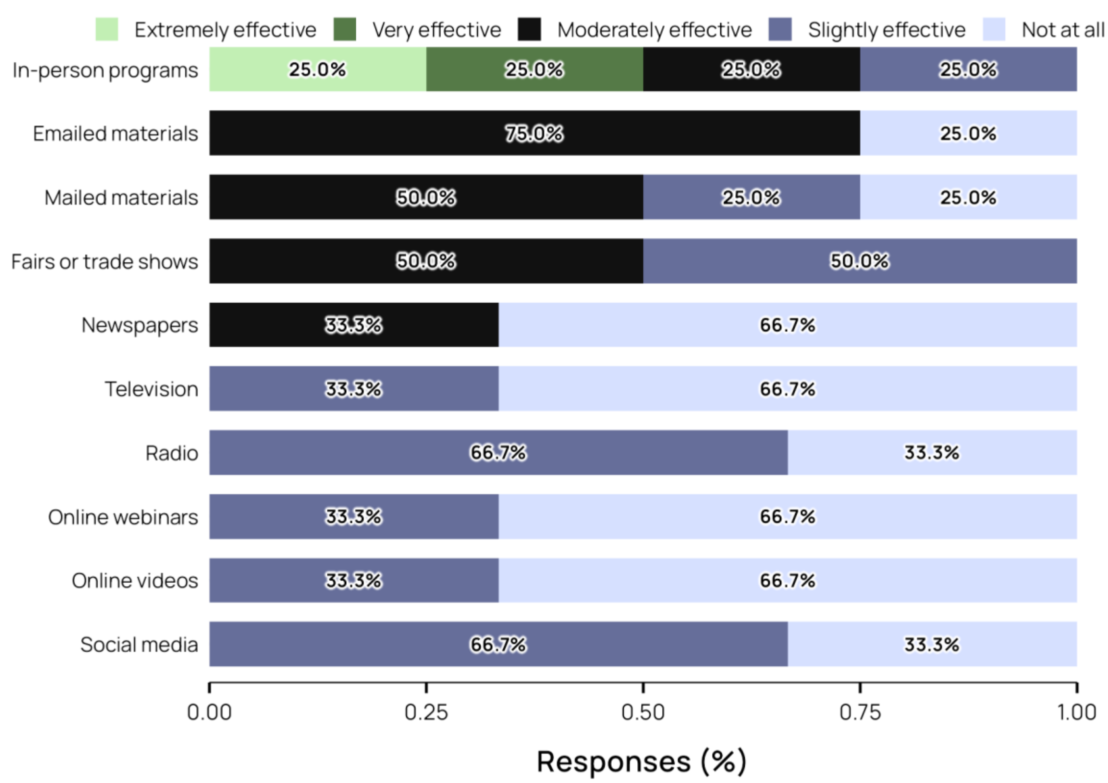

Figure 12. Perceived effectiveness of different education and outreach communication methods.

Watershed Planning, Education, and Communication

All of our respondents had at least some familiarity with the watershed planning documents developed for the Mission and Aransas Rivers and three quarters indicated that the planning documents probably should be updated (Figures 10D, 10E). Figure 11 shows the response rate of topics that respondents felt were most impactful for water quality in the watershed. Septic system maintenance was chosen by 60% of respondents. Landowner conservation practices and feral hog management were also frequently selected. Topics on urban stormwater management and K-12 education were not chosen by any of our respondents. Other topics indicated by stakeholders included WWTF education, pesticide/herbicide application education, and proper tillage practices.

In-person programs had the highest perception of effectiveness among our respondents (Figure 12). Emailed materials, mailed materials, and fairs or trade shows generally had moderate perceptions of effectiveness. All other types of media were perceived as only slightly effective or not effective at all.

Discussion

Since their initial impairment listings, fecal indicator bacteria concentrations have remained relatively constant in the Mission River Tidal and has slightly improved in Aransas River Tidal (although not enough to achieve a delisting). Since 2006, the geometric means averages in the Aransas River Tidal have declined and significant declining trends in indicator bacteria concentration provide some evidence that stakeholder efforts have improved water quality.

Management measures focused on conservation plans, feral hog management, urban stormwater, and expanded monitoring saw the most activity. Under Control Action 1, all WWTFs now operate under permitted fecal indicator bacteria concentration limits. Most of these WWTFs also achieve average discharge concentrations well below half their limit. Based on limited stakeholder feedback, there is indication that watershed planning documents should be updated.

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