FINAL

TEXAS COASTAL WATERS: NUTRIENT REDUCTION STRATEGIES REPORT

Prepared for:

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY, TEXAS PARKS AND WILDLIFE DEPARTMENT, TEXAS GENERAL LAND OFFICE, U.S. DEPARTMENT OF THE INTERIOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF AGRICULTURE, U.S. ENVIRONMENTAL PROTECTION AGENCY

Prepared by:

PARSONS

AUGUST 2019

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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
AU	Assessment Unit
BMP	Best management practice
CAFO	Concentrated animal feeding operation
CBBEP	Coastal Bend Bays & Estuaries Program
CCBNEP	Corpus Christi Bay National Estuary Program
CF	Carry-forward
cfs	Cubic feet per second
Chl *a*	Chlorophyll-*a*
CMP	Coastal Management Program
CPPE	Conservation Practice Physical Effect
CS	Concern screening level
CWA	Clean Water Act
CWQM	Continuous water quality monitoring
CWSRF	Clean Water State Revolving Fund
CZB	Coastal Zone Boundary
DOI	U.S. Department of the Interior
EMC	Event mean concentrations
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FOTG	Field Office Technical Guide
FSA	Farm Service Agency
GIS	Geographic information system
GLO	General Land Office
HMI	Holistic Management International
HRI	Harte Research Institute
HU	Historically Underserved
HUC	Hydrologic unit codes
ILOS	Integrated Level of Support
lbs/acre/year	Pound(s) per acre per year
LOS	Level of Support
µg/L	Microgram(s) per liter
mg/L	Milligram(s) per liter
MGD	Millions of gallons per day
MS4	Municipal Separate Storm Sewer System
NADP	National Atmospheric Deposition Program
NGO	Non-governmental organizations
NH_3-N	Ammonia nitrogen
NLCD	National Land Cover Database

Acronym	Definition
NO_3-N	Nitrate nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRA	Nueces River Authority
NRCS	Natural Resource Conservation Service
NRDA	Natural Resource Damage Assessment
OP	Orthophosphate
OSSF	On-site sewage facility
PDARP	Programmatic Damage Assessment and Restoration Plan
RRC	Railroad Commission of Texas
RWA	Receiving Water Assessment
SC	Standard Criteria
SL	Screening level
SSURGO	Soil Survey Geographic Database
STEPL	Spreadsheet Tool for Estimating Pollutant Loading
SWCD	Soil and Water Conservation District
SWQM	Surface Water Quality Monitoring
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TDS	Total dissolved solids
TIG	Trustee Implementation Group
TMDL	Total maximum daily load
TN	Total nitrogen
TNC	The Nature Conservancy
TP	Total phosphorus
TPDES	Texas Pollution Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TSWQS	Texas Surface Water Quality Standards
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
TXBAD	Texas Basin Assessment Databases
TxDOT	Texas Department of Transportation
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQMP	Water Quality Management Plan
WPP	Watershed Protection Plan
WWTP	Wastewater treatment plant

EXECUTIVE SUMMARY

Scientists predict that the 2019 dead zone, technically known as hypoxia, in the Gulf of Mexico will increase to a record 8,000 square miles across the continental shelf. Hypoxia in Gulf waters is caused by nutrient-laden nonpoint source pollution, which causes algal blooms that strip the water column of oxygen when the algae decompose.

This report, developed by the Texas Natural Resource Damage Assessment (NRDA) Trustee Implementation Group (TIG), is designed to address eutrophication and its effects on coastal waters as part of their Programmatic Damage Assessment and Restoration Plan (PDARP). This report aims to advance the specific PDARP strategy called "Nutrient Reduction Restoration Type" by recommending the expansion of existing water quality programs dedicated to preventing, reducing, and mitigating nonpoint source nutrient runoff in partnership with stakeholders in target watersheds.

The goals of the Nutrient Reduction Restoration Type identified in the PDARP are:

- Reduce nutrient loadings to Texas Gulf Coast estuaries, habitats, and resources that are threatened by chronic eutrophication, hypoxia, or harmful algal blooms or that suffer habitat losses associated with water quality degradation;
- Where appropriate, collocate nutrient load reduction projects with other restoration projects to enhance ecological services provided by other restoration approaches; and
- Enhance the ecosystem services of existing and restored Gulf Coast habitats.

What follows is a summary of the Nutrient Reduction Strategies Report including:

- The method and results of narrowing down Texas coastal watersheds to those that provide the best opportunity to reduce nonpoint source nutrients;
- A description of the priority watersheds; and
- An evaluation of management strategies which, if implemented, would reduce nonpoint source nutrients that cause eutrophication in a coastal watershed.

ES 1.0 Criteria for Target Watershed Identification

The TIG recognized the need to develop an assessment method for prioritizing coastal watersheds to implement the goals of the Nutrient Reduction Restoration Type strategy. The TIG developed this report to document the data assessment methods and processes used to identify high-priority candidate watersheds with chronic coastal water quality concerns caused by nutrient loads. Targeting resources in high-priority areas and coordinating the implementation of nutrient reduction efforts at a watershed level along with other habitat and resource restoration approaches will help provide ecosystem-scale benefits to the nearshore Gulf Coast. Water quality assessment results are available for 271 segments (classified and unclassified river segments, lakes, estuaries) contained wholly or partially within the Texas Coastal Zone Boundary. A variety of data sources were used to evaluate the 271 segments, including:

- Data from Texas Commission on Environmental Quality (TCEQ) water quality monitoring assessment cycles in 2006, 2008, 2010, 2012, and 2014
- Land use/land cover data from the U.S. Geological Survey
- Point and nonpoint source pollution categories

These data types were organized into a consolidated searchable format, whereupon the following stepwise process was applied to all 271 segments. Combined, these steps make up the evaluation criteria that establish a list of potential candidate watersheds that could present opportunities for targeting nonpoint source nutrient reduction strategies. Water quality parameters of interest included the most recent available data for total phosphorus, orthophosphate, nitrate nitrogen (NO_3 N), ammonia nitrogen (NH_3-N), and chlorophyll-*a* (Chl *a*).

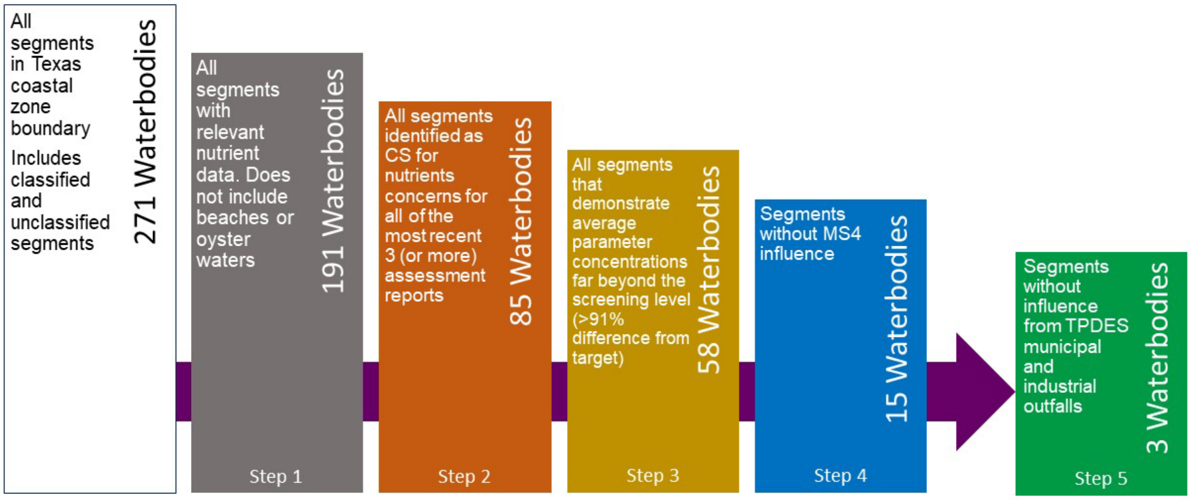

Figure ES-1 Screening Process for Determining Nonpoint Source Nutrient Reduction Opportunities

The screening process, summarized in Figure ES-1 above, started with looking at those waterbodies with applicable nutrient data, then identifying those that had been designated as waterbodies of concern for nutrients in the most recent TCEQ Surface Water Quality Monitoring biannual reports. An algorithm was applied to the 85 qualifying waterbodies to determine which of them exhibited nutrient concentrations that substantially exceeded regulatory screening levels. The final 58 waterbodies were evaluated to determine if water quality might be significantly influenced by point-source pollution from municipal separate storm sewer systems and industrial or municipal wastewater treatment plants. This step resulted in three target watersheds:

- Petronila Creek above Tidal (2204), Petronila Creek Tidal (2203)
- San Fernando Creek (2492A)
- Lower Guadalupe River (1801, 1802, 1803, and includes Lower San Antonio River 1901)

Hydrologic and pollutant fate-and-transport connections between the freshwater tributaries of the San Antonio Bay and Baffin Bay systems led the TIG to use three key directives to guide the remaining watershed assessment efforts to prioritize where to target nutrient reduction strategies.

1. Use 12-digit HUCs as the unit of assessment for the project.
2. Do not consider assessing/targeting 12-digit hydrologic unit codes (HUCs) that drain directly into either the San Antonio Bay or Baffin Bay systems because their geographic area, and therefore nutrient load contribution, is dwarfed by the watershed area and flows delivered by the watersheds of the main tributaries.
3. Use best professional judgment to recommend how far inland beyond the Coastal Zone Boundary should 12-digit HUCs be assessed to characterize nutrient loadings that are impacting:
    a. Guadalupe River (1801, 1802, 1803) and San Antonio River (1901) which contribute most of the nutrient load to the San Antonio Bay system; and
    b. Petronila Creek above Tidal (2204), Petronila Creek Tidal (2203), and San Fernando Creek (2492A) which contribute most of the nutrient load to the Baffin Bay system.

These directives are guided by the fact that successful nutrient reduction strategies implemented in an upstream segment (e.g., 1801, 1901, and 2204) should result in water quality benefits in the downstream segments and bay system. Using geographic information system technology to evaluate land use and hydrology, fourteen 12-digit HUCs within the San Antonio Bay watershed and fifty-one 12-digit HUCs within the Baffin Bay watershed were identified for further evaluation. In the San Antonio Bay watershed, the HUCs are limited to the lower portions of the Guadalupe River and San Antonio River watersheds (see Figure ES-2). In the Baffin Bay watershed, the HUCs are limited to the Petronila Creek and San Fernando Creek watersheds (See Figure ES-3).

ES 2.0 Evaluation of Recommended Target Watersheds

The data assessment methods and results used to narrow down the number of 12-digit HUC areas that should be considered for targeting nutrient reduction strategies are described below. The evaluation and prioritization of the 12-digit HUCs within the three target watersheds focused on land use, potential nutrient loading rates, and nutrient sources.

Individual stream segments and waterbodies are impacted by management practices at the watershed scale; therefore, it was imperative to understand land use patterns and nutrient sources throughout each watershed to determine the causes of high nutrient concentrations. While the Lower Guadalupe and San Fernando both exhibit high nutrient loads without discernible urban influences, there was a conspicuously large area of cultivated cropland within the Petronila Creek watershed (approximately 72 percent of the entire watershed area).

Data analysis and modeling provided the following comparison between the three target watersheds:

- It is estimated that 83 to 85 percent of the nutrient loading in the Lower Guadalupe River watershed comes from sources associated with pasture/grassland and cropland.
- An estimated 85 to 92 percent of the nutrient loading in the San Fernando Creek watershed comes from sources associated with pasture/grassland and cropland.
- In the Petronila Creek watershed, an estimated 98 percent of the nutrient loading comes from sources associated with pasture/grassland and cropland.

When looking at each of the three watersheds in terms of estimated nitrogen and phosphorus loads across Lower Guadalupe River, San Fernando Creek, and Petronila Creek watersheds, a clear group of 12-digit HUCs distinguish themselves from the rest as having a higher potential for nonpoint source nutrients. Figure ES-4 represents this data analysis identifying a group of nine 12-digit HUCs designated as Tier 1 (highest priority) watersheds that were selected for targeting of nonpoint source reduction strategies. All Tier 1 12-digit HUCs are adjacent to each other, and all but one is in the Petronila Creek watershed.

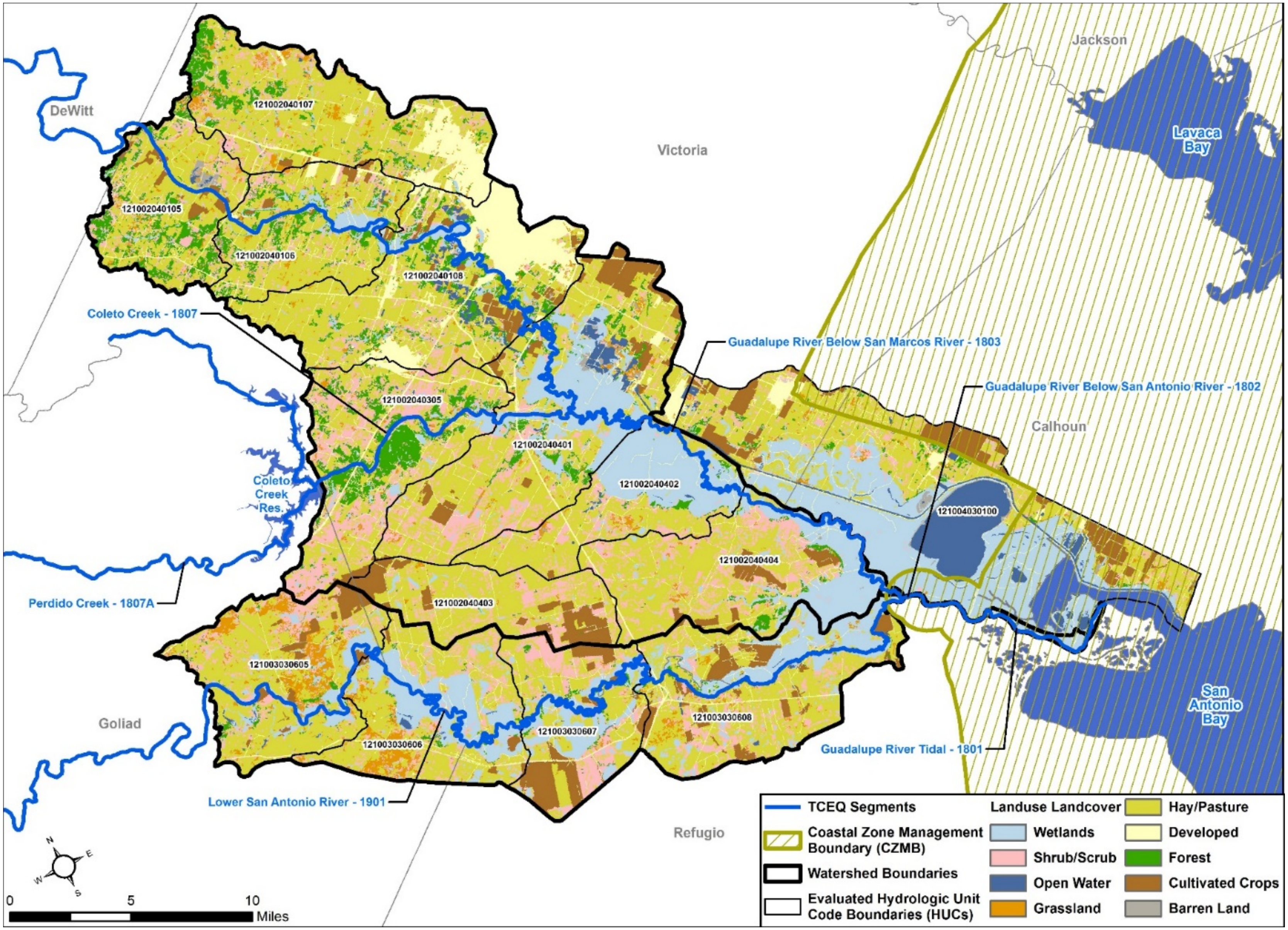

Figure ES-2 Lower Guadalupe River Watershed Land Use and Land Cover

Figure ES-3 San Fernando Creek and Petronila Creek Watersheds Land Use and Land Cover

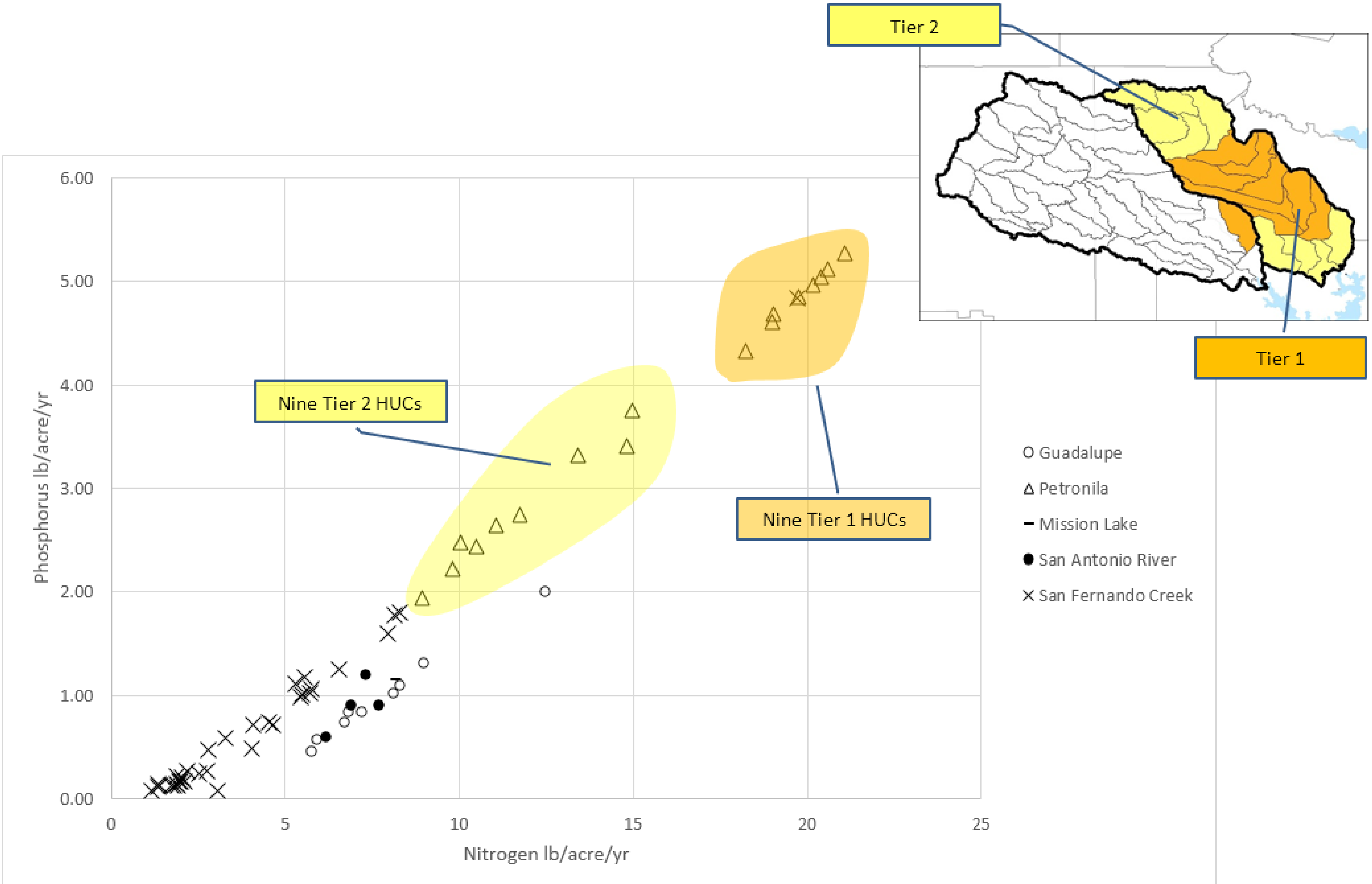

Figure ES-4 Phosphorus/Nitrogen Scatterplot of all HUCs

ES 3.0 Evaluation of Restoration Approaches

The report identifies a menu of voluntary best management practices (BMPs) that may be used to reduce nutrient loads from cropland, pastureland, privately-held off-field areas and road rights-of-way. Most of the potential strategies identified to reduce nutrient loading in Petronila Creek are tailored to the dry-land agricultural practices and livestock pastureland employed in the watershed. Some recommended strategies include:

- Cover crops
- Reduced tillage and no-till management
- Filter and/or contour buffer strips
- Grassed waterways
- Conservation cover (land retirement)
- Crop rotations
- Field borders
- Farm-based nutrient management plans
- Controlled drainage structures
- Herbaceous and forested riparian zones
- Mulching
- Streambank and shoreline protection
- Strip cropping
- Terracing
- Vegetative and herbaceous wind barriers
- Wetland creation and restoration
- Fencing livestock from streambanks
- Prescribed grazing

Nutrient management strategies to consider in Petronila Creek are numerous and should be evaluated on a case-by-case basis depending on cost effectiveness, landowner willingness, soil type, topography, crop type, agribusiness market conditions, planting and harvesting methods, livestock type, size of operation, annual precipitation, and other field specific factors. While all options should be considered, some BMPs are more likely to be implemented than others given the area land use and topography. Some measures are more effective than others. Costs vary between measures as well. A cost comparison of some of the management strategies is presented to aid decision makers in prioritizing the implementation of the most effect management strategies and obtaining an order of magnitude of the required financial resources needed.

Management strategies implemented by the TIG may expand or complement efforts already in place. Management strategies can also be implemented on lands not in agricultural production such as building retention ponds and wetlands along stormwater conveyance channels that feed directly into Petronila Creek.

Engagement of stakeholders and landowners to develop individual projects that employ effective and feasible strategies will be necessary to determine what will eventually be the overall approach to nutrient reduction in the Petronila Creek watershed. Consideration of specific management practices should not be limited to those listed above. It is critical to engage local stakeholders in the assessment and evaluation of a watershed's water quality impairments and concerns, as well as in the development and implementation of necessary management strategies to abate nonpoint source pollution (TCEQ 2017). Cooperation from local stakeholders will be crucial to promote a sense of equitable responsibility. Achieving buy-in from private entities and local governments will be required to implement these recommendations and may require some public engagement either directly or through steering committees and/or technical advisory groups.

The TIG recognizes that coordination and communication between landowners, ranchers, farmers and local, regional, state, and federal land and water resource management agencies will be paramount to taking the next step to advance Nutrient Reduction Restoration Strategies in the Petronila Creek Watershed.

SECTION 1
INTRODUCTION

1.1 Background Information

Nutrient pollution can pose a significant threat to rivers, bays, and estuaries along the Texas Gulf Coast. Eutrophication--the enrichment of an aquatic system by nutrients--fuels the growth of phytoplankton, periphyton, and other primary producers at the base of the estuarine food web. In aquatic ecosystems, nitrogen and phosphorus are typically the key nutrients for primary producers. Chlorophyll-*a* concentrations (the primary indicator of the amount of phytoplankton in the water) may reach high levels in the waters of the bayous and bays, particularly in the spring and summer months. Just as plants in a yard or garden grow more rapidly after fertilizers are applied, algal blooms can occur when enough nutrients are present in the water. The subsequent die-off and decomposition of large amounts of algae in the water can lead to hypoxic (low oxygen) conditions and fish kills. The combination of nutrients, high chlorophyll-*a* concentrations, high water temperatures, and low dissolved oxygen that is frequently observed along the Texas coast is thought to be primarily responsible for fish kills (typically of Gulf menhaden) in the summer months (Gonzalez 2011).

One study (Thronson and Quigg 2008) found the leading cause of fish kills in Texas coastal waters was low oxygen concentrations caused by both physical (e.g., elevated water temperature) and biological factors (a result of nutrient enrichment). In the 55-year period studied, about two thirds of the mortalities from low oxygen concentrations were caused by excess nutrient loads.

Many existing local, state, regional, and federal programs across the Gulf of Mexico are working to address nutrient pollution in coastal waters. These include the eight National Estuary Programs, Gulf of Mexico Alliance, Environmental Protection Agency's (EPA) Gulf of Mexico program, United States Department of Agriculture's (USDA) Gulf of Mexico Initiative, Gulf Coast Ecosystem Restoration Council, and many others. In addition to these regional ecosystem-focused programs, other specific regulatory and voluntary programs are being implemented in Texas that aim to address nutrient sources of pollution in surface waters. Examples of these are the Texas Pollution Discharge Elimination Program (TPDES), Municipal Separate Storm Sewer System (MS4) program, Texas Nonpoint Source Management Program, Texas Coastal Nonpoint Source Pollution Control Program, and various USDA cost-share programs.

Building upon these initiatives, the Texas Natural Resource Damage Assessment (NRDA) Trustee Implementation Group (TIG) developed a strategy called "Nutrient Reduction Restoration Type" to address eutrophication and its effects on coastal waters as part of their Programmatic Damage Assessment and Restoration Plan (PDARP) (Deepwater Horizon NRDA Trustees 2016). The Texas TIG includes the following state and federal agencies:

- Texas Parks and Wildlife Department (TPWD)
- Texas General Land Office (GLO)
- Texas Commission on Environmental Quality (TCEQ)
- U.S. Department of the Interior (DOI)
- National Oceanic and Atmospheric Administration (NOAA)
- USDA
- USEPA

The goals of the Nutrient Reduction Restoration Type strategy identified in the PDARP are:

- Reduce nutrient loadings to Texas Gulf Coast estuaries, habitats, and resources that are threatened by chronic eutrophication, hypoxia, or harmful algal blooms or that suffer habitat losses associated with water quality degradation;
- Where appropriate, collocate nutrient load reduction projects with other restoration projects to enhance ecological services provided by other restoration approaches; and
- Enhance the ecosystem services of existing and restored Gulf Coast habitats.

Major nutrient sources include agricultural runoff, municipal and industrial wastewater, urban stormwater runoff, atmospheric deposition, and other forms of nonpoint source pollution. A combination of agricultural, stormwater, and forestry management practices, creation and enhancement of wetlands, hydrologic restoration, and coastal and riparian conservation could be implemented in coordination with land owners, conservation groups, and local, state, and federal agencies to reduce nutrient loads and chronic water quality degradation affecting coastal streams, habitats, and estuarine and marine resources. While all these practices would contribute to the goal of reducing nutrient loads to the Gulf Coast, the PDARP recognizes that agriculture and its associated land use practices is a principal nutrient source – especially in Texas with 76 percent of land use in agriculture (USDA 2019).

The TIG recognized the need to develop an assessment method for prioritizing coastal watersheds to implement the goals of the Nutrient Reduction Restoration Type. The TIG developed this report to document the data assessment methods and processes used to identify high-priority candidate watersheds with chronic coastal water quality concerns caused by nutrients. Targeting resources in high priority areas and coordinating the implementation of nutrient reduction efforts at a watershed level – along with other habitat and resource restoration approaches – will help provide ecosystem-scale benefits to the nearshore Gulf Coast. While the PDARP specifically aims to address impacts to coastal waters, nutrient sources from inland watersheds must also be considered in this study if restoration efforts are to be successful. As such, this project was designed to investigate and develop strategies that capitalize on existing programs and willing partners within and upstream of the Coastal Zone Boundary (CZB) to advance the goals of the Nutrient Reduction Restoration Type strategy. The CZB displayed in Figure 1-1 defines the Texas Coastal Zone Management area as provided in Texas Administrative Code, Title 31, §503.1. The Texas CZB, including the Gulf of Mexico area, encompasses approximately 13,826 square miles and includes portions of 18 counties.

Figure 1-1 Texas Coastal Zone Boundary

This report summarizes the results of the Texas Gulf Coast Nutrient Reduction – Watershed Assessment project. It is organized to communicate both the process of the data assessment review and the results. The remaining sections of this report are described below.

- Section 2 – Development of Initial Criteria for Target Watershed Identification: Development of criteria for identification of select watersheds within the CZB that are impacted primarily by nonpoint source pollution;
- Section 3 – Evaluation of Recommended Target Watersheds: Using a refined list of watersheds based on the initial criteria, a summary of the characterization of specific nonpoint sources of nutrient pollution that serve as the basis for targeting the implementation of nutrient reduction restoration strategies;
- Section 4 – Evaluation of Restoration Approaches: Evaluation of potential nutrient reduction strategies and their cost effectiveness in the target watershed(s);
- Section 5 – Identification of Key Watershed Stakeholders: Identification of non-governmental organizations (NGOs), local governments, watershed stakeholder groups, and other organizations currently working in identified target watersheds to address nonpoint source nutrient reduction and advance water quality improvement/restoration;
- Section 6 – Summary of Findings: Recommended nutrient reduction opportunities in target watersheds that meet the goals of the PDARP Nutrient Reduction Restoration Type; and
- Section 7 – References.

SECTION 2
DEVELOPMENT OF INITIAL CRITERIA FOR TARGET WATERSHED IDENTIFICATION

This section summarizes the methods used for assessing existing data to identify and prioritize coastal waterbodies that are impacted by nutrient sources originating from nonpoint sources of pollution. Using available datasets, specific criteria were developed to evaluate streams, reservoirs, bays, and estuaries in the Texas CZB to establish a list of high-priority candidate watersheds where there are potential opportunities for implementing nutrient reduction strategies to improve coastal water quality. This section summarizes the preliminary evaluation of data sources and various criteria proposed for creating a list of high-priority candidate coastal watersheds that may be demonstrating water quality impacts associated with nonpoint sources of nutrients.

2.1 Data Collection

The Trustees collected and evaluated existing data to establish evaluation criteria for characterizing Texas coastal waterbodies (freshwater and tidal streams, reservoirs, estuaries and coastal bays) where nonpoint sources of nutrients are potentially causing chronic water quality impacts.

The data sources used to develop the initial evaluation criteria include the following:

- TCEQ Surface Water Quality Monitoring (SWQM) Integrated Report
- TCEQ SWQM Texas Basin Assessment Databases (TXBAD)
- TCEQ 2014 Guidance for Assessing and Reporting Surface Water Quality in Texas (June 2015)
- Texas Surface Water Quality Standards (TSWQS)

Section 305(b) of the Clean Water Act (CWA) of 1972 requires states and the EPA to compile a biennial report to the U.S. Congress on the nation's water quality conditions. In the State of Texas, the TCEQ SWQM staff perform 305(b) assessments by comparing water quality monitoring data to TSWQS Criteria and Screening Levels established for Texas waters. The water quality monitoring data included in the evaluation for the assessment are collected and reported by multiple entities including, but not limited to TCEQ, GLO, TPWD, the Texas State Soil and Water Conservation Board (TSSWCB), the United States Geological Survey (USGS), the Galveston Bay Foundation, the Coastal Bend Bays & Estuaries Program (CBBEP), river authorities and municipalities. The surface water quality assessment summary data are stored in the SWQM database called TXBAD. The TXBAD data assessment results serve as the source for the biennial inventory and assessment of water quality reported in the Texas Integrated Report of Texas Surface Water Quality. An Integrated Report Year is also referred to as an assessment cycle.

Copies of the TXBAD tables for assessment cycles in 2006, 2008, 2010, 2012, and 2014 were acquired from TCEQ and used as the primary data source in the development of the evaluation criteria summarized in this section. Waterbodies, or segments, are divisions of streams, rivers, bays, estuaries, wetlands, lakes or reservoirs that are defined in the TSWQS. Segments are intended to have relatively homogenous chemical, physical, and hydrologic characteristics. These segments are further delineated into one or more Assessment Units (AUs), which can include zero to multiple water quality monitoring stations. AUs are the level at which raw water quality sample data are compared to water quality standards criteria and screening levels in the 305(b) assessment. The TXBAD tables acquired include assessment summary information that is reported in the "Water Body Assessments by Basin" reports at the AU level and do not include the raw surface water quality data. The TXBAD tables include the following data:

- Standard Criteria (SC) or Screening Level (SL) applied to each assessment parameter (e.g., dissolved oxygen, ammonia)
- Number of samples included in the assessment period of record
- Number of samples that exceed criteria
- Mean of exceeded values
- Level of Support (LOS) assigned based on the immediate sample data for that cycle
- Integrated Level of Support (ILOS), which is the overall level of support reported for that AU parameter
- Dataset Qualifier (for example "AD" for Adequate Data, "LD" for Limited Data)
- TCEQ cause (e.g., depressed dissolved oxygen, ammonia)
- Impairment categories (4a, 4b, 4c, 5a, 5b, 5c)

The ILOS may differ from the LOS because of limited data, best professional judgment applied by the assessor, or a "carry-forward" (CF) concern or impairment. CFs are reported in cases where sample data are temporally or spatially not representative, and/or the current assessment cycle does not contain adequate sample data to assess (10 samples are considered adequate). In these cases, the previous assessment cycle's ILOS is duplicated in that cycle as a CF if there was a concern in the antecedent assessment cycle.

Segments identified in the CZB evaluated in this report include classified and unclassified segments, as defined in the TSWQS. For unclassified segments not included in the TSWQS, Aquatic Life Uses and criteria are presumed based on the stream-flow type established from available flow data, information provided by local monitoring staff, and recent Receiving Water Assessments (RWAs) as listed in TXBAD. The SCs and SLs applied to these segments are derived from the TCEQ Guidance for Assessing and Reporting Surface Water Quality in Texas (2015).

In addition to the assessed water quality data described above, geospatial data sources were used to map segments of concern as evaluation criteria were applied. The use of the geospatial data layers also helped guide a more detailed analysis of hydrology, potential nutrient sources, and other spatial characteristics related to applying the evaluation criteria. The following geospatial data sources were used in the development of secondary evaluation criteria to further advance the process of selecting candidate waterbodies for nutrient reduction strategies:

- USGS 12-digit Hydrologic Units (HUCs)
- TCEQ Wastewater Outfalls Point Shapefile
- TCEQ Water Quality Permit Database http://www1.tceq.texas.gov/wqpaq/index.cfm?fuseaction=home.PermitSearch
- Existing Watershed Protection Plans (WPP)
- TCEQ MS4 Phase I jurisdictions (EPA Urbanized Areas)
- National Atmospheric Deposition Program data for nitrogen
- Geographic information system (GIS) shapefile of the TCEQ Surface Water Quality Monitoring Locations
- 2014 Assessment Unit line and polygon shape files for the entire state

- U.S. Census Data

2.1.1 Atmospheric Deposition

One of the data sources identified in subsection 2.1 above did not turn out to be a useful evaluation criterion for inclusion in the data development process. Nitrogen loads from atmospheric deposition were investigated as a possible criterion for evaluating nutrient impacts to coastal water bodies. Four National Atmospheric Deposition Program (NADP) monitoring stations were identified in or near the CZB. Two of the four stations (TX39 and TX53) have not operated in over 10 years, which led to their elimination from consideration. This left the stations in Beeville (TX03) and Attwater Prairie Chicken National Wildlife Refuge (TX10). Only data from the Beeville station were specifically investigated given its proximity to the CZB and its completeness of data in recent years. However, it was clear that the limited amount of atmospheric deposition data for nitrogen available and its spatial resolution across the CZB were insufficient to be useful in prioritizing nutrient-related impacts at the segment level.

2.1.2 Fish Kills

Excess nutrients in waterbodies can result in algal blooms that can produce toxins that are harmful to fish and shellfish. Red tide is one form of harmful algae blooms, but fish kills can also be caused by brown tides and golden alga blooms.

To incorporate ecological responses of nutrient pollution into the selection criteria, the TPWD fish kill database was referenced for events attributed to algal blooms. The database has records of fish kills in coastal watersheds that are the result of algal blooms or depressed dissolved oxygen, which can result from decomposition of the bloom's biomass. For fish kills to be considered for inclusion in the database they must be witnessed, reported, and investigated. It is likely that the frequency of fish kills is much greater than what is recorded in the database. While the data confirm that Texas coastal watersheds do experience these ecological events that can be attributed to nutrient loads, the data are too sparse to use as a criterion for selecting target watersheds.

2.2 Data Analysis

Water quality assessment results from TXBAD data are available for the 271 segments contained wholly or partially within the Texas CZB. Data queries focused on the AUs of the classified and unclassified segments that are within or intersect the CZB line (Figure 1-1). These records were organized into a consolidated searchable format. The stepwise process described in Section 2.2.1 was then applied to all 271 segments. Combined, these steps make up the evaluation criteria that established a list of potential candidate watersheds that could present opportunities for targeting nonpoint source nutrient reduction strategies.

2.2.1 Evaluating Water Quality Conditions

Step 1: The first step in the evaluation process involved the removal of all segments with no available instream nutrient data. Secondly, any segments evaluated only for microbial contamination, such as oyster waters use or recreational beach advisories, were removed from consideration because there is no evidence that nutrient loading is associated with impacting the designated uses of oyster waters and beach recreation. Eighty segments were removed using these two steps, leaving 191 segments with relevant water quality data within the CZB.

Step 2: In this step, the focus of data analysis was to narrow the list to those segments that have assessed data that specifically indicate concerns for water quality impacts associated with nutrients or eutrophication. Using assessed data from the 2006, 2008, 2010, 2012 and 2014 TXBAD tables, all 191 segments were queried to identify AUs with assessment results for the following nutrient parameters:

- Total phosphorus (TP),
- Orthophosphate (OP),
- Nitrate nitrogen (NO_3-N),
- Ammonia nitrogen (NH_3-N), and
- Chlorophyll-*a* (Chl *a*)

The AU-level assessed nutrient data available for each assessment cycle was then summarized for each segment by ranking the ILOS in order of increased significance with Non-Support as the most significant (rank 1) and Not Assessed as the least significant (rank 6):

1. Non-Supporting (NS)
2. Concern for Near Non-Attainment (CN)
3. Concern for Screening Level (CS)
4. No Concern (NC)
5. Fully Supporting (FS)
6. Not Assessed (NA)

Only CS, NC, and NA levels of support may apply to nutrients, whereas segments assessed for dissolved oxygen could result in any of the above support states. The overall nutrient ILOS for a segment was generated by selecting the minimum of all ILOS ranks for any nutrient parameter in all AUs for each assessment cycle.

Table 2-1 lists the nutrient-associated parameters and their respective screening levels as defined in the TCEQ 2014 Guidance for Assessing and Reporting Surface Water Quality in Texas that were applied by the SWQM staff for each assessment cycle.

Table 2-1 Screening Levels for Nutrient Parameters

Water Body Type	Nutrients	Screening Level[1]
Freshwater Stream	NH_3-N NO_3-N OP TP Chl *a*	0.33 mg/L 1.95 mg/L 0.37 mg/L 0.69 mg/L 14.1 µg/L
Reservoir	NH_3-N NO_3-N OP TP Chl *a*	0.11 mg/L 0.37 mg/L 0.05 mg/L 0.20 mg/L 26.7 µg/L
Tidal Stream	NH_3-N NO_3-N OP TP Chl *a*	0.46 mg/L 1.10 mg/L 0.46 mg/L 0.66 mg/L 21.0 µg/L

Water Body Type	Nutrients	Screening Level[1]
Estuary	NH_3-N	0.10 mg/L
	NO_3-N	0.17 mg/L
	OP	0.19 mg/L
	TP	0.21 mg/L
	Chl *a*	11.6 µg/L

[1] For this evaluation, the screening level applied during the Integrated Reports assessments was used, which occasionally deviated from the recommended screening level for various reasons.

mg/L – milligram(s) per liter

µg/L – microgram(s) per liter

The resulting overall nutrient ILOS for each assessment cycle and segment was then sorted chronologically as illustrated in Appendix A. Accordingly, segments with consistent nutrient-related impacts in recent years are of more interest than those that have been identified as an occasional concern. Segments were eliminated from further consideration if nutrient parameters were not reported as a CS in all the most recent three assessment cycles of the evaluation (2010, 2012, and 2014). Some of these segments were identified as a CF nutrient concern during previous assessment cycle(s) and were not evaluated in every assessment cycle. Of the 191 segments remaining, this elimination step resulted in a list of 85 segments that have been consistently identified as impacted for nutrients in recent years, including 13 segments with at least one nutrient parameter CF in at least one assessment cycle. The 85 segments in Appendix A may demonstrate chronic nutrient-related water quality impacts.

Step 3: Using the original dataset included in Step 2 above, this step involved more detailed data analysis aimed at evaluating the magnitude of nutrient concerns for the 85 remaining segments. The following sequence outlines the method developed for establishing an SL excursion index, which is simply a calculation that demonstrates the magnitude of deviation above each nutrient SL as a measurement to characterize water quality concerns.

1. For this evaluation, assessment records were eliminated if the ILOS was not reported as a CS. For example, if one of 10 samples for an AU exceeded its screening level, and the AU did not qualify as a CS, then that record was not considered in this calculation step. Occasional nutrient excursions were considered ephemeral and therefore were excluded from this evaluation.
2. The TXBAD tables were queried for the SL values applied to each nutrient as well as the mean of the exceeded values reported by SWQM staff.
3. Using the various exceedance values available for each nutrient parameter from each AU, the nutrient data were normalized by applying the following equation to establish a common scale:

$$\frac{\left| \text{Mean of Exceeded Values} - \text{SL} \right|}{\text{SL}} \times 100$$

   where the absolute value of the difference between the SL and the mean of the exceeded values was divided by the SL and then multiplied by 100.
4. This established a magnitude measurement (deviation from SL) expressed as a percentage, as calculated above. These magnitude measurements were then averaged for all nutrients in all AUs for each assessment cycle separately.

5. This evaluation further summarized the data on the segment level by taking the mean of all assessment years, resulting in an SL excursion index for each segment that represents an overall deviation from nutrient SLs in general.
6. A frequency histogram was then plotted to investigate the distribution of the nutrient excursions. The average percent magnitude measurements were lognormally distributed, so the data were transformed with a log10 function. A breakpoint in the frequency distribution of segments was identified at approximately 91% (Figure 2-1). In other words, a cluster of segments emerges that can be defined as those segments that significantly exceed the various nutrient SLs. Twenty-seven segments with an average level excursion of less than 91% over any of the nutrient SLs were eliminated from further analysis, leaving 58 segments for further consideration.

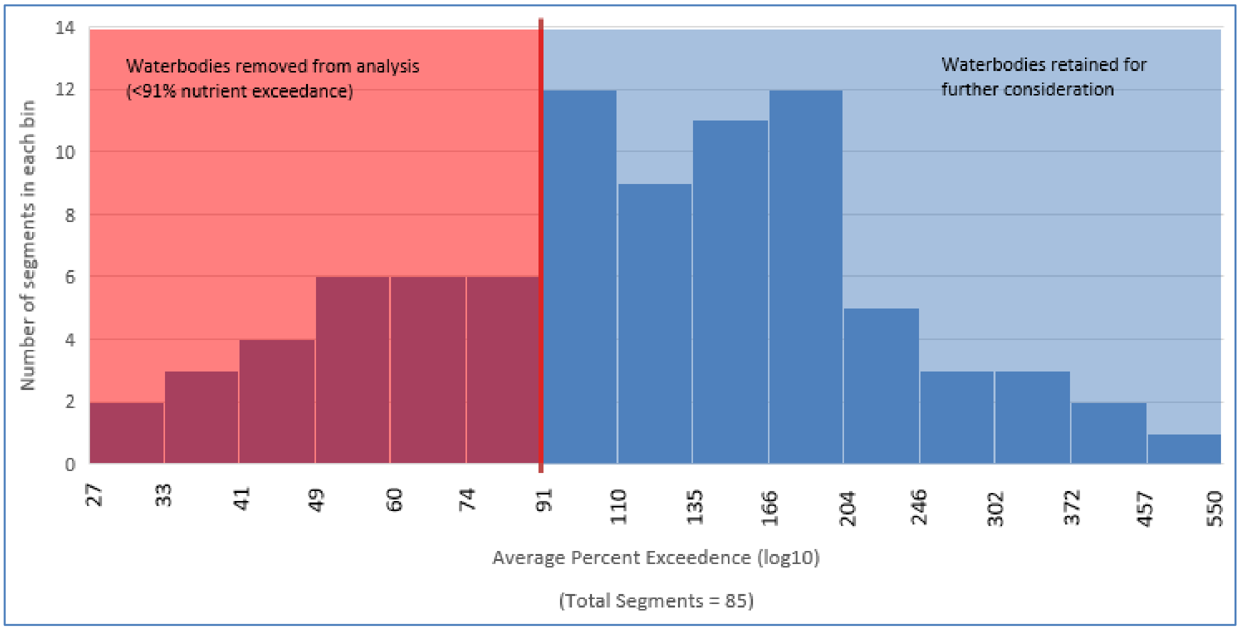

Figure 2-1 Frequency Distribution of Average Percent Exceedance of Nutrient Screening Levels

The coupling of the evaluation criteria in steps 2 and 3 results in a practical method for narrowing down the list of coastal waterbodies that demonstrate some level of water quality impacts associated with nutrient loadings. Table 2-2 lists all 85 segments for consideration resulting from Step 2. The bold records identify the 58 segments with significant nutrient concerns above the 91% threshold resulting from Step 3. Table 2-2 also includes nutrient magnitude measurement averages that were calculated for each nutrient individually, which differ from the overall averages described above due to the weighting of the number of samples averaged at each stage of calculations. The individual nutrient averages are displayed for informational purposes only and were not included in any segment elimination process. If data were not available for a specific nutrient, the ILOS for that nutrient for all assessment cycles was reported, which is more informative than a blank cell. If data were available for evaluation, the ILOS indicates them as described above. However, if there were Insufficient Data, "ID" was reported to reflect data gaps in the assessment records or indicates that no water quality monitoring sample data were available for inclusion in the 305(b) assessments. Figures 2-2 and 2-3 provide the spatial distribution of the 58 segments with nutrient concerns along the Texas Coast that were retained for further consideration.

Table 2-2 List of Segments with Exceedances of Nutrient Screening Levels

Code	Description
NS	Non-Supporting
CN	Concern for Near Non-Attainment
CS	Concern for Screening Level
NC	No Concern
FS	Fully Supporting
NA	Not Assessed
ID	Insufficient Data – either from assessment data gaps or lack of data to evaluate for assessment
CZB	Coastal Zone Boundary

Notes:
BOLD = above 91% threshold

2014 Assessment Segment Information				Average Percent Deviation Above the Screening Level for each Nutrient Calculated Individually (All Assessment Cycles Combined)					Overall Average of the Percent Deviation Above Screening Level	Screening Level Excursion Index (used to develop the 91% threshold)	2014 Assessment for Dissolved Oxygen
Row Number	**Segment in CZB**	**Segment Name**	**Segment Type**	**Ammonia a**	**Chlorophyll-a b**	**Nitrate c**	**Orthophosphorus d**	**Total Phosphorus e**	**a+b+c+d+e/n**	**Average Deviation over all Assessment Cycles**	**ILOS**
1	0501B	Little Cypress Bayou	Tidal Stream	NA	ID	NC	369	ID	369	369	NS: 5c
2	0701	Taylor Bayou/North Fork Taylor Bayou Above Tidal	Freshwater Stream	NC	112	NC	NC	NC	112	108	NS: 5b
3	0702A	Alligator Bayou and Main Canals A, B, C, and D	Freshwater Stream	NC	136	NC	NC	NC	136	131	NC
4	0704	Hillebrandt Bayou	Freshwater Stream	83	233	NC	NC	NC	158	172	NS: 5b
5	0801C	Cotton Bayou	Tidal Stream	NC	139	656	274	190	315	358	CN
6	1002	Lake Houston	Reservoir	NC	56	123	252	115	137	101	NC
7	1006	Houston Ship Channel Tidal	Tidal Stream	127	297	167	113	82	157	141	NC
8	1007	Houston Ship Channel/Buffalo Bayou Tidal	Tidal Stream	227	NC	272	131	93	181	185	NC
9	1007F	Berry Bayou Above Tidal	Freshwater Stream	358	ID	361	468	216	350	316	NC
10	1007H	Pine Gully Above Tidal	Freshwater Stream	153	ID	NC	NC	NC	153	153	NS: 5c
11	1007I	Plum Creek Above Tidal	Freshwater Stream	178	ID	NC	NC	NC	178	178	NS: 5c
12	1007O	Unnamed Tributary of Buffalo Bayou	Freshwater Stream	193	ID	NC	NC	NC	193	193	NS: 5c
13	1013	Buffalo Bayou Tidal	Tidal Stream	NC	NC	281	105	72	153	160	NC
14	1013C	Unnamed Non-Tidal Tributary of Buffalo Bayou Tidal	Freshwater Stream	382	ID	NC	NC	NC	382	382	NS: 5c
15	1014	Buffalo Bayou Above Tidal	Freshwater Stream	NC	NC	204	258	116	193	186	NC
16	1017	Whiteoak Bayou Above Tidal	Freshwater Stream	76	NC	214	296	119	176	165	NC
17	1101	Clear Creek Tidal	Tidal Stream	NC	179	117	61	54	103	96	NC
18	1103	Dickinson Bayou Tidal	Tidal Stream	NC	109	NC	NC	NC	109	109	NS: 5b

2014 Assessment Segment Information				Average Percent Deviation Above the Screening Level for each Nutrient Calculated Individually (All Assessment Cycles Combined)					Overall Average of the Percent Deviation Above Screening Level	Screening Level Excursion Index (used to develop the 91% threshold)	2014 Assessment for Dissolved Oxygen
Row Number	**Segment in CZB**	**Segment Name**	**Segment Type**	**Ammonia a**	**Chlorophyll-a b**	**Nitrate c**	**Orthophosphorus d**	**Total Phosphorus e**	**a+b+c+d+e/n**	**Average Deviation over all Assessment Cycles**	**ILOS**
19	1113	Armand Bayou Tidal	Tidal Stream	NC	228	NC	NC	NC	228	223	NS: 5b
20	1113B	Horsepen Bayou Tidal	Tidal Stream	152	NC	317	165	104	185	197	CN
21	1301	San Bernard River Tidal	Tidal Stream	NC	100	NC	NC	NC	100	100	NC
22	1402	Colorado River Below La Grange	Freshwater Stream	NC	130	53	57	NC	80	92	NC
23	1501	Tres Palacios Creek Tidal	Tidal Stream	NC	103	NC	NC	NC	103	103	NS: 5b
24	1701	Victoria Barge Canal	Estuary	NC	154	290	NC	NC	222	222	NC
25	1801	Guadalupe River Tidal	Tidal Stream	NC	NC	115	NC	NC	115	115	NC
26	1901	Lower San Antonio River	Freshwater Stream	NC	178	216	72	45	128	125	NC
27	2101	Nueces River Tidal	Tidal Stream	NC	93	NC	NC	NC	93	93	NC
28	2201	Arroyo Colorado Tidal	Tidal Stream	38	138	166	26	21	78	125	NS: 5a
29	2201A	Harding Ranch Drainage Ditch Tributary (A) to the Arroyo Colorado Tidal	Freshwater Stream	127	NC	NC	NC	NC	127	127	ID
30	2201B	Unnamed Drainage Ditch Tributary (B) in Cameron County Drainage District #3	Tidal Stream	NC	78	285	NC	NC	182	182	ID
31	2202	Arroyo Colorado Above Tidal	Freshwater Stream	219	162	122	82	38	125	104	NC
32	2203	Petronila Creek Tidal	Reservoir	NC	179	NC	NC	60	119	158	NC
33	2204	Petronila Creek Above Tidal	Freshwater Stream	NC	594	NC	NC	NC	594	553	NC
34	2301	Rio Grande Tidal	Tidal Stream	NC	194	268	NC	NC	231	204	NC
35	2421	Upper Galveston Bay	Estuary	50	124	151	NC	35	90	102	NC
36	2422	Trinity Bay	Estuary	NC	97	149	NC	24	90	105	NC
37	2423A	Oyster Bayou	Tidal Stream	NC	152	NC	NC	NC	152	152	NC
38	2424B	Lake Madeline	Estuary	NC	182	NC	NC	29	105	153	NS: 5c
39	2425	Clear Lake	Estuary	112	182	175	60	76	121	125	NC
40	2426	Tabbs Bay	Estuary	135	NC	374	72	61	160	167	NC
41	2427	San Jacinto Bay	Estuary	150	190	459	70	75	189	198	NC
42	2428	Black Duck Bay	Estuary	NC	197	124	NC	54	125	126	NC
43	2429	Scott Bay	Estuary	135	78	453	60	77	161	177	NC
44	2430	Burnett Bay	Estuary	115	173	371	58	75	158	164	NC
45	2430A	Crystal Bay	Estuary	110	137	457	82	87	174	190	NC
46	2436	Barbours Cut	Estuary	108	ID	303	61	52	131	137	NC

2014 Assessment Segment Information				Average Percent Deviation Above the Screening Level for each Nutrient Calculated Individually (All Assessment Cycles Combined)					Overall Average of the Percent Deviation Above Screening Level	Screening Level Excursion Index (used to develop the 91% threshold)	2014 Assessment for Dissolved Oxygen
Row Number	**Segment in CZB**	**Segment Name**	**Segment Type**	**Ammonia a**	**Chlorophyll-a b**	**Nitrate c**	**Orthophosphorus d**	**Total Phosphorus e**	**a+b+c+d+e/n**	**Average Deviation over all Assessment Cycles**	**ILOS**
47	2437	Texas City Ship Channel	Estuary	102	78	124	NC	271	144	121	NC
48	2438	Bayport Channel	Estuary	87	163	141	404	279	215	209	CS
49	2454A	Cox Lake	Reservoir	NC	484	362	300	46	298	256	CS
50	2456	Carancahua Bay	Estuary	NC	182	274	42	73	143	146	NC
51	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	Estuary	NC	91	291	NC	NC	191	163	NC
52	2471A	Little Bay	Estuary	NC	109	NC	NC	NC	109	109	NC
53	2484	Corpus Christi Inner Harbor	Estuary	72	102	190	NC	NC	122	126	NC
54	2485	Oso Bay	Estuary	3460	125	NC	NC	88	1224	294	NS: 5b
55	2485A	Oso Creek	Tidal Stream	NC	173	835	350	180	384	389	NC
56	2491	Laguna Madre	Estuary	50	140	482	NC	NC	224	239	NS: 5b
57	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	Estuary	NC	192	NC	NC	NC	192	192	NC
58	2492A	San Fernando Creek	Tidal Stream	NC	137	189	516	364	302	294	NC
59	0508C	Hudson Gully	Tidal Stream	NA	ID	NC	43	ID	43	43	NS: 4a
60	0511E	Terry Gully	Freshwater Stream	NA	ID	NA	30	ID	30	30	CN
61	0702	Intracoastal Waterway Tidal	Tidal Stream	NC	72	NC	NC	NC	72	72	NC
62	0801	Trinity River Tidal	Tidal Stream	NC	48	NC	NC	NC	48	48	NC
63	0801B	Old River	Tidal Stream	NA	70	NC	NC	NC	70	70	NC
64	0901	Cedar Bayou Tidal	Tidal Stream	NC	68	NC	NC	NC	68	68	CS
65	1005	Houston Ship Channel/San Jacinto River Tidal	Tidal Stream	NC	NC	40	NC	NC	40	37	NC
66	1007R	Hunting Bayou Above Tidal	Freshwater Stream	200	NA	40	NC	NC	120	60	NS: 5c
67	1102	Clear Creek Above Tidal	Freshwater Stream	52	NC	84	77	74	72	67	CS
68	1111	Old Brazos River Channel Tidal	Estuary	NC	41	171	NC	NC	106	74	NC
69	1201	Brazos River Tidal	Tidal Stream	NC	79	42	NC	NC	60	64	NC
70	1401	Colorado River Tidal	Tidal Stream	NC	108	73	NC	NC	90	78	NC
71	1604	Lake Texana	Reservoir	NC	NC	80	170	59	103	83	NC
72	1802	Guadalupe River Below San Antonio River	Freshwater Stream	NC	NC	51	NA	NC	51	51	NC
73	2102	Nueces River Below Lake Corpus Christi	Freshwater Stream	NC	53	NC	NC	NC	53	53	NC
74	2421A	Clear Lake Channel	Estuary	90	ID	NC	NC	19	55	55	ID
75	2423	East Bay	Estuary	NC	57	NC	NC	NC	57	57	NC

2014 Assessment Segment Information				Average Percent Deviation Above the Screening Level for each Nutrient Calculated Individually (All Assessment Cycles Combined)					Overall Average of the Percent Deviation Above Screening Level	Screening Level Excursion Index (used to develop the 91% threshold)	2014 Assessment for Dissolved Oxygen
Row Number	**Segment in CZB**	**Segment Name**	**Segment Type**	**Ammonia a**	**Chlorophyll-a b**	**Nitrate c**	**Orthophosphorus d**	**Total Phosphorus e**	**a+b+c+d+e/n**	**Average Deviation over all Assessment Cycles**	**ILOS**
76	2424A	Highland Bayou	Tidal Stream	NC	77	NC	NC	NC	77	77	CN
77	2424D	Offatts Bayou	Estuary	NC	36	NC	NC	NC	36	36	NC
78	2424E	English Bayou	Estuary	NC	27	NC	NC	NC	27	27	CS
79	2431	Moses Lake	Estuary	NC	62	NC	NC	29	45	53	NC
80	2439	Lower Galveston Bay	Estuary	NC	64	76	NC	NC	70	66	NC
81	2452A	Tres Palacios Harbor	Estuary	90	83	NC	NC	NC	87	87	CN
82	2453	Lavaca Bay/Chocolate Bay	Estuary	NC	43	NC	NC	NC	43	43	NC
83	2485B	Unnamed tributary of Oso Creek	Tidal Stream	NC	ID	NC	22	41	31	35	ID
84	2485D	West Oso Creek	Tidal Stream	NC	ID	NC	NC	47	47	47	NA
85	2501	Gulf of Mexico	Ocean	NC	83	NC	NC	NC	83	83	NC

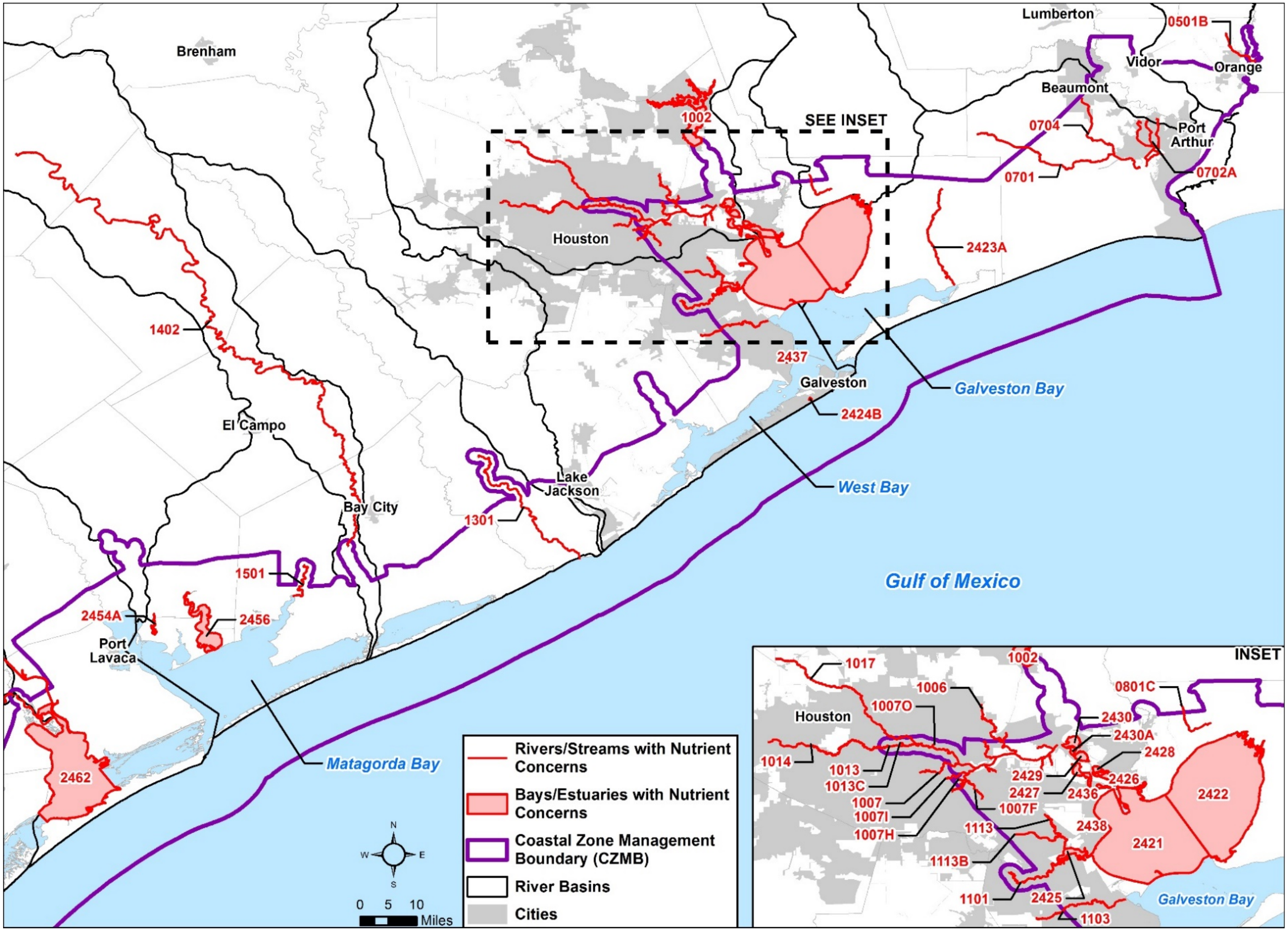

Figure 2-2 Texas Upper Coast Segments with Significant Nutrient Concerns (n=58)

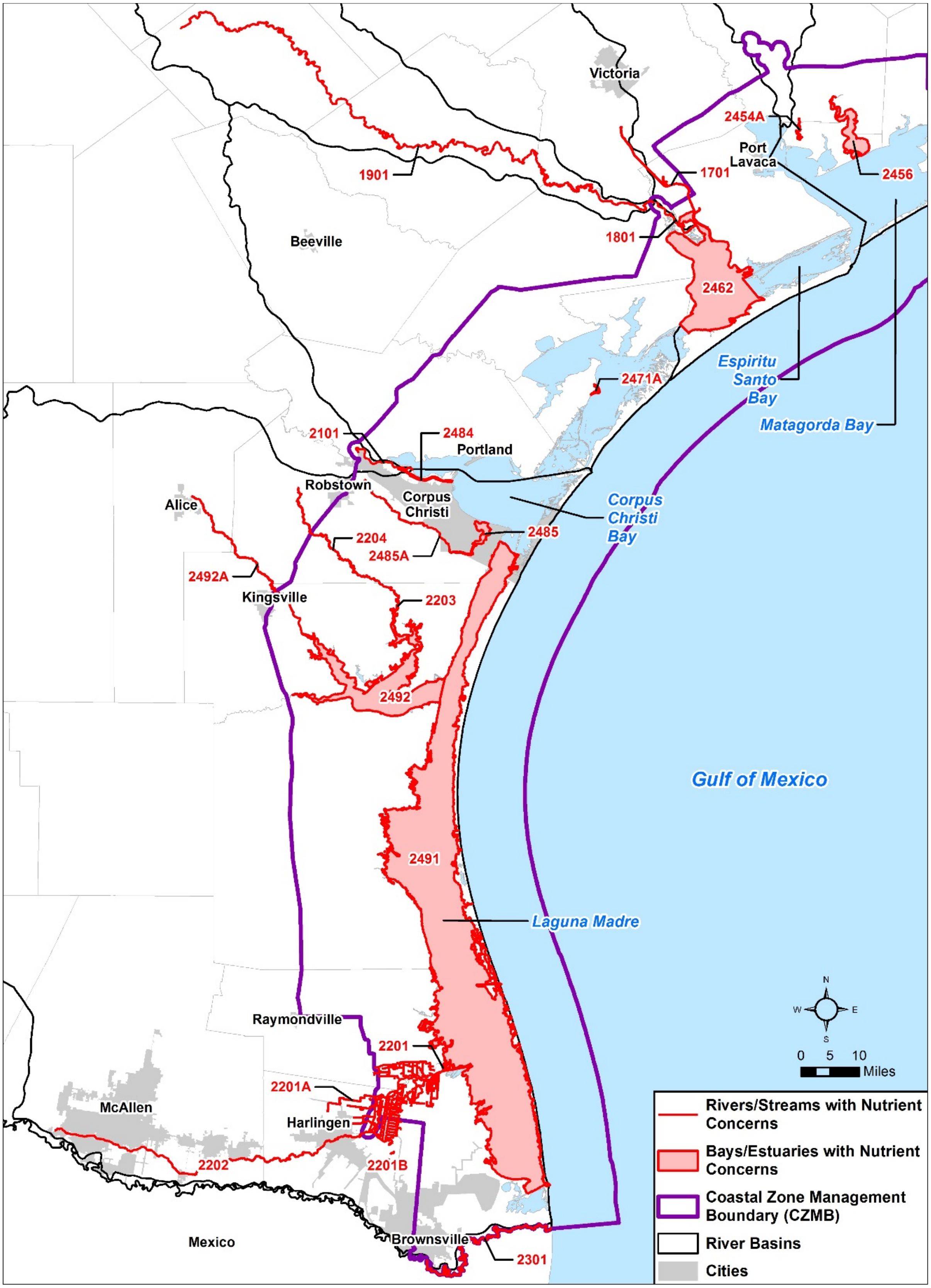

Figure 2-3 Texas Lower Coast Segments with Significant Nutrient Concerns (n=58)

2.2.2 Point Source Influences

Step 4: The next evaluation criteria used to evaluate the list of 58 segments were primarily geospatial relationships associated with potential point sources of nutrient loading and proximity to the CZB. For Steps 4 and 5, the analysis of information and application of evaluation criteria move from a segment-based approach to a watershed-based approach. The list from Step 3 was joined with the USGS 12-digit HUC watersheds to better understand the spatial relationships between the remaining segments, the CZB, and point sources of nutrient pollution that influence coastal water quality. Initially, segments such as 1402 and 1604, 1901, 2201B, and 2202 (see Figures 2-2 and 2-3) were removed from further consideration because more than 95 percent of their individual watersheds lie outside the CZB. However, this aspect of how much of a watershed of interest lies outside of the CZB is reconsidered as a criterion later in the prioritization process.

Next, point sources of nutrients were evaluated by first mapping MS4 Phase I and Phase II jurisdictions. All segments that fall primarily within an MS4 Phase I or Phase II jurisdiction were removed from further consideration. Any MS4 area accounting for less than 20 percent of the watershed acreage of a segment was retained on the list. MS4 jurisdictions are an important evaluation criterion because the NRDA program cannot target restoration efforts at pollutant sources that are addressed by National Pollutant Discharge Elimination System (NPDES) permit requirements. Combined, these two steps removed 43 segments from further consideration.

The MS4 evaluation step was mostly a simple geospatial analysis resulting in the elimination of segments primarily around the areas of Houston, Corpus Christi, Beaumont, Freeport, and Brownsville. Two additional segments that had less than 20 percent of their respective watersheds under an MS4 jurisdiction were removed from further consideration: Taylor Bayou (segment 0701) and Hillebrandt Bayou (segment 0704). After a closer evaluation of the assessed data for these two waterbodies, it was determined that the data from 2006 through 2014 did not demonstrate consistent, significant nutrient impacts upstream of potential municipal sources. A water quality concern associated with segment 0701 in the reach downstream of the confluence with segment 0704 is evident; however, this portion of 0701 flows through an MS4 jurisdiction.

Step 4 resulted in the removal of 43 segments, leaving 15 segments for further consideration as target watersheds. Table 2-3 presents these 15 segments and the average excursion (% difference) above each nutrient SL from Step 3 above. The list of 15 segments was also evaluated to confirm that the nutrient concern classification in the last three assessment cycles was not simply the result of a carry-forward CS from a previous cycle. All 15 segments were confirmed to have been independently evaluated each of the last three assessment cycles. Table 2-3 also identifies which segments are listed for dissolved oxygen in category 5b of the 2014 CWA §303(d) list, and if there is a watershed protection plan associated with the segment. Category 5(b) segments are impaired waterbodies that the TCEQ has identified as candidates for possible water quality standards revision. These characteristics were added to Table 2-3 as additional information that is important to help further prioritize the list of 15 segments.

Figure 2-5, which follows Section 2.2.3, provides a simple conceptual diagram of the evaluation criteria described above and the process used to identify segments in the Texas CZB considered impacted by nonpoint sources of nutrients.

2.2.3 Dissolved Oxygen

Using dissolved oxygen impairment as an evaluation criterion was initially considered. The rationale was that segments with both dissolved oxygen impairments and nutrient concerns would indicate direct effects due to nutrient enrichment. However, meeting this dual requirement of showing both dissolved oxygen impairments "AND" nutrient concerns resulted in a significant reduction of segment candidates because a limited number of segments were dissolved oxygen impaired (see Figure 2-8 and Appendix B). Most of the coastal segments either met dissolved oxygen criteria, or dissolved oxygen was not assessed. Further evaluation of the data also indicated that most of segments remaining were associated with MS4 areas when applying this dual requirement as an evaluation criterion. In other words, where segments with dissolved oxygen impairments have been identified, urbanized areas typically cover a considerable portion of the contributing watershed.

The initial evaluation of assessed dissolved oxygen data seems to suggest that bays and estuaries have a higher propensity for having dissolved oxygen concerns. There are a multitude of natural and anthropogenic factors that, when coupled together, can result in low dissolved oxygen conditions in bays and estuaries. Of the final 15 segments, only 1501 (Tres Palacios) and 2491 (Laguna Madre) were listed for dissolved oxygen impairment in the 2014 303(d) List of Impaired Waters. Figure 2-4 displays the relationship between the 58 waterbodies identified in Step 3 with nutrient concerns and the assessment results of compliance with the dissolved oxygen criterion.

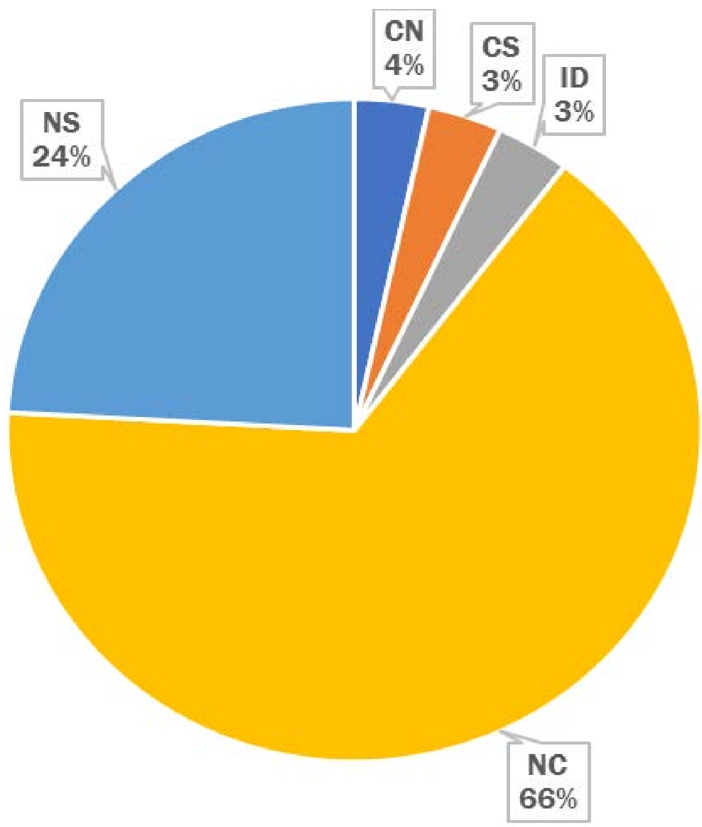

Figure 2-4 2014 Dissolved Oxygen ILOS for Nutrient-Impacted Coastal Waters (n=58)

Table 2-3 Screening Results Summary

2014 Assessment Segment Information				Average Percent Deviation Above the Screening Level for each Nutrient Calculated Individually (All Assessment Cycles Combined)					Overall Average of the Percent Deviation Above Screening Level	Screening Level Excursion Index (used to develop the 91% threshold)	2014 Assessment for Dissolved Oxygen	WPP
Row Number	**Segment Number**	**Segment Name**	**Segment Type**	**Ammonia a**	**Chlorophyll-a b**	**Nitrate c**	**Orthophosphorus d**	**Total Phosphorus e**	a+b+c+d+e/n	**Average Deviation over all Assessment Cycles**	**ILOS: Impairment Category**	
1	1301	San Bernard River Tidal	Tidal Stream	NC	**100**	NC	NC	NC	100	100	NC	Yes
2	1501	Tres Palacios Creek Tidal	Tidal Stream	NC	**103**	NC	NC	NC	103	103	NS: 5b	Yes
3	1701	Victoria Barge Canal	Estuary	NC	**154**	**290**	NC	NC	222	222	NC	No
4	1801	Guadalupe River Tidal	Tidal Stream	NC	NC	**115**	NC	NC	115	115	NC	No
5	2203	Petronila Creek Tidal	Reservoir	NC	**179**	NC	NC	**60**	119	158	NC	No
6	2204	Petronila Creek Above Tidal	Freshwater Stream	NC	**594**	NC	NC	NC	594	553	NC	No
7	2422	Trinity Bay	Estuary	NC	**97**	**149**	NC	**24**	90	105	NC	No
8	2423A	Oyster Bayou	Tidal Stream	NC	**152**	NC	NC	NC	152	152	NC	No
9	2454A	Cox Lake	Estuary	NC	**484**	**362**	**300**	**46**	298	256	CS	No
10	2456	Carancahua Bay	Estuary	NC	**182**	**274**	**42**	**73**	143	146	NC	No
11	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	Estuary	NC	**91**	**291**	NC	NC	191	163	NC	No
12	2471A	Little Bay	Estuary	NC	**109**	NC	NC	NC	109	109	NC	No
13	2491	Laguna Madre	Estuary	**50**	**140**	**482**	NC	NC	224	239	NS: 5b	No
14	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	Estuary	NC	**192**	NC	NC	NC	192	192	NC	No
15	2492A	San Fernando Creek	Tidal Stream	NC	**137**	**189**	**516**	**364**	302	294	NC	No

Notes:
BOLD = above 91% threshold

Code	**Description**
NS	Non-Supporting
CN	Concern for Near Non-Attainment
CS	Concern for Screening Level
NC	No Concern
FS	Fully Supporting
NA	Not Assessed
ID	Insufficient Data; either from assessment data gaps or lack of data to evaluate for assessment.
ILOS	Integrated Level of Support
WPP	Watershed Protection Plan

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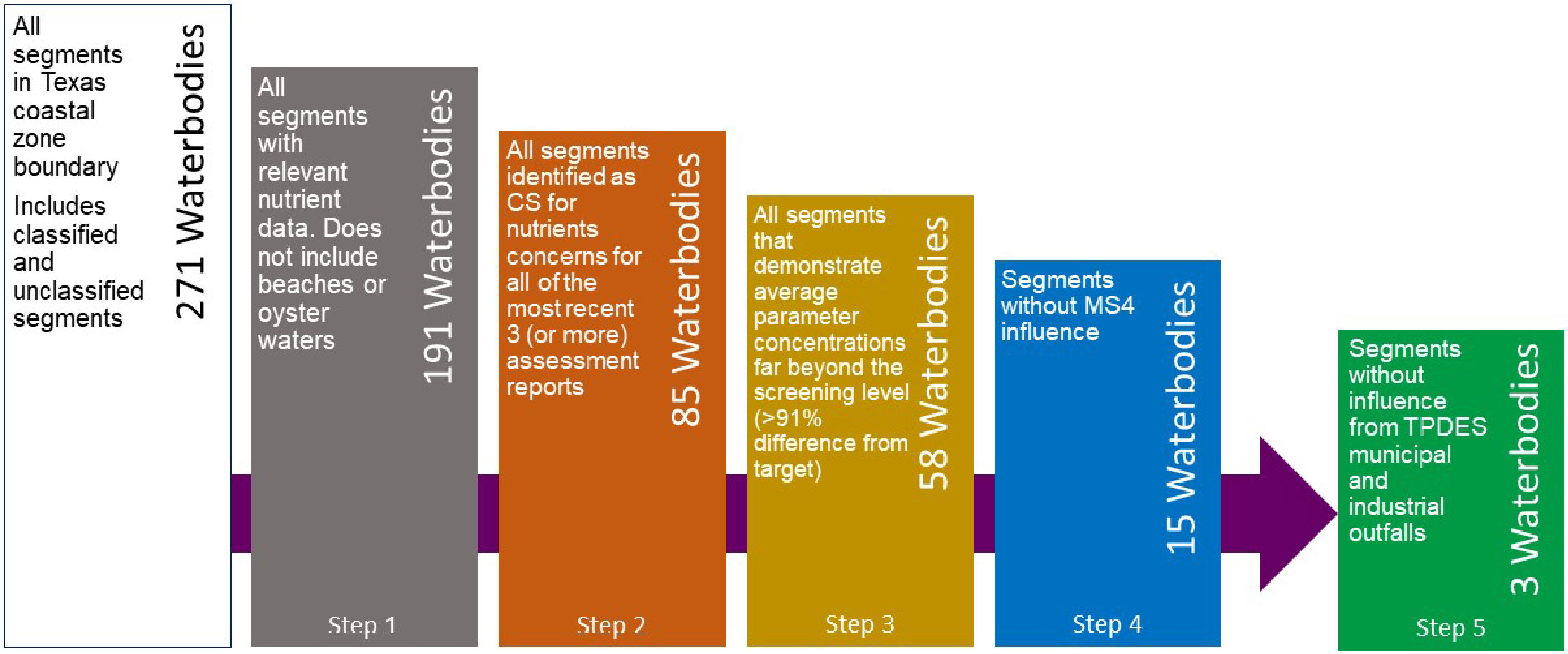


Figure 2-5 Summary of the Watershed Prioritization Process

Step 5: The final step involved applying best professional judgement to determine if municipal and industrial wastewater treatment plant (WWTP) outfalls that discharge within the watersheds of the 15 segments are a significant source of nutrients.

Using the TCEQ Water Quality Permit Database, permitted outfalls within each watershed were compiled to determine if the contribution of nutrients from WWTPs are contributing a significant amount of the overall nutrient load to the waterbody. Table 2-4 summarizes the number and volume of permitted outfalls of the municipal and industrial dischargers within the watershed of each segment. Appendix C provides a detailed list of all the TPDES outfalls identified in Table 2-4. In evaluating the municipal and industrial dischargers, the number of outfalls, proximity of outfall to the segment, and total permitted flow (a relative measure of cumulative wastewater flows) were used to characterize the potential influence these facilities may have on instream water quality relevant to nutrients. Any segments that are subject to more than 2 million gallons per day (MGD) of municipal and/or industrial effluent flow were considered subject to significant potential nutrient loading from continuous, active, point source dischargers.

Table 2-4 TPDES Permitted Outfalls

Segment	Segment Name	Watershed Acreage	Surface Water Miles or Acres	Number of Active Permitted Outfalls	Type	Permitted Flow (MGD)
1301	San Bernard River Tidal	139,456	34 Miles	5	Municipal	2.28
1501	Tres Palacios Creek Tidal	99,674	10 Miles	4	Municipal	0.36
1701	Victoria Barge Canal	102,405	1,024 Acres	5	Municipal	10.95
				5	Industrial	1.53
1801	Guadalupe River Tidal	28,596	10 Miles	0		
2203	Petronila Creek Tidal	26,657	594 Acres	0		
2204	Petronila Creek Above Tidal	209,260	40 Miles	6	Municipal	0.527
2422	Trinity Bay	83,556	78,641 Acres	11	Municipal	2.75
				1	Industrial	1616
2423A	Oyster Bayou	115,051	22 Miles	1	Municipal	0.01
2454A	Cox Lake	23,981	352 Acres	0		
2456	Carancahua Bay	53,997	12,061 Acres	2	Municipal	0.025
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	275,204	83,976 Acres	4	Municipal	0.435
				1	Industrial	3.7
2471A	Little Bay	147,052	226 Acres	1	Municipal	2.5
2491	Laguna Madre	1,401,954	480,878 Acres	23	Municipal	42.614
				8	Industrial	211.09

Segment	Segment Name	Watershed Acreage	Surface Water Miles or Acres	Number of Active Permitted Outfalls	Type	Permitted Flow (MGD)
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	420,923	65,025 Acres	4	Municipal	0.15
2492A	San Fernando Creek	189,970	46 Miles	6	Municipal	9.34
				2	Industrial	unknown

Figures 2-6 through 2-8 present the 15 segments, their watersheds, and municipal and industrial permitted outfall locations.

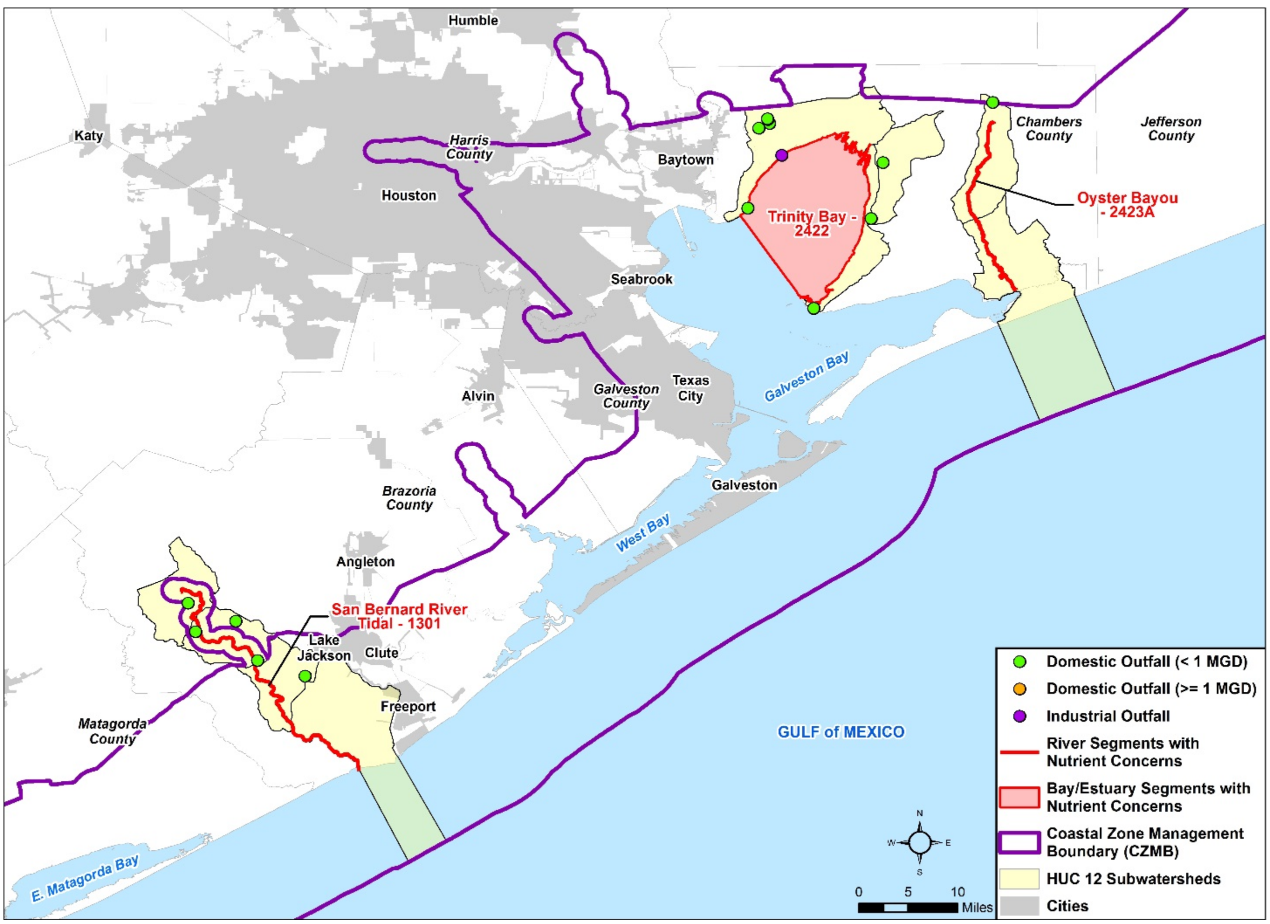


Figure 2-6 Non-urban, Nutrient-impacted Watersheds within the Coastal Zone Boundary (Northern Coast)

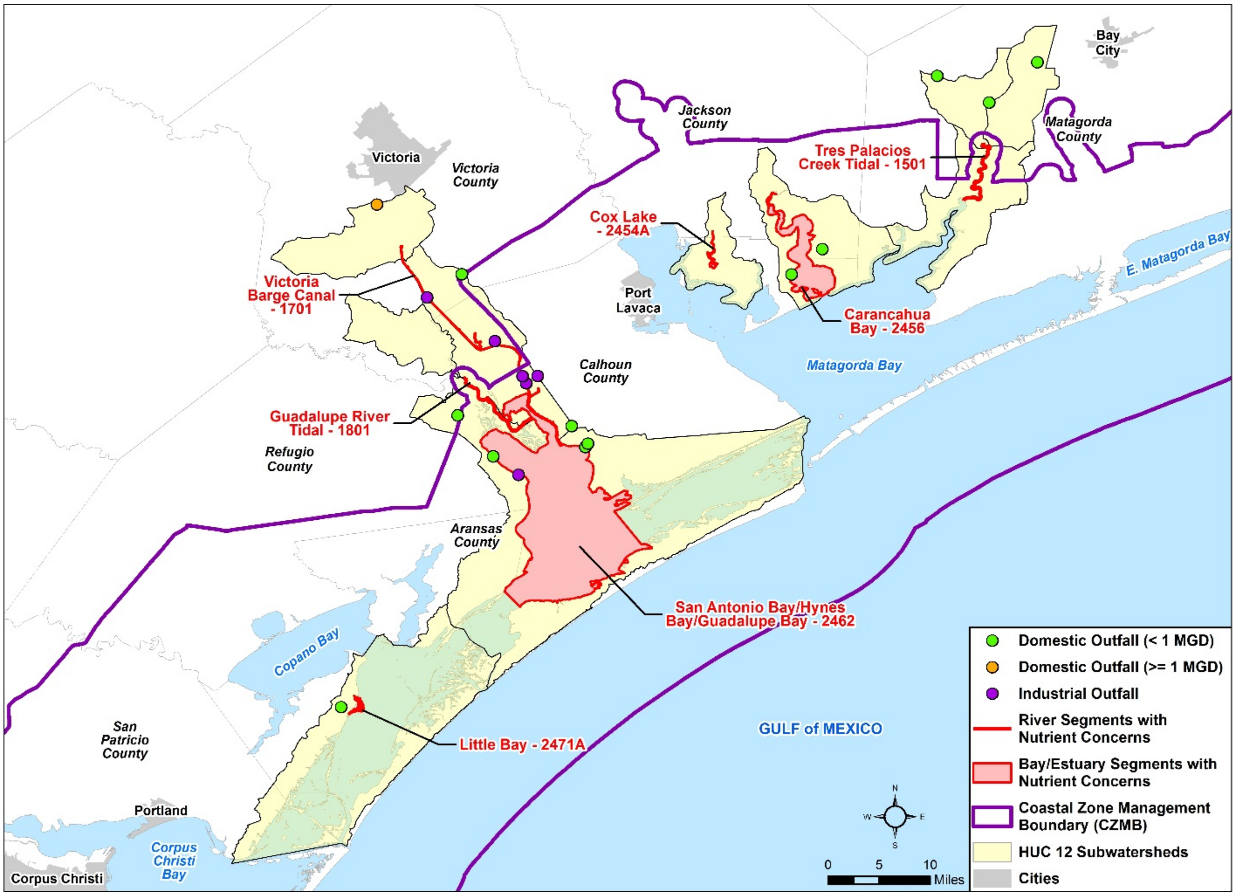


Figure 2-7 Non-urban, Nutrient-impacted Watersheds within the Coastal Zone Boundary (Central Coast)

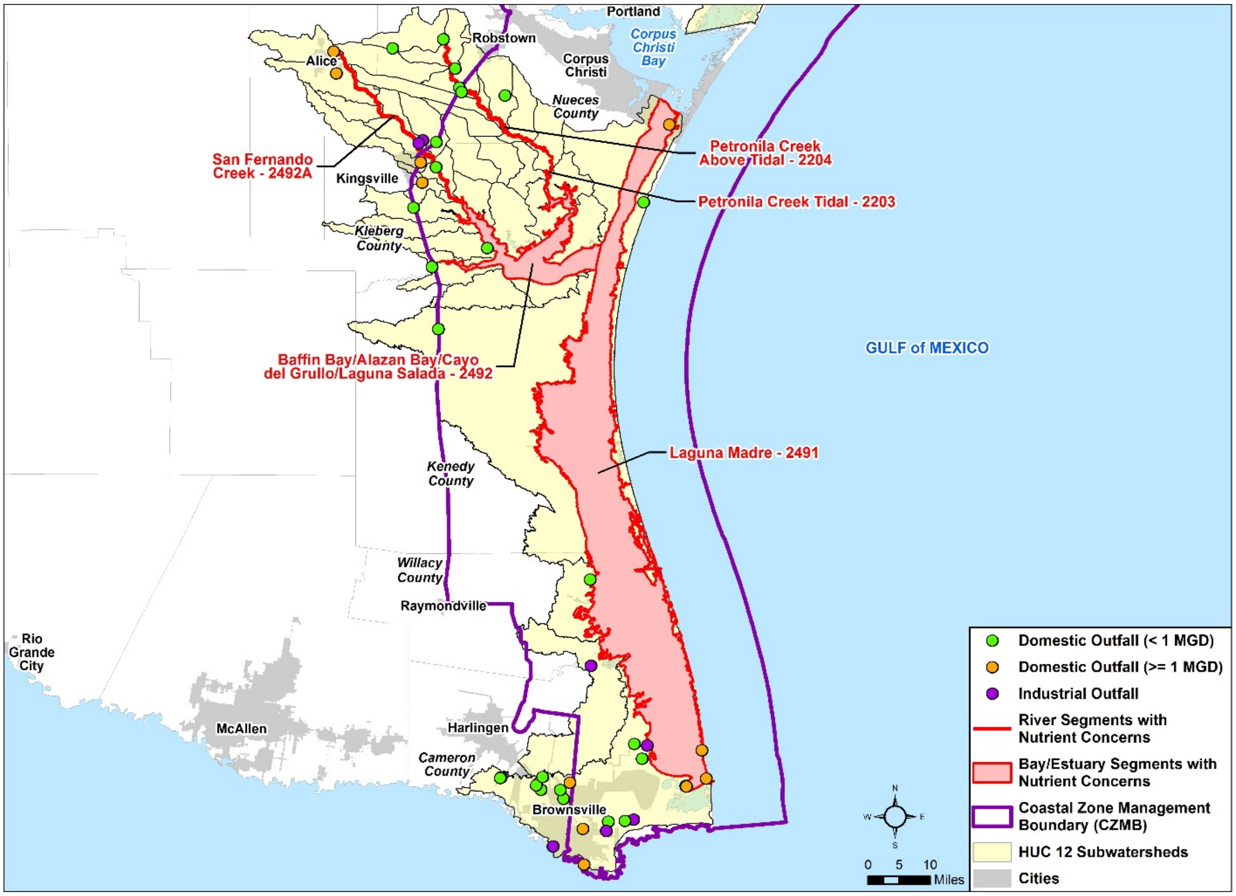


Figure 2-8 Non-urban, Nutrient-impacted Watersheds within the Coastal Zone Boundary (Southern Coast)

2.3 Consideration of Additional Characteristics for Prioritizing Watersheds

Additional characteristics were considered and evaluated for the short list of the remaining 15 segments to support the final recommendations of watershed prioritization. The 15 segments include one freshwater reservoir, eight tidal rivers and six bays/estuaries. The additional characteristics used to prioritize the list of 15 segments included:

1. Influence of the point source nutrient loads shown in Table 2-4 where watersheds with wastewater flows of less than 2 MGD are considered better candidates for targeting nutrient reduction strategies;
2. Hydrologic connectivity to downstream segments identified as having nutrient concerns; and
3. Potential feasibility of the success of implementing landscape-scale nonpoint source best management practices (BMPs) (e.g., watersheds with higher percentages of agricultural land uses rather than forestland or developed land are considered better candidates for targeting nutrient reduction restoration strategies).

Table 2-5 uses green (a positive characteristic) and red (a limiting characteristic) to suggest which segments are better candidates to focus on for further evaluation of nonpoint sources of nutrients that are causing coastal water quality impacts.

Special mention needs to be made that the primary reason Tres Palacios Creek Tidal (segment 1501) and Laguna Madre (segment 2491) are not priorities is because they are listed as Category 5(b) segments in the Texas Integrated Report. Any waterbody with a potential for a change in water quality standards criteria would not make a suitable candidate for gaining public support for targeting implementation resources to address a water quality issue.

Table 2-5 Recommended Prioritization of Watersheds

Segment	Segment Name	Magnitude of Deviation from SL	Influence of Point Source Nutrient Loads	Connectivity to Other Nutrient Concerns	Feasibility of Landscape-Scale Nonpoint Source BMPs
1801	Guadalupe River Tidal	115	None	Yes	High
2203	Petronila Creek Tidal	158	None	Yes	High
2204	Petronila Creek Above Tidal	553	Insignificant	Yes	High
2492A	San Fernando Creek	294	Significant	Yes	High
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	163	Significant	Yes	Low
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	192	Insignificant	Yes	Low
1501	Tres Palacios Creek Tidal	103	Insignificant	No	High
2423A	Oyster Bayou	152	Insignificant	No	High
2454A	Cox Lake	256	None	No	High
2456	Carancahua Bay	146	Insignificant	No	High
1301	San Bernard River Tidal	100	Significant	No	High
1701	Victoria Barge Canal	222	Significant	Yes	Low
2422	Trinity Bay	105	Significant	No	Low
2471A	Little Bay	109	Significant	No	Low
2491	Laguna Madre	239	Significant	Yes	Low

Two watersheds exhibit all three positive characteristics:

- 1801 – Guadalupe River Tidal. Tidal Stream. The Guadalupe River has no permitted outfalls within 20 miles of the tidal segment. It flows into the San Antonio Bay estuary which also demonstrates impacts associated with nutrients. The watershed of Guadalupe River Tidal is ~28,000 acres, which makes it a viable candidate for targeting landscape-scale nutrient reduction strategies.
- 2203/2204 – Petronila Creek Tidal and Above Tidal. Freshwater/Tidal Stream. These two segments have very high chlorophyll-*a* concentrations and an insignificant number of permitted outfalls. The two watersheds combined cover ~236,000 acres that drain into Alazan Bay and Baffin Bay, which are also nutrient impacted. These characteristics make

these two segments viable candidates for targeting landscape-scale nutrient reduction strategies.

With this qualitative assessment/prioritization stage of the project completed, the TIG acknowledged that further deliberation and environmental and programmatic factors needed to be applied to substantiate these two watershed areas as the target areas for consideration of implementing nutrient reduction strategies. The prioritization process summarized in Section 2 of this report aimed to focus primarily on nutrient concerns in coastal waterbodies within the CZB. However, once the final two recommended watersheds were identified, the TIG recognized that a broader perspective needed to be considered for the remainder of the project.

The San Antonio Bay (Segment 2462) and Baffin Bay (Segment 2492) systems have identified nutrient concerns and are possible priority candidates. Both are hydrologically connected to the final two recommended watersheds, Guadalupe River Tidal (San Antonio Bay) and Petronila Creek Tidal and above Tidal (Baffin Bay). The contributing watersheds to the respective bay systems are huge (the San Antonio Bay watershed stretches more than 120 miles inland). It was neither practical nor prudent to identify nutrient reduction strategies over such large watershed areas. Bays and estuaries have a complex suite of overland, atmospheric, wetland, and tributary inputs from multiple watersheds, as well as mixing from adjacent bays and offshore waters. Given these complexities, it would not be possible to determine with certainty all the sources of potential nutrient loading for these two bay systems. However, if a stream identified with nutrient concerns flows into a nutrient-impacted bay or estuary, then a strong case could be made to promote that stream's watershed as a recommended target for nutrient reductions. Following this basic premise, the TIG deemed it necessary to investigate upstream contributions of nutrients originating outside the CZB. For example, Guadalupe River Tidal (1801) flows into San Antonio Bay (2462), and both exhibit consistent nutrient concerns. Furthermore, the Lower San Antonio River (1901), also identified with nutrient concerns and previously removed from consideration for targeting, directly contributes nutrients into Guadalupe River Tidal. Likewise, Petronila Creek above Tidal (2204), Petronila Creek Tidal (2203) and San Fernando Creek (2429A), all identified as having nutrient concerns, deliver nutrient loads to the Baffin Bay system.

These hydrologic and pollutant fate-and-transport connections between the freshwater tributaries of the San Antonio Bay and Baffin Bay systems led the TIG to use three key directives to guide the remaining watershed assessment efforts to prioritize where to target nutrient reductions restoration strategies.

1. Use 12-digit HUCs as the unit of assessment for the project.
2. Do not consider assessing/targeting 12-digit HUCs that drain directly into either the San Antonio Bay or Baffin Bay systems because their geographic area, and therefore nutrient contribution, is dwarfed by the watershed area and flows delivered by the watersheds of the main tributaries.
3. Use best professional judgment to recommend how far inland beyond the CZB 12-digit HUCs should be assessed to characterize nutrient loads that are impacting:
    a. Guadalupe River (1801, 1802, 1803) and San Antonio River (1901) which contribute most of the nutrient load to the San Antonio Bay system; and
    b. Petronila Creek above Tidal (2204), Petronila Creek Tidal (2203), and San Fernando Creek (2492A) which contribute most of the nutrient load to the Baffin Bay system.

These directives are guided by the fact that successful nutrient reduction strategies implemented in an upstream segment (e.g., 1801, 1901, and 2204) should result in water quality benefits in the downstream segments and bay system. Using GIS to evaluate land use and hydrology, fourteen 12-digit HUCs within the San Antonio Bay watershed and fifty-one 12-digit HUCs within the Baffin Bay watershed were identified for further evaluation. In the San Antonio Bay watershed, the HUCs are limited to the lower portion of the Guadalupe River and San Antonio River watersheds. In the Baffin Bay watershed, the HUCs are limited to the Petronila Creek and San Fernando Creek watersheds.

The remaining sections of this report focus on describing the assessment methods and results used to narrow down the number of 12-digit HUCs that should be areas considered for targeting nutrient reduction strategies.

SECTION 3
EVALUATION OF RECOMMENDED TARGET WATERSHEDS

This section summarizes the data and watershed assessment approach used to further prioritize 12-digit HUCs within the Guadalupe and San Antonio Rivers, and Petronila Creek, and San Fernando Creek watersheds within the Baffin Bay watershed. Figure 3-1 shows the location and scale of these watersheds relative to the Texas coast. The following discussion includes an evaluation and prioritization of the 12-digit HUCs within these three watersheds focusing on land use, potential nutrient loading rates, and nutrient sources.

3.1 Watershed Descriptions

Since the three watersheds are all located along the coastal bend area of Texas, some generalizations can be made. The watershed study area includes the East Central Texas Plain, the South Texas Plain and the Western Gulf Coast Plain ecoregions. The East Central Texas Plains is comprised of gently sloping sandy loam and clay loam soils. The area is rural interspersed with small towns. The economy is dominated by cattle ranching and the oil and gas industry. Hydraulic fracturing of the Eagle Ford Shale formation has increased dramatically in the last decade.

The Western Gulf Coastal Plain is mostly flat with abundant grassy areas and fewer trees than the East Central Texas Plains. Row crops are more common in the coastal plain than in the rangelands of central Texas. Farming, ranching, and the petroleum industry influence the land use activities of the coastal plain.

Extending west of the Gulf Coastal Plain is the South Texas Plains ecoregion, which is characteristically dry and brushy compared to the coastal region. Primary vegetation consists of mesquite, acacia, and prickly pear mixed with areas of grassland.

The watershed areas have an average yearly rainfall of 28 to 40 inches. The primary aquifer is the Gulf Coast Aquifer which is separated into two aquifers: the Chicot and Evangeline. These units crop out in belts that trend northeast to southwest (i.e., parallel to the coastline) and dip to the southeast at an angle greater than the slope of the land surface. Groundwater flows southeast toward the Gulf of Mexico and occurs under confined and unconfined conditions (TWDB 1968).

3.2 Lower Guadalupe River Watershed

For the purposes of this evaluation, the watershed area of the lower Guadalupe River includes nine 12-digit HUCs of the Guadalupe River from San Antonio Bay to DeWitt County and the Coleto Creek watershed to Coleto Creek Reservoir (Figure 3-2). This evaluation area also includes four 12-digit HUCs associated with the Lower San Antonio River up to approximately 25 miles from the CZB and one HUC that drains directly into Greens Lake and Mission Lake. The watershed, as defined, represents the land area that directly impacts nutrient concentrations at the mouth of the Guadalupe River Tidal at San Antonio Bay. Classified segments in the evaluation area include 1801, 1802, 1803, 1807, and a portion of 1901. The Coleto Creek Reservoir watershed is not included because the reservoir likely serves as a sediment trap and nutrient sink.

The evaluation area covers 387,854 acres (606 square miles) of Texas' coastal bend and includes significant portions of the City of Victoria. Less than 0.5 percent of the Lower Guadalupe River watershed assessed in this report falls within the CZB. The Coleto Creek confluence is located about 15 miles upstream of where the Guadalupe River discharges into San Antonio Bay. The San Antonio River feeds into the Guadalupe River about 5 miles upstream of the mouth. The Guadalupe River basin provides a median discharge of 1,750 cubic feet per second (cfs) measured at the confluence with the San Antonio River.

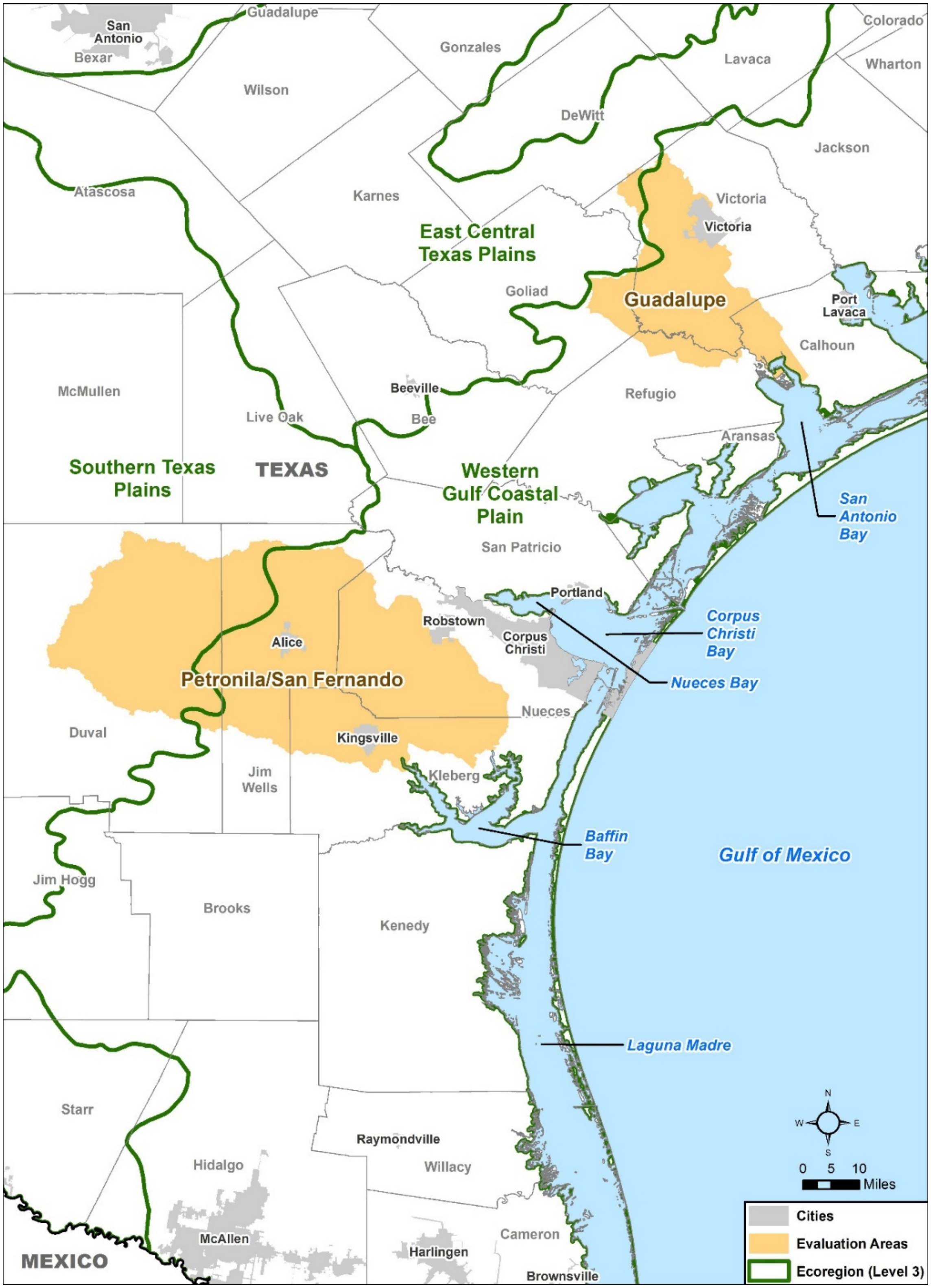


Figure 3-1 Nutrient Load and Source Evaluation Areas

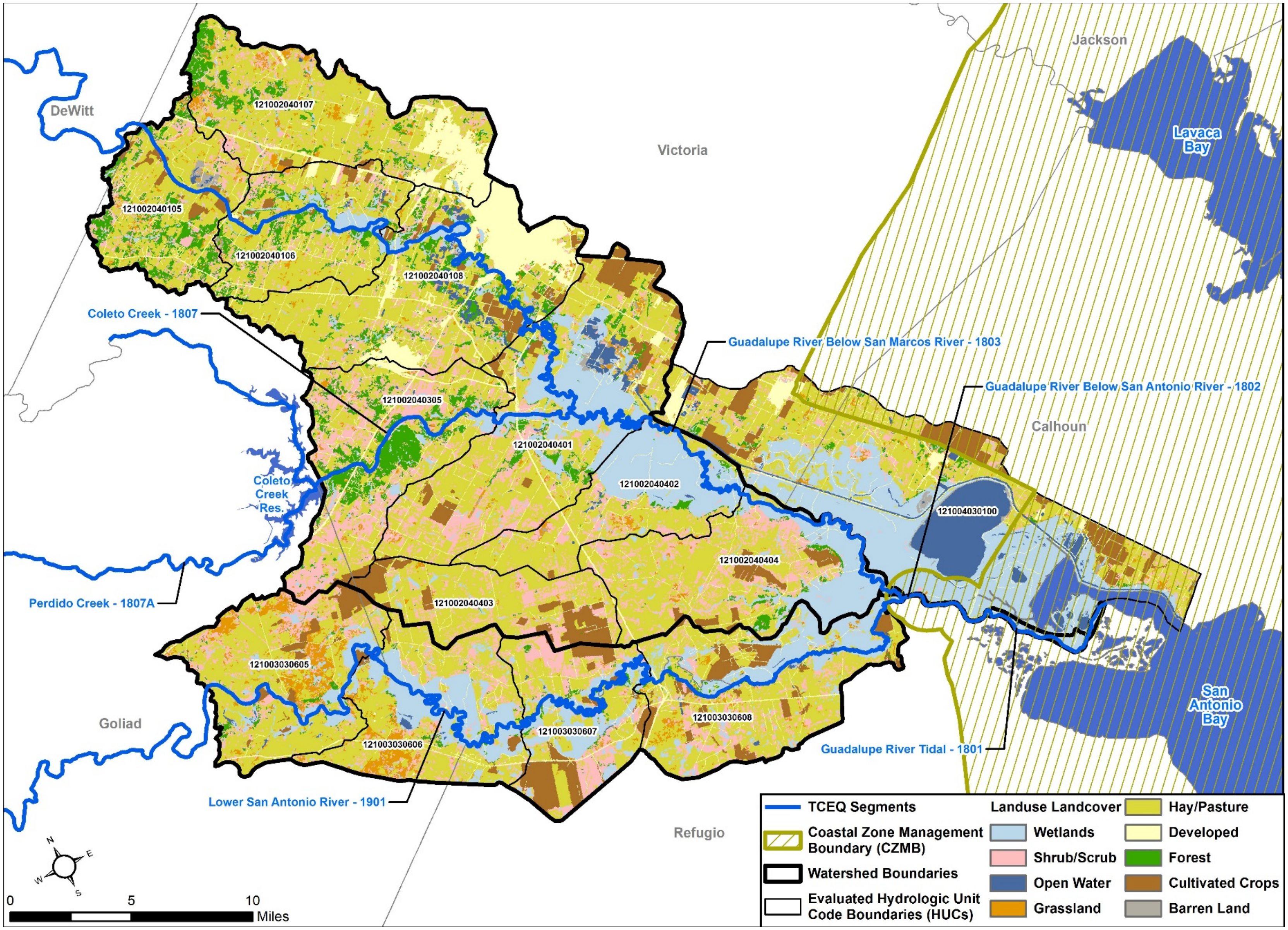


Figure 3-2 Lower Guadalupe River Watershed Land Use and Land Cover

Most of the Lower Guadalupe watershed is in Victoria County; however, parts of Goliad, Calhoun, and Refugio counties are also included.

The Guadalupe River Tidal (segment 1801) section is an 11-mile marshy, tidal reach extending one-half mile downstream of the GBRA Salt Water Dam to San Antonio Bay. Upstream of the Salt Water Barrier to the confluence of the San Antonio River, the Guadalupe River below San Antonio River (0.4-mile long segment 1802) is a slow-moving coastal river characterized by log jams and fractured flow patterns. The 75-mile portion of the Guadalupe River below San Marcos (lower part of segment 1803) included in the study area is a slow, coastal river with silty substrates and lined with pecan forest bottomlands. The river is subject to relatively frequent flooding, inundating the riparian zones and allowing for the exchange of sediment and woody debris between the river and the floodplain (GBRA 2013). It flows south past the cities of Cuero and Victoria.

Coleto Creek, downstream of the Coleto Creek Reservoir, is approximately 15 miles long with a median flow of 5.6 cfs (GBRA 2013). Flow is dependent on releases from the reservoir. The portion of the Lower San Antonio River (segment 1901) evaluated in this assessment includes four 12-digit HUCs upstream of the confluence with the Guadalupe River.

3.2.1 Land Use and Land Cover

Tidal marshes and riparian wetlands dominate the main river corridors. Uplands are primarily used for pasture, with cultivated cropland and scrubland interspersed throughout. Further upstream in the Coleto Creek and Guadalupe River riparian zones, tracts of forested bottomlands are present. The acreages and percentages of the land use/land cover categories presented in Table 3-1 were derived from the 2011 National Land Cover Database (NLCD) (USGS 2011). The NLCD data were reclassified into categories that generally correspond to pollutant source categories discussed later in Section 3.2.

3.2.2 Beneficial Uses and Impairments, Other Ongoing Studies and Projects

Bacterial impairments on Sandies and Elm Creeks were being investigated in the total maximum daily load (TMDL) project that finished data collection in 2008. This TMDL was never finalized due to stakeholder concerns about an appropriate contact recreational use designation (GBRA 2013).

A general use nitrate-nitrogen concern was identified in the 2014 Texas Integrated Report on assessment unit 1803_01, which includes the lower 25 miles of the segment (Table 3-2). The average nitrate-nitrogen value was assessed at 8.47 mg/L, which was more than four times the concern screening level of 1.95 mg/L. The elevated nitrate concentrations were not identified in any of the four other assessment units of the segment, which were all located upstream of the confluence with Coleto Creek (TCEQ 2014a). This concern was most likely because data collection from a historical monitoring station (16579) was discontinued in 2006 after the station was found to be located within the mixing zone of an industrial wastewater discharge and therefore not representative of ambient conditions in this portion of the stream. An alternative monitoring station has not been established in this assessment unit due to site access concerns in this portion of the river (GBRA 2017).

Table 3-1 Land Use and Land Cover Classifications in the Lower Guadalupe Watershed

Land Use Categories										
Hydrologic Unit Code	Open Water	Developed	Barren Land	Forest	Shrub/Scrub	Grassland	Hay/Pasture	Cultivated Crops	Wetlands	Total Area
Acres of Land										
121102040105	189	936	306	3,410	3,140	753	8,714	761	231	18,440
121102040106	279	1,382	53	2,406	2,347	549	9,982	554	1,555	19,106
121102040107	37	5,028	27	2,757	3,477	1,577	14,962	132	470	28,467
121102040108	1,194	9,542	45	3,055	3,086	713	14,338	1,590	1,881	35,444
121102040305	128	1,833	83	4,748	8,738	622	8,793	287	1,197	26,428
121102040401	1,449	2,298	358	1,736	5,966	810	16,765	3,359	8,725	41,466
121102040402	292	548	27	292	2,178	307	6,981	48	7,758	18,430
121102040403	0	341	0	32	2,913	118	8,819	3,051	318	15,591
121102040404	204	945	18	667	5,437	205	12,064	1,490	7,558	28,588
121103030605	236	387	3	533	3,771	2,830	12,422	1,677	2,960	24,817
121103030606	337	709	22	228	3,025	1,574	10,283	356	7,086	23,621
121103030607	187	576	16	442	3,833	158	6,085	3,035	3,910	18,242
121103030608	215	1,331	7	290	3,587	673	12,713	2,793	6,664	28,275
121104030100	10,314	4,546	447	826	3,046	907	14,660	5,138	21,054	60,938
Total Acres	15,061	30,401	1,414	21,421	54,543	11,795	157,582	24,269	71,367	387,854
Land Use Percentage										% Total Area
121102040105	1.02%	5.08%	1.66%	18.49%	17.03%	4.08%	47.26%	4.13%	1.25%	4.75%
121102040106	1.46%	7.23%	0.28%	12.59%	12.28%	2.88%	52.24%	2.90%	8.14%	4.93%
121102040107	0.13%	17.66%	0.10%	9.68%	12.21%	5.54%	52.56%	0.46%	1.65%	7.34%
121102040108	3.37%	26.92%	0.13%	8.62%	8.71%	2.01%	40.45%	4.49%	5.31%	9.14%
121102040305	0.49%	6.93%	0.31%	17.97%	33.06%	2.35%	33.27%	1.09%	4.53%	6.81%

Land Use Categories										
Hydrologic Unit Code	**Open Water**	**Developed**	**Barren Land**	**Forest**	**Shrub/Scrub**	**Grassland**	**Hay/Pasture**	**Cultivated Crops**	**Wetlands**	**Total Area**
121102040401	3.49%	5.54%	0.86%	4.19%	14.39%	1.95%	40.43%	8.10%	21.04%	10.69%
121102040402	1.59%	2.97%	0.15%	1.58%	11.82%	1.66%	37.88%	0.26%	42.09%	4.75%
121102040403	0.00%	2.19%	0.00%	0.20%	18.68%	0.76%	56.56%	19.57%	2.04%	4.02%
121102040404	0.71%	3.30%	0.06%	2.33%	19.02%	0.72%	42.20%	5.21%	26.44%	7.37%
121103030605	0.95%	1.56%	0.01%	2.15%	15.19%	11.40%	50.05%	6.76%	11.93%	6.40%
121103030606	1.43%	3.00%	0.09%	0.96%	12.81%	6.66%	43.53%	1.51%	30.00%	6.09%
121103030607	1.02%	3.16%	0.09%	2.42%	21.01%	0.87%	33.36%	16.64%	21.43%	4.70%
121103030608	0.76%	4.71%	0.03%	1.03%	12.69%	2.38%	44.96%	9.88%	23.57%	7.29%
121104030100	16.93%	7.46%	0.73%	1.35%	5.00%	1.49%	24.06%	8.43%	34.55%	15.71%
% of Watershed	3.88%	7.84%	0.36%	5.52%	14.06%	3.04%	40.63%	6.26%	18.40%	100.00%

Table 3-2 Assessment Units in the Lower Guadalupe River Watershed

Segment	Average Concentration When Exceeding the Screening Value (# of Exceedances/# of Records)			
	Nitrate (mg/L)	Ammonia (mg/L)	Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)
1801_01 (Tidal)	2.47 (18/25)	<0.46 (0/26)	<0.66 (0/24)	37.85 (2/25)
1802_01 (Freshwater)	3.13 (45/79)	<0.33 (0/41)	0.71 (2/79)	21.07 (7/80)
1803_01 (Freshwater)	No data[1]			
1803_02 (Freshwater)	No data			
1803_04 (Freshwater)	<1.95 (0/26)	<0.33 (0/26)	<0.69 (0/26)	<14.1 (0/26)
1807_01 (Freshwater)	<1.95 (0/96)	<0.33 (0/60)	<0.69 (0/98)	22.9 (3/97)
1901_01 (Freshwater)	6.72 (68/79)	0.37 (1/41)	1.02 (44/79)	29.25 (16/80)
1901_06 (Freshwater)	6.5 (38/41)	<0.33 (0/41)	0.98 (24/39)	43.67 (3/6)

[1] Data exist for 1803_01 from 2005, but the station is no longer monitored because it is within the mixing zone of a stormwater outfall.

[2] Highlighted values indicate the assessment unit was listed as a concern in 2014 Report.

The average of samples that exceeded the general use nutrient screening level of 1.95 mg/L for nitrate-nitrogen for Segment 1802 is assessed in the Texas Integrated Report as 3.13 mg/L. Other nutrient assessment parameters such as total phosphorus, ammonia nitrogen, and chlorophyll-a were also evaluated with no concerns (TCEQ 2014a).

The 2014 Texas Integrated Report reported 2.47 mg/L as the mean of samples that exceeded the general use nitrate-nitrogen screening level of 1.10 mg/L for tidal waterbodies in Segment 1801. Eighteen of the 25 measurements that were analyzed for the assessment exceeded these screening levels. High nitrate-nitrogen levels may contribute to eutrophic conditions in the waterbody that can lead to low dissolved oxygen concentrations for the aquatic ecosystem. Although nitrate nitrogen levels appeared to be elevated in the last assessment, other nutrients such as ammonia nitrogen and total phosphorus were not concerns. Chlorophyll-*a* is a common response indicator for excessive algae and nutrient enrichment, but these concentrations were also below the assessed screening level (TCEQ 2014a).

According to the 2014 Texas Integrated Report, the Lower San Antonio River is identified as impaired for not supporting the primary contact recreational use. Elevated levels of *E. coli* bacteria have been identified in several reaches throughout the Lower San Antonio River Watershed. A fish community impairment has also been documented. Habitat, nitrate, total phosphorus, and chlorophyll-*a* have been listed as concerns.

3.3 San Fernando Creek Watershed

The San Fernando Creek watershed includes thirty-four 12-digit HUCs. San Fernando Creek is formed by the confluence of Chiltipin and San Diego creeks one-mile northeast of Alice in central Jim Wells County and runs southeast for about 46 miles, forming the Kleberg-Nueces county line, to its mouth on Cayo del Grullo, seven miles southeast of Kingsville in east central Kleberg County. The evaluation area representing the San Fernando watershed covers 814,672 acres (1,273 square miles). Approximately 4 percent of the San Fernando Creek watershed falls within the CZB. The evaluation area includes the entire drainage basin of San Fernando Creek (Figure 3-3), including the tributary Santa Gertrudis Creek, which enters the San Fernando about one mile before spilling into the

Cayo del Grullo arm of the Baffin Bay estuary. San Fernando Creek stream flow is not measured on a regular basis. Portions of the San Fernando Creek watershed fall within Duval, Jim Wells, and Kleberg counties.

San Fernando Creek is an intermittent stream in its upper reaches. Specific information is not available to define the upstream extent of the tidal boundary in the creek. It traverses flat to rolling terrain with local escarpments, surfaced by sandy and clay loams and dark clays that support brush, grasses, cacti, and mesquite. Blue-green algal mats grow in the creek's lowest reaches (TSHA 2018a). While primarily flowing through rural areas, the creek flows through the City of Alice and the City of Kingsville.

3.3.1 Land Use and Land Cover

The land cover of the watershed is dominated by shrubland, especially in its upper reaches. Cropland and pasture begin appearing in the area of Alice and further toward the coast. The land use and land cover categories are summarized in Table 3-4.

3.3.2 Beneficial Uses and Impairments, Other Ongoing Studies and Projects

The creek has had an impairment for bacteria for primary contact recreation since 2006 that is being carried forward in the Draft 2014 Integrated Report. There was a gap in enterococcus sampling, but recent data confirm the impairment. There are several small and medium WWTPs that discharge into the creek. There are also smaller communities on septic systems in the area. *E. coli* data also exceed the standard for primary contact recreation (Nueces River Authority [NRA] 2017). San Fernando Creek has concerns for nitrates, chlorophyll-*a*, and total phosphorus which are highlighted in Table 3-3. There appears to be a decreasing trend for chlorophyll-*a* concentrations, but based on the post-2014 assessment data, concerns will likely remain for these parameters.

Table 3-3 Assessment Units in the San Fernando Creek and Petronila Creek Watersheds

Segment	Average Concentration When Exceeding the Screening Value (# of Exceedances/# of Records)			
	Nitrate (mg/L)	Ammonia (mg/L)	Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)
2203_01 (Tidal)	<0.37 (0/26)	2.81 (1/25)	0.32 (14/22)	87.23 (13/23)
2204_01 (Freshwater)	2.1 (1/35)	<0.33 (0/34)	<0.69 (0/33)	93.76 (29/32)
2204_02 (Freshwater)	2.18 (1/36)	<0.33 (0/35)	1.05 (8/35)	113.68 (26/32)
2492A_01 (Freshwater)	2.35 (20/27)	<0.46 (0/26)	2.5 (26/26)	50.0 (11/25)

Highlighted values indicate the assessment unit was listed as a concern in the 2014 Report.

Figure 3-3 San Fernando Creek and Petronila Creek Watersheds Land Use and Land Cover

Table 3-4 Land Use and Land Cover Classification in the San Fernando Creek Watershed

Hydrologic Unit Code	Land Use Categories									
	Open Water	Developed	Barren Land	Forest	Shrub/Scrub	Grassland	Hay/Pasture	Cultivated Crops	Wetlands	Total
Acres of Land										
121102040101	0	1,036	62	723	19,839	1,161	607	0	773	24,201
121102040102	0	426	2	323	17,452	969	1,178	0	570	20,920
121102040103	0	781	4	137	7,516	775	2,231	0	487	11,930
121102040104	0	440	3	90	17,274	1,048	4,288	0	529	23,671
121102040105	0	545	65	154	14,197	977	2,254	0	484	18,676
121102040106	0	677	8	57	18,098	730	4,514	1,012	684	25,780
121102040107	0	805	53	338	12,453	273	3,147	2,633	605	20,306
121102040108	0	782	48	171	13,183	523	2,679	1,901	692	19,978
121102040109	0	917	168	509	11,055	710	4,675	7,639	1,088	26,760
121102040201	6	1,579	46	1,003	10,575	494	9,089	6,269	1,502	30,564
121102040202	6	1,481	55	825	8,202	739	10,293	7,645	850	30,096
121102040203	112	1,720	81	65	17,233	683	6,020	4,647	1,599	32,160
121102040204	30	917	16	50	5,035	337	4,437	2,930	410	14,161
121102040205	73	2,692	128	110	11,024	1,261	7,995	5,673	533	29,489
121102040206	22	2,499	212	111	1,487	982	2,196	3,095	162	10,765
121102040301	0	551	241	395	17,115	3,324	3,856	0	1,149	26,631
121102040302	0	596	102	103	15,572	1,469	5,111	0	853	23,806
121102040303	0	399	7	35	7,752	652	4,959	107	479	14,389
121102040304	0	878	8	80	15,610	665	2,745	643	879	21,508
121102040305	2	1,322	43	366	19,287	1,114	5,183	341	1,306	28,965
121102040306	0	672	3	180	16,387	1,104	5,901	4	913	25,164

Land Use Categories										
Hydrologic Unit Code	**Open Water**	**Developed**	**Barren Land**	**Forest**	**Shrub/Scrub**	**Grassland**	**Hay/Pasture**	**Cultivated Crops**	**Wetlands**	**Total**
121102040307	0	453	7	32	7,111	176	2,163	0	334	10,275
121102040308	0	508	18	8	7,637	556	2,922	0	468	12,118
121102040309	0	1,061	47	97	12,685	594	3,546	244	643	18,917
121102040310	1	1,774	7	256	7,570	356	5,965	442	396	16,767
121102040401	13	1,700	123	142	25,018	408	9,204	0	2,654	39,263
121102040402	0	998	7	265	11,273	381	4,830	151	993	18,897
121102040403	16	1,786	28	721	20,615	490	9,471	4,321	1,865	39,314
121102040404	195	4,669	115	990	6,583	727	6,928	7,478	1,349	29,033
121102040405	0	5,212	76	1,383	5,634	627	7,676	14,760	953	36,320
121102040406	9	575	39	264	5,046	350	4,358	3,233	569	14,443
121102040407	71	4,551	630	444	9,755	1,480	6,915	18,647	1,193	43,687
121102040408	89	1,739	71	16	462	269	526	20,771	92	24,036
121102040409	10	4,951	37	437	11,796	749	9,144	3,668	893	31,685
Total	656	51,690	2,560	10,878	407,529	27,148	167,007	118,254	28,948	814,672
Land Use Percentage										**% Total Area**
121102040101	0.0%	4.3%	0.3%	3.0%	82.0%	4.8%	2.5%	0.0%	3.2%	3.0%
121102040102	0.0%	2.0%	0.0%	1.5%	83.4%	4.6%	5.6%	0.0%	2.7%	2.6%
121102040103	0.0%	6.5%	0.0%	1.1%	63.0%	6.5%	18.7%	0.0%	4.1%	1.5%
121102040104	0.0%	1.9%	0.0%	0.4%	73.0%	4.4%	18.1%	0.0%	2.2%	2.9%
121102040105	0.0%	2.9%	0.3%	0.8%	76.0%	5.2%	12.1%	0.0%	2.6%	2.3%
121102040106	0.0%	2.6%	0.0%	0.2%	70.2%	2.8%	17.5%	3.9%	2.7%	3.2%
121102040107	0.0%	4.0%	0.3%	1.7%	61.3%	1.3%	15.5%	13.0%	3.0%	2.5%
121102040108	0.0%	3.9%	0.2%	0.9%	66.0%	2.6%	13.4%	9.5%	3.5%	2.5%

Land Use Categories										
Hydrologic Unit Code	Open Water	Developed	Barren Land	Forest	Shrub/Scrub	Grassland	Hay/Pasture	Cultivated Crops	Wetlands	Total
121102040109	0.0%	3.4%	0.6%	1.9%	41.3%	2.7%	17.5%	28.5%	4.1%	3.3%
121102040201	0.0%	5.2%	0.1%	3.3%	34.6%	1.6%	29.7%	20.5%	4.9%	3.8%
121102040202	0.0%	4.9%	0.2%	2.7%	27.3%	2.5%	34.2%	25.4%	2.8%	3.7%
121102040203	0.3%	5.3%	0.3%	0.2%	53.6%	2.1%	18.7%	14.4%	5.0%	3.9%
121102040204	0.2%	6.5%	0.1%	0.4%	35.6%	2.4%	31.3%	20.7%	2.9%	1.7%
121102040205	0.2%	9.1%	0.4%	0.4%	37.4%	4.3%	27.1%	19.2%	1.8%	3.6%
121102040206	0.2%	23.2%	2.0%	1.0%	13.8%	9.1%	20.4%	28.8%	1.5%	1.3%
121102040301	0.0%	2.1%	0.9%	1.5%	64.3%	12.5%	14.5%	0.0%	4.3%	3.3%
121102040302	0.0%	2.5%	0.4%	0.4%	65.4%	6.2%	21.5%	0.0%	3.6%	2.9%
121102040303	0.0%	2.8%	0.0%	0.2%	53.9%	4.5%	34.5%	0.7%	3.3%	1.8%
121102040304	0.0%	4.1%	0.0%	0.4%	72.6%	3.1%	12.8%	3.0%	4.1%	2.6%
121102040305	0.0%	4.6%	0.1%	1.3%	66.6%	3.8%	17.9%	1.2%	4.5%	3.6%
121102040306	0.0%	2.7%	0.0%	0.7%	65.1%	4.4%	23.4%	0.0%	3.6%	3.1%
121102040307	0.0%	4.4%	0.1%	0.3%	69.2%	1.7%	21.1%	0.0%	3.2%	1.3%
121102040308	0.0%	4.2%	0.2%	0.1%	63.0%	4.6%	24.1%	0.0%	3.9%	1.5%
121102040309	0.0%	5.6%	0.2%	0.5%	67.1%	3.1%	18.7%	1.3%	3.4%	2.3%
121102040310	0.0%	10.6%	0.0%	1.5%	45.1%	2.1%	35.6%	2.6%	2.4%	2.1%
121102040401	0.0%	4.3%	0.3%	0.4%	63.7%	1.0%	23.4%	0.0%	6.8%	4.8%
121102040402	0.0%	5.3%	0.0%	1.4%	59.7%	2.0%	25.6%	0.8%	5.3%	2.3%
121102040403	0.0%	4.5%	0.1%	1.8%	52.4%	1.2%	24.1%	11.0%	4.7%	4.8%
121102040404	0.7%	16.1%	0.4%	3.4%	22.7%	2.5%	23.9%	25.8%	4.6%	3.6%
121102040405	0.0%	14.3%	0.2%	3.8%	15.5%	1.7%	21.1%	40.6%	2.6%	4.5%
121102040406	0.1%	4.0%	0.3%	1.8%	34.9%	2.4%	30.2%	22.4%	3.9%	1.8%

Land Use Categories										
Hydrologic Unit Code	**Open Water**	**Developed**	**Barren Land**	**Forest**	**Shrub/Scrub**	**Grassland**	**Hay/Pasture**	**Cultivated Crops**	**Wetlands**	**Total**
121102040407	0.2%	10.4%	1.4%	1.0%	22.3%	3.4%	15.8%	42.7%	2.7%	5.4%
121102040408	0.4%	7.2%	0.3%	0.1%	1.9%	1.1%	2.2%	86.4%	0.4%	3.0%
121102040409	0.0%	15.6%	0.1%	1.4%	37.2%	2.4%	28.9%	11.6%	2.8%	3.9%
% of Watershed	0.1%	6.3%	0.3%	1.3%	50.0%	3.3%	20.5%	14.5%	3.6%	100.0%

3.4 Petronila Creek Watershed

The Petronila Creek watershed includes seventeen 12-digit HUCs. Located southwest of Corpus Christi, Petronila Creek (Figure 3-3) runs 44 miles from the confluence of Agua Dulce and Banquete creeks to its mouth on the Cayo del Mazon arm of the Baffin Bay estuary. The area evaluated includes the tidal and above-tidal portions of the creek and totals 432,473 acres (676 square miles). Approximately 39 percent of the Petronila Creek watershed falls within the CZB. Portions of the Petronila Creek watershed fall within Jim Wells, Nueces, and Kleberg counties.

Petronila Creek is fed by several tributaries that serve as drainage ditches for agricultural cropland. The main stem of the creek (sum of the below and above tidal segments) is approximately 45 miles long. There are no routinely monitored gauge stations on Petronila Creek to provide a mean or median streamflow.

The surrounding terrain varies from flat local shallow depressions to some locally dissected rolling areas. It is surfaced by clay and sandy loams that support water-tolerant hardwoods, conifers, grasses, some scrub brush, and cacti. The last six miles of the creek lie amongst tidal flats surfaced by blue-green algal mats and crustaceans (TSHA 2018b).

3.4.1 Land Use and Land Cover

The watershed is primarily farmland interspersed with several small communities and cities. Petronila Creek flows through the City of Driscoll, at US 77. A few small WWTPs discharge to this segment, and a hazardous waste landfill is permitted for stormwater discharge.

The Petronila Creek catchment area is dominated by cropland (Table 3-5) primarily planted to cotton and grain sorghum, with smaller acreage planted to corn and other vegetables. These are dryland crops, and irrigation is not a significant consideration (Corpus Christi Bay National Estuary Program [CCBNEP] 1996). Other land cover of note includes scrub that serve as rangeland for livestock.

3.4.2 Beneficial Uses and Impairments

Petronila Creek Above Tidal (2204) has been impaired for chloride, sulfates, and total dissolved solids (TDS) since 1999. TMDLs for chloride, sulfate, and TDS were approved in 2007. As a result of the implementation plan, soils of high chloride content were identified and removed, a continuous water quality monitoring (CWQM) station was installed and monitored, and groundwater-to-surface water interactions were studied (TCEQ 2014b). The CWQM station was discontinued in February 2016 after it was determined that sufficient data had been gathered to help understand the relationship between water level and pollutant concentrations (NRA 2017). Petronila Creek Above Tidal (2204) also has concerns for chlorophyll-*a*, which is highlighted in Table 3-3.

Table 3-5 Land Use and Land Cover Classification in the Petronila Creek Watershed

Land Use Categories										
Hydrologic Unit Code	Open Water	Developed	Barren Land	Forest	Shrub/ Scrub	Grassland	Hay/ Pasture	Cultivated Crops	Wetlands	Total Area
Acres of Land										
121102050501	4	1,517	50	111	8,953	376	2,352	10,377	601	24,341
121102050502	0	1,119	241	621	4,787	228	1,912	7,971	686	17,563
121102050503	24	2,566	172	813	9,918	498	5,478	11,345	962	31,775
121102050504	0	916	14	787	6,338	228	3,854	14,327	884	27,346
121102050505	22	1,859	25	263	3,996	684	4,186	20,475	631	32,142
121102050506	52	1,649	52	57	683	963	2,928	22,809	603	29,795
121102050601	48	781	140	12	352	346	731	21,218	230	23,857
121102050602	0	1,065	70	230	1,263	447	1,906	27,405	653	33,038
121102050603	5	1,012	102	23	402	175	718	23,949	364	26,751
121102050604	0	1,280	126	93	968	157	1,286	25,111	268	29,289
121102050605	0	482	33	2	188	28	107	14,179	179	15,198
121102050606	61	944	151	23	372	274	320	25,209	431	27,785
121102050607	125	1,058	389	173	1,039	561	362	19,313	529	23,547
121102050608	104	974	562	117	4,058	2,181	2,225	15,416	1,022	26,657
121102050801	0	591	6	2	166	79	72	28,553	25	29,494
121102050802	3	245	84	4	1,175	199	609	16,050	615	18,983
121102050803	45	471	776	53	3,903	436	236	8,575	416	14,911
Total	492	18,528	2,993	3,382	48,560	7,858	29,281	312,280	9,099	432,473
Land Use Percentage										**% Total Area**
121102050501	0.0%	6.2%	0.2%	0.5%	36.8%	1.5%	9.7%	42.6%	2.5%	6.6%
121102050502	0.0%	6.4%	1.4%	3.5%	27.3%	1.3%	10.9%	45.4%	3.9%	4.8%

Land Use Categories										
Hydrologic Unit Code	**Open Water**	**Developed**	**Barren Land**	**Forest**	**Shrub/ Scrub**	**Grassland**	**Hay/ Pasture**	**Cultivated Crops**	**Wetlands**	**Total Area**
121102050503	0.1%	8.1%	0.5%	2.6%	31.2%	1.6%	17.2%	35.7%	3.0%	8.6%
121102050504	0.0%	3.3%	0.1%	2.9%	23.2%	0.8%	14.1%	52.4%	3.2%	7.4%
121102050505	0.1%	5.8%	0.1%	0.8%	12.4%	2.1%	13.0%	63.7%	2.0%	8.7%
121102050506	0.2%	5.5%	0.2%	0.2%	2.3%	3.2%	9.8%	76.6%	2.0%	8.1%
121102050601	0.2%	3.3%	0.6%	0.0%	1.5%	1.4%	3.1%	88.9%	1.0%	6.5%
121102050602	0.0%	3.2%	0.2%	0.7%	3.8%	1.4%	5.8%	82.9%	2.0%	9.0%
121102050603	0.0%	3.8%	0.4%	0.1%	1.5%	0.7%	2.7%	89.5%	1.4%	7.2%
121102050604	0.0%	4.4%	0.4%	0.3%	3.3%	0.5%	4.4%	85.7%	0.9%	7.9%
121102050605	0.0%	3.2%	0.2%	0.0%	1.2%	0.2%	0.7%	93.3%	1.2%	4.1%
121102050606	0.2%	3.4%	0.5%	0.1%	1.3%	1.0%	1.2%	90.7%	1.6%	7.5%
121102050607	0.5%	4.5%	1.7%	0.7%	4.4%	2.4%	1.5%	82.0%	2.2%	6.4%
121102050608	0.4%	3.7%	2.1%	0.4%	15.2%	8.2%	8.3%	57.8%	3.8%	7.2%
121102050801	0.0%	2.0%	0.0%	0.0%	0.6%	0.3%	0.2%	96.8%	0.1%	6.8%
121102050802	0.0%	1.3%	0.4%	0.0%	6.2%	1.0%	3.2%	84.5%	3.2%	4.4%
121102050803	0.3%	3.2%	5.2%	0.4%	26.2%	2.9%	1.6%	57.5%	2.8%	3.4%
% of Watershed	0.1%	4.3%	0.7%	0.8%	11.2%	1.8%	6.8%	72.2%	2.1%	100.0%

The Railroad Commission of Texas (RRC) investigated whether oil and gas operations were contributing to high salinity in Petronila Creek. In 2008, the Phase III report concluded that oil and gas wasteland fields and other unknown sources were contributing chlorides to Petronila Creek through groundwater. The RRC has also been implementing a program to plug/abandon wells and remove contaminated soils (NRA 2017).

Petronila Creek Tidal (2203) has been listed as having an impairment for bacteria for primary contact recreation since the 2010 Texas Integrated Report. The segment also has concerns for pH, total phosphorus, and chlorophyll-*a,* which are highlighted in Table 3-3. Based on post-2014 assessment data, the segment will most likely remain listed for the impairment and all concerns.

3.5 Data Inputs for Nutrient Load Modeling

Analysts applied the Spreadsheet Tool for Estimating Pollutant Loading (STEPL) to obtain an estimate of nonpoint source pollutant loading delivered from sixty-five 12-digit HUCs that flow to the San Antonio Bay and Baffin Bay systems. This assessment estimated loads of total nitrogen, phosphorus, and sediments from individual 12-digit HUC watersheds draining to the bay systems. The geographic area for which these estimates were derived for the San Antonio Bay and Baffin Bay systems are displayed in Figures 3-2 and 3-3.

STEPL provides a user-friendly Visual Basic interface to create a customized spreadsheet-based model in Microsoft Excel. The model employs simple algorithms to calculate nutrient and sediment loads from different land uses. STEPL can also estimate the load reductions that would result from the implementation of various BMPs. The model computes surface runoff, nutrient loads (including nitrogen, phosphorus, and 5-day biological oxygen demand), and sediment delivery based on various land uses and management practices. STEPL estimates loading from the following categories: urban, cropland, pastureland, forest, feedlots, septic tanks, user-defined lands, gully and streambank erosion, and groundwater. Urban loads can be further subdivided into commercial, industrial, institutional, transportation, multi-family residential, single-family residential, cultivated, vacant, and open space. However, this subdivision was not conducted in this assessment.

Data inputs to STEPL that were extracted from geographic data included land use acreages, livestock populations, number of feedlots, selected soil properties, and number of households and population using septic tanks.

Land Use Using GIS, land use acreages for each 12-digit HUC were extracted from the 2011 USGS NLCD at 30-m resolution. STEPL uses the following land use categories: cropland, urban, forest, pasture, feedlots, and user-defined. Woody wetlands and shrub/scrubland were grouped with deciduous, evergreen, and mixed forest in the forest category. Developed lands were handled in two ways. First, developed (open) land was used as such in STEPL. Second, the low-, medium- and high-density developed lands enumerated in the NLCD were divided into the STEPL categories single-family residential, multi-family residential, institutional, transportation, industrial, and commercial. This division was performed by manually inspecting satellite imagery of land features identified as developed land in the NLCD dataset. Grasslands and pasture were grouped into the pasture/hay category in STEPL. Land areas covered by permanent water features were not considered in STEPL. Cropland acreage was used as such. The remaining two land uses in the NLCD (barren and herbaceous wetlands) were placed into the “user-defined” category in STEPL.

Soil Using GIS, the acreage of the soil map unit for each 12-digit HUC was extracted using GIS from the Natural Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database. Overall soil properties for each HUC were averages of surface soil layers for all map units covering at least 1,000 acres in a watershed. The key soil properties used in STEPL included the hydrologic soil group and the soil erodibility factor (K).

Septic The number of households in each HUC using septic systems for waste disposal, and the average number of persons in each household, were estimated based on the 1990 census data, as provided by the STEPL data extraction tool (http://it.tetratech-ffx.com/steplweb/steplweb.html). The percentage of septic systems exhibiting chronic failure were estimated in surveys performed by Reed, Stowe, and Yanke (2001, 2002) for the Texas Onsite Wastewater Treatment Research Council. These estimates were provided for five regions in Texas, two of which occur in the area. Duval, Jim Wells, Goliad, and Victoria counties occur in on-site wastewater region 3, for which a septic chronic malfunction rate of 4.1% was estimated. Calhoun, Kleberg, Nueces, and Refugio counties occur in region 4, for which a 12% malfunction rate was estimated. The number of people directly discharging domestic wastewater without treatment was assumed to be negligible.

Livestock Agricultural animal populations for each HUC were estimated from the 2012 agricultural census of the USDA's National Agricultural Statistical Service. These data are only provided at a county level. However, HUC-based estimates were retrieved using the STEPL data extraction tool. STEPL also uses the livestock numbers in a HUC to estimate the number of feedlots in a watershed. STEPL estimates water quality impacts associated with presumed feedlots based on the assumption that collection and disposal of livestock manure is applied year-round to crop land or pasture land.

While the STEPL assumptions regarding the occurrence of feedlots in these watersheds are questionable, it should be noted that the STEPL-predicted water quality impacts attributed to feedlots in this report are insignificant – they are predicted to comprise less than 0.2% of total nitrogen and phosphorus loads in the Petronila Creek watershed and less than 2% of total nitrogen and phosphorus in the San Fernando Creek watershed. In other words, since there are no feedlots and application of manure does not occur in the Petronila or San Fernando creek watersheds (according to local NRCS technical specialists), targeting reductions of manure application to cropland and pasture land from livestock appears unnecessary.

Erosion STEPL applies the Universal Soil Loss Equation to estimate soil erosion. In general, the default STEPL estimates of the R, LS, C, and P factors by land use for each county were applied, while K factors were extracted from SSURGO, then averaged by HUC. However, because the erosional characteristics of barren land and herbaceous wetlands in the "user-defined" land use category are very different, the cover factor C was adjusted between 1 (no cover) for barren lands and 0.001 (for wetlands) based on the percentage of the barren acreage in the "user-defined" category. Thus, if barren lands comprised 25% of the "user-defined" area, the C factor was 0.25.

Runoff The average nitrogen, phosphorus, and suspended solids concentrations in runoff from developed lands were the median event mean concentrations (EMCs) for the CCBNEP (1996). The EMC for rangeland was applied to forest/scrubland because the primary type of forest in this area is the mesquite scrub forest type. The default STEPL concentrations for cropland and pasture vary with manure application, which in turn depends on the density of livestock on pastureland in the watershed. The STEPL default concentrations were used in these circumstances. Reference runoff curve numbers were those from the NRCS (1986).

Other Notes

- Loads were not estimated for groundwater and gully and streambank erosion due to a lack of available data.
- The county average soil nitrogen and phosphorus concentration estimates included in the STEPL model were applied without further modification due to a lack of local data.
- The county average annual rainfall, frequency, and intensity data estimates in the STEPL model were used without further modification.

- Point sources were not included in these loading estimates. Also, these loading estimates are based on loads from land to the stream and do not include instream attenuation, losses and transformations.

3.6 Other Factors Influencing Instream Nutrient Concentrations

A study of nutrient pollution in surface waters would not be complete without consideration of all potential sources. Some of the identified pollutant sources have been considered and incorporated into the previous screening analysis. Others have not explicitly been components of modeling or analysis and are not suitable as factors in this evaluation. While the focus of this report is identifying watersheds that provide the greatest opportunity for nutrient nonpoint source reduction, the following discussion is an acknowledgement of typical sources of nutrients that either represent direct discharges or were not explicitly modeled.

Wastewater Treatment Plants Permitted wastewater discharges are known sources of nutrient loading to receiving waters. Permitted wastewater discharges include various municipal and industrial WWTPs that are point sources of pollution permitted under the NPDES program administered by TCEQ. Most municipal and industrial WWTPs do not currently have specific effluent limits for nutrients. When operated efficiently, WWTPs are effective at reducing nutrient loads in wastewater effluent discharged to receiving waters. However, when a sewer collection system receives excessive infiltration/inflow, the WWTP may be overwhelmed and not have the capacity to properly treat the wastewater resulting in an unauthorized wastewater bypass. No matter the reasons, the release of improperly treated wastewater from a WWTP is a permit violation. The consequence is that it is possible for the municipal wastewater bypasses to contain elevated nutrient levels and other untreated pollutants. Industrial WWTP discharges, which are governed by industry-specific effluent guidelines, can be a source of nutrient loading to receiving waters. The number and location of municipal and industrial WWTPs in each watershed are presented in Figures 3-4 and 3-5; however, the contributions of those sources are not incorporated into the resulting load estimates.

Wildlife There are no specific population estimates available for the wide array of wildlife species in the watershed. However, it is acknowledged that wildlife populations are a potential source of nutrients. Wildlife contributes urine and fecal matter to the riparian corridors as well as to most upland areas. For the purposes of this evaluation, it is assumed that the contributions of wildlife to nutrient concentrations in waterways are background sources that are uniform across each watershed.

Feral Hogs (Invasive Species) Feral hogs in Texas are an invasive species with populations estimated at over 2 million head (Texas A&M AgriLife Extension Service 2012). Their high rate of reproduction, spending most of each day in secluded habitats of riparian corridors, and their destructive rooting activities make feral hogs particularly detrimental to water quality. Hogs prefer bottomlands such as rivers, creeks, and drainage swales when available. Hogs are generally found in dense vegetation cover often associated with water, but also do well in drought-prone environments. During hot weather, feral hogs enjoy wallowing in wet, muddy areas and are never far from dense protective cover. They tend to concentrate in areas of food availability, especially where there are nut-producing trees or agricultural crops (Taylor 2003). Typical of all wild mammals, urine and feces from feral hogs contribute nutrients to streams. Their destructive foraging habits in riparian corridors can also be the cause of significant sediment loads to streams. Hog numbers specific to the evaluation areas are not available to use as a discriminating factor in nutrient loads among HUCs, but populations are acknowledged to contribute to nutrient loads.

<u>Concentrated Animal Feeding Operations (CAFOs)</u> An animal feeding operation is defined by TCEQ in rule (30 Texas Administrative Code Chapter 321, Subchapter B) as a lot or facility, other than an aquatic animal production facility, where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period and the animal confinement areas do not sustain crops, vegetation, forage growth, or postharvest residues in the normal growing season over any portion of the lot or facility. Animal counts are then applied to determine if an operation is a CAFO and therefore a point source that requires a permit. The animal thresholds outlined by rule are:

- A large CAFO: 700 mature dairy cattle (whether milkers or dry cows); and
- A medium CAFO: 300 to 999 cattle other than mature dairy cattle or veal calves. Cattle includes but is not limited to heifers, steers, bulls, and cow/calf pairs; or 200 to 699 mature dairy cattle (whether milkers or dry cows) (TCEQ 2009).

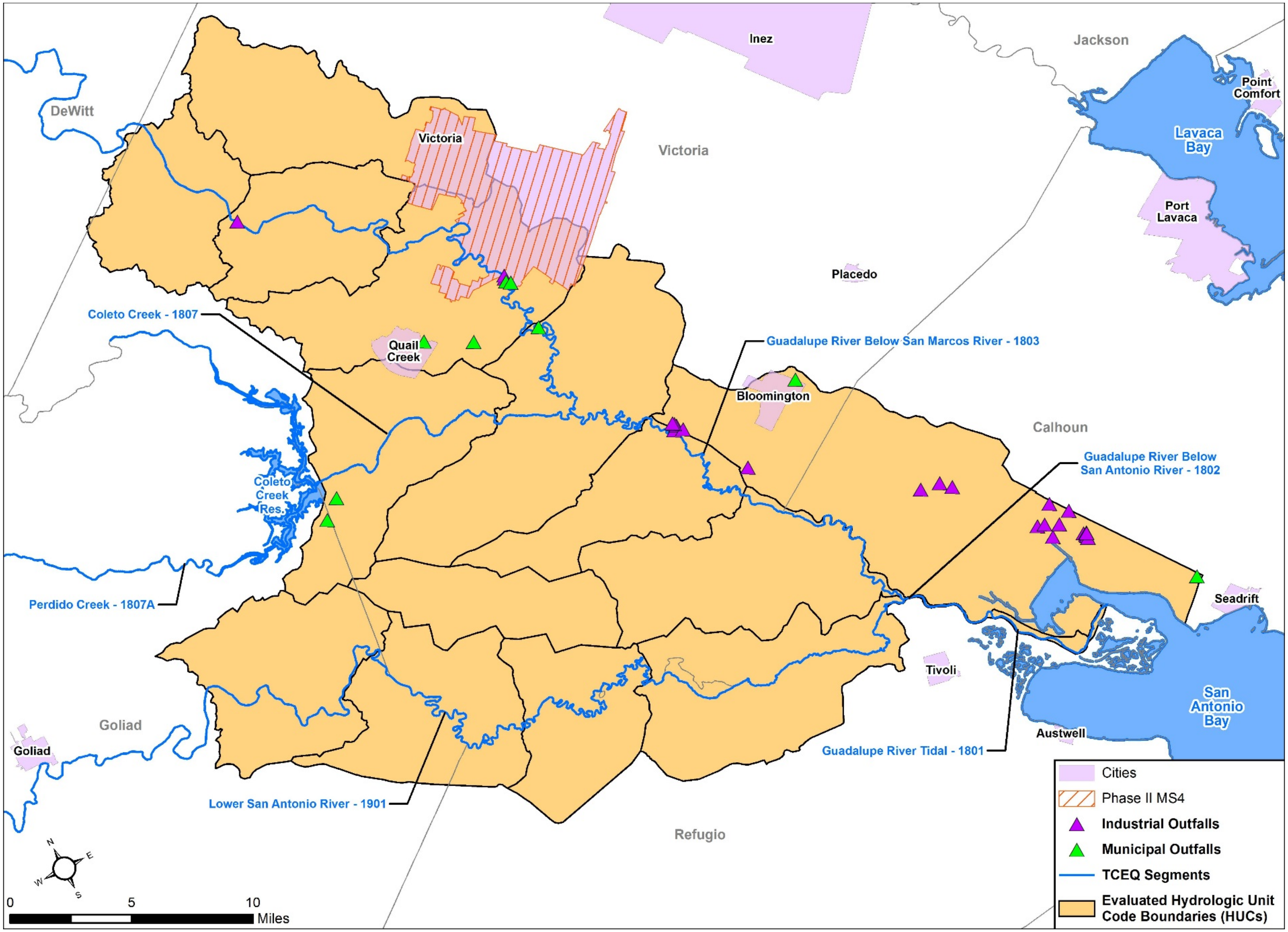


Figure 3-4 Permitted Dischargers in the Lower Guadalupe River Watershed

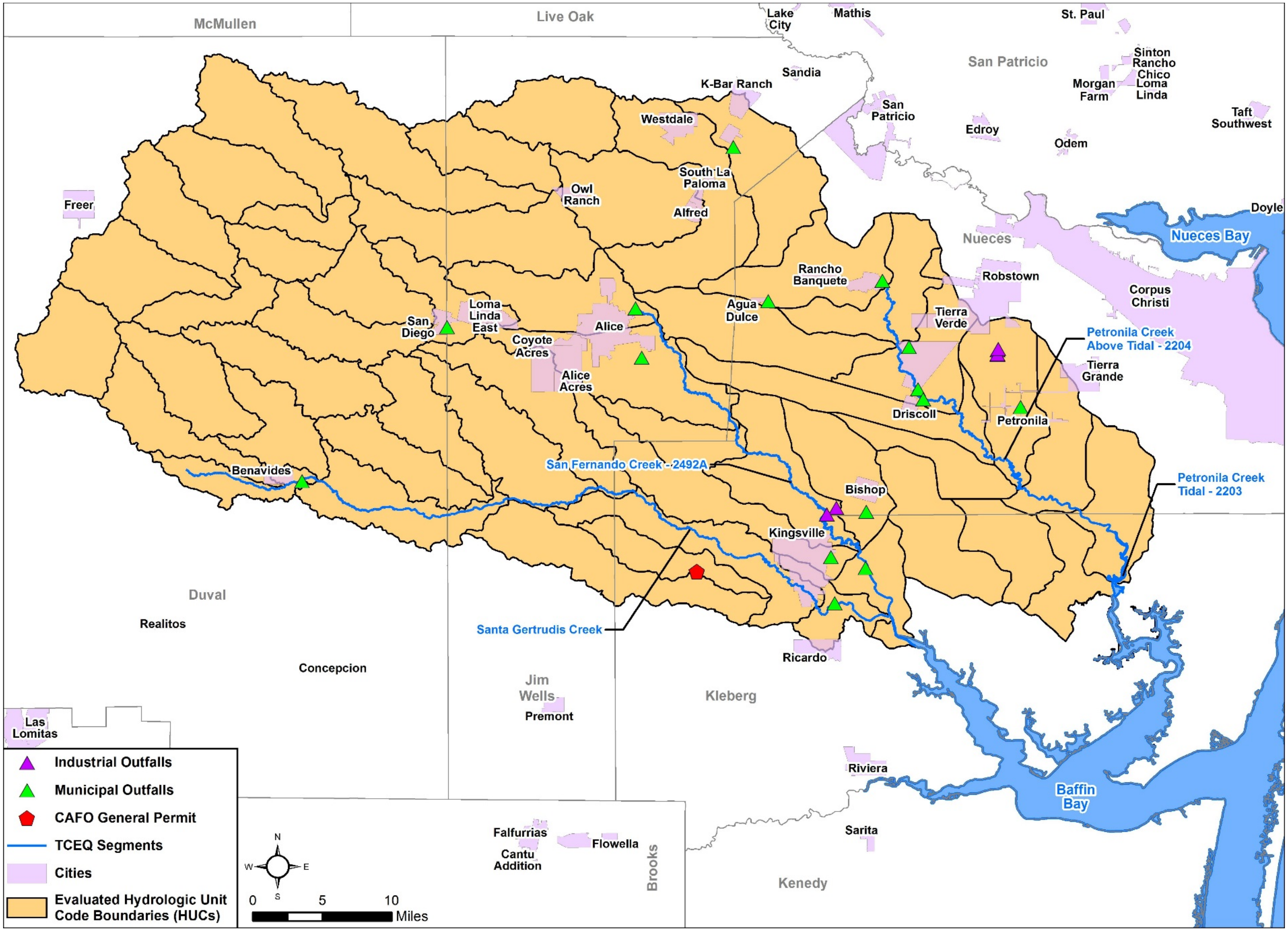


Figure 3-5 Permitted Dischargers in the San Fernando Creek and Petronila Creek Watersheds

The only CAFO within the evaluation area (Figure 3-5) is in the San Fernando Creek watershed. This CAFO has a general permit and operates in accordance with the requirements and BMPs prescribed in the TCEQ General Permit to Discharge Wastes, General Permit Number TXG920000 (TCEQ 2009). Manure and wastewater from CAFOs contain pollutants such as phosphorus and ammonia (EPA 2013). However, CAFOs are recognized as no-discharge facilities and are not considered to contribute pollutant loads when designed and operated properly. As a result, CAFOs are not considered a direct discharge source of nutrients. Under catastrophic events defined as the 25-year, 24-hour rainfall event, the potential exists for bacteria and nutrients to be directly discharged from CAFO retention facilities to a receiving water.

Urban Runoff Developed land is already considered in the land use inputs to STEPL. However, there are direct discharges associated with municipalities as stormwater outfalls. Although the percentage of developed land (residential, commercial, and industrial land use/land cover) in all three watersheds is less than 8 percent, nutrient loads are produced from this land use category when considering the watershed as a whole. Within each 12-digit HUC, the buildup of nutrient loads occurs on developed land in a variety of ways.

Sources of nutrients originating from cities, towns, and subdivisions that build up on developed land can originate from domestic pets, livestock, wildlife, local and regional atmospheric deposition, use of detergents, gardening, vegetative detritus from urban lawn clippings and leaf litter, and fertilizer application. It is common for houses in small towns to have multiple dogs and cats where most homeowners may not typically pick up pet waste. Livestock such as sheep, goats, ponies, and horses can be found in some developed areas in spaces less than what is typical on rural farms and ranches. Mammalian and avian wildlife are common in urban and residential areas due to the abundance of food sources and protection from hunting and predation. Human waste from failed on-site sewage facilities (OSSFs) may also accumulate in urban or rural residential areas. Nutrients transported from developed land to receiving waters depends on a wide array of factors, including, but not limited to, precipitation amounts, intensity, and duration, land slope, vegetative cover, soil properties, solar radiation, and percentage of impervious cover. The Nationwide Urban Runoff Program, which EPA sponsored in the years 1978 through 1983, showed that stormwater runoff from developed land is a significant source of pollutants (EPA 1983). In the 2004 national study, *Report to Congress: Impacts and Control of CSOs and SSOs*, the annual volume of urban stormwater runoff discharged from municipalities was estimated to be nearly equivalent to the volume of treated wastewater discharged to receiving waters (EPA 2004). Table 3-6 presents an excerpt from the Nationwide Urban Runoff Program study to demonstrate that there are significant differences in nutrient concentrations measured in runoff from urban land use compared to non-urban areas (EPA 1983).

Table 3-6 National Median Event Mean Concentrations for Urban Land Uses

Pollutant	Units	Residential		Mixed		Commercial		Open / Non-Urban	
		Median	CV	Median	CV	Median	CV	Median	CV
Nitrate + Nitrite	µg/L	736	0.83	558	0.67	572	0.48	543	0.91
Total Phosphorus	µg/L	383	0.69	263	0.75	201	0.67	121	1.66
Soluble Phosphorus	µg/L	143	0.46	56	0.75	80	0.71	26	2.11

Source: EPA Nationwide Urban Runoff Program, 1983.

It is important to point out that, from a regulatory perspective, EPA segregates urban runoff into two categories under the CWA. Some areas of developed land in each watershed may fall under the requirements of the NPDES MS4 program. Urban runoff from these areas is considered a permitted point source. The City of Victoria is the only municipality within the three watersheds with a Phase 2 MS4 permit. Urban runoff from developed areas outside areas designated as an MS4 is considered nonpoint source pollution and is not subject to requirements under the NPDES MS4 regulations.

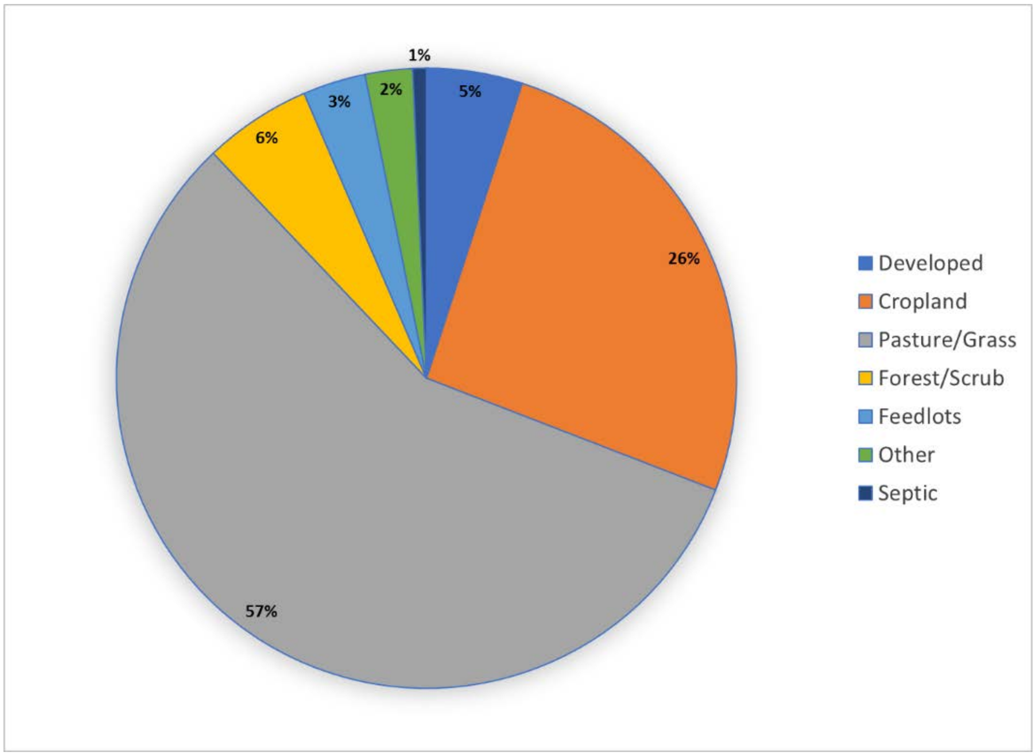
Atmospheric Deposition Previous studies indicate that nitrogen deposition from the atmosphere is a significant contributor of nutrients to the Texas coast (CBBEP 2008). The CBBEP estimates that 46% of the input into the nitrogen budget of the Coastal Bend Bays is attributable to atmospheric deposition. As noted in Section 2.1.1, the lack of monitoring stations makes characterizing nitrogen loads within each 12-digit HUC impossible. Therefore, for the purposes of this study, atmospheric deposition of nutrients is considered a background source and uniform across the Guadalupe and Baffin Bay watershed areas.

3.7 Lower Guadalupe River Watershed - Nutrient Sources and Load Estimates

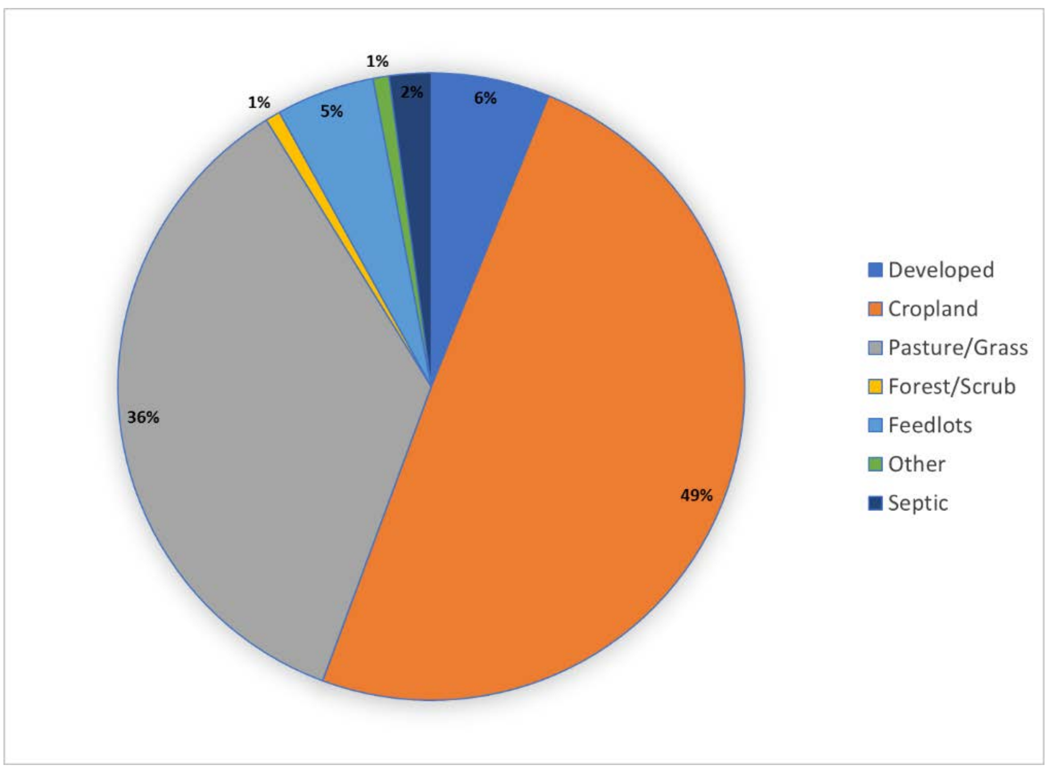
Derived from the STEPL analysis, Figure 3-6 presents the sum of the total nitrogen and phosphorus loads for seven land use categories from the fourteen 12-digit HUCs assessed in the Lower Guadalupe River watershed. Uplands in the watershed are dominated by hay/pasture land, and the streams are flanked by lowland forest floodplains. As indicated in Figure 3-6, it is estimated that 83 to 85 percent of the nutrient load comes from sources associated with pasture/grassland and cropland. Nutrient loads associated with these two land use types may be influenced by land application of livestock manure and/or commercial fertilizer, wildlife populations, feral hog populations, livestock grazing, and hunting camps. Nutrient loads deposited on pasture and crop land can be transported to receiving waters by rainfall runoff. The combined acreage of open water, developed land, barren land, forest, and wetlands accounts for approximately 36 percent of the total acreage in the Lower Guadalupe River watershed. It would not be practical to target nutrient reduction strategies in these land use categories. Conversely, targeting the land area that includes shrub/scrub, grassland, hay/pasture and cultivated crops aligns with agricultural related land use activities associated with the 12-digit HUCs contributing the highest nitrogen and phosphorus loads.

Figures 3-7 and 3-8 show the results of the STEPL modeling for each 12-digit HUC assessed in terms of, respectively, total nitrogen and total phosphorus loads. Nitrogen load estimates in the Lower Guadalupe River watershed generally range from 5.72 pounds per acre per year (lbs/acre/year) to 12.48 lbs/acre/year. Phosphorus loading estimates in the Lower Guadalupe River watershed generally range from 0.47 to 2.01 lbs/acre/year. Appendix D provides a table summarizing the nitrogen and phosphorous yield totals for each 12-digit HUC. It is believed that rainfall runoff (nutrient load) from the largest 12-digit HUC 121004030100 (50,600 acres in Calhoun County) does not flow into the Guadalupe River (1801, 1802 or 1803). Nutrient loads from this HUC drain directly into Greens Lake, Mission Lake, and the Guadalupe Bay arm of San Antonio Bay.

Despite the often-elevated phosphorus contributions from the San Antonio River, the Guadalupe River Tidal (Segment 1801) section never exceeded the screening concentration of 0.66 mg/L for total phosphorus (Table 3-2).



Nitrogen Loads – Lower Guadalupe River Watershed



Phosphorus Loads – Lower Guadalupe River Watershed

Figure 3-6 Percent Distribution of Nutrient Loads Contributed by Landuse Category

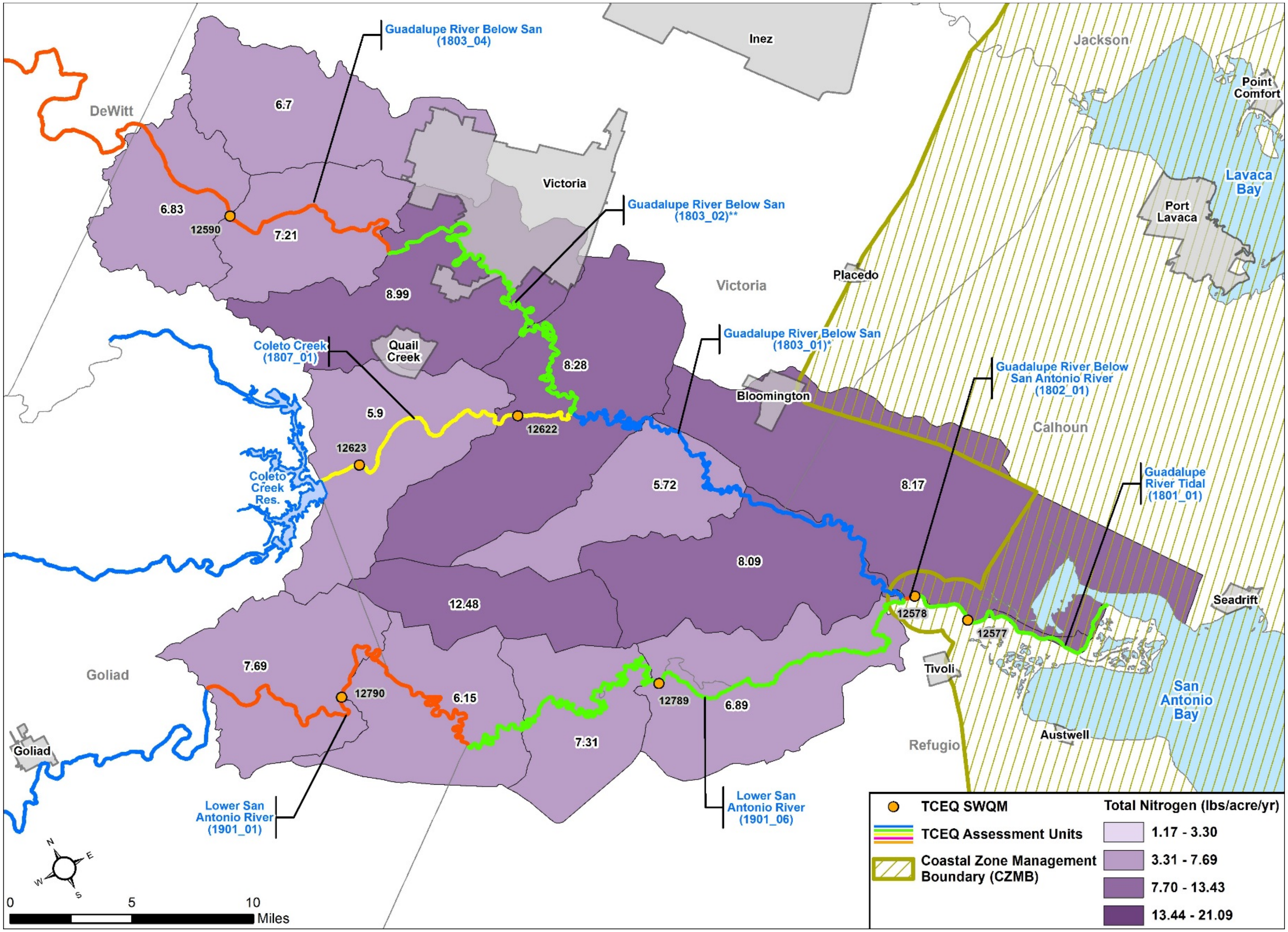


Figure 3-7 Lower Guadalupe River 12-Digit HUCs - Nitrogen Load Estimates

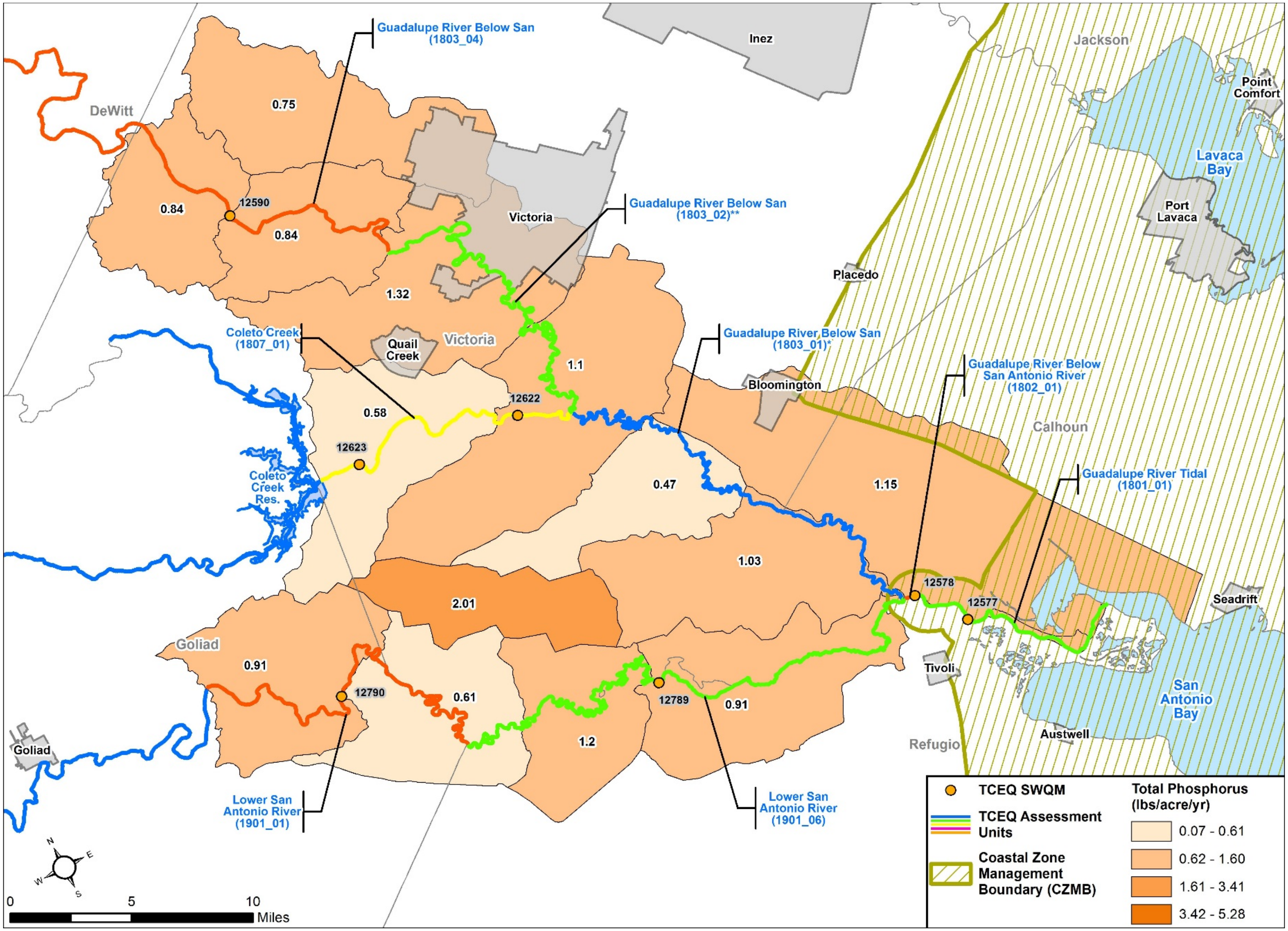
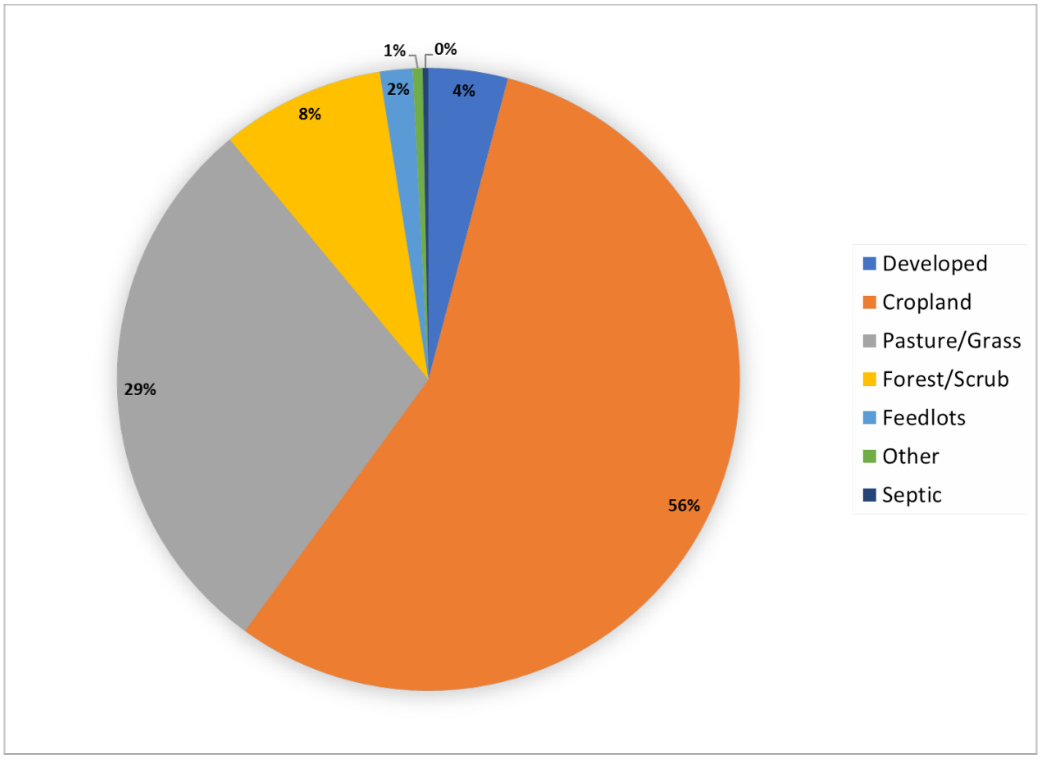


Figure 3-8 Lower Guadalupe River 12-Digit HUCs - Phosphorus Load Estimates

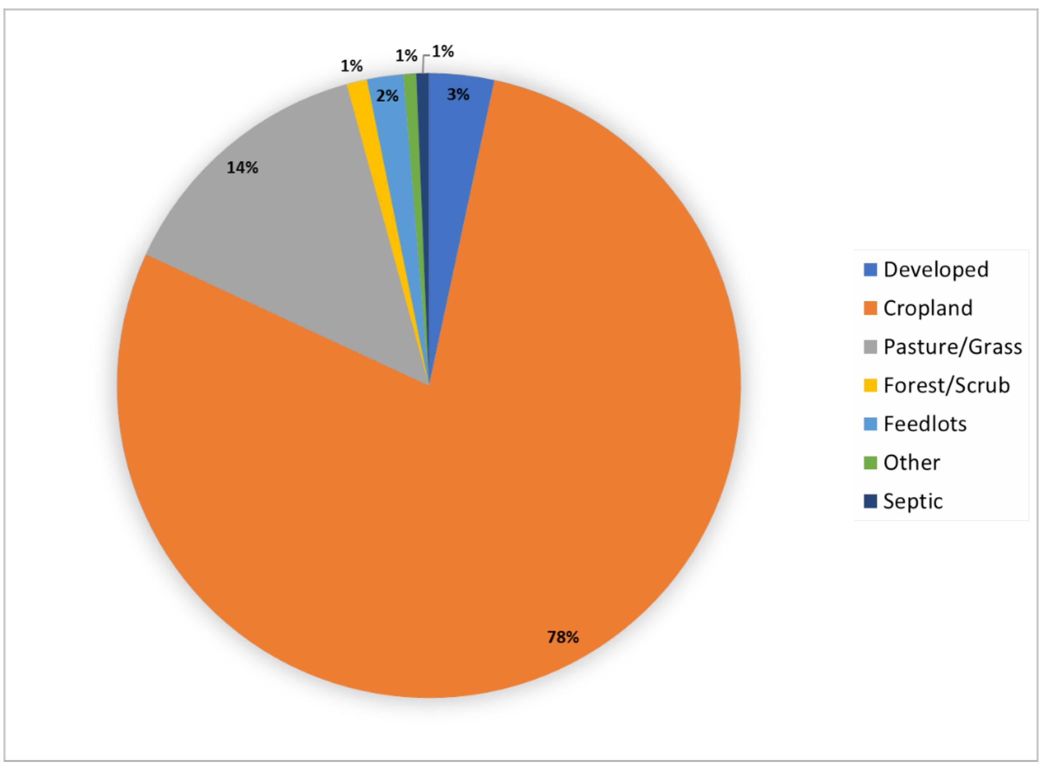
3.8 San Fernando Creek Watershed - Nutrient Sources and Load Estimates

Derived from the STEPL analysis, Figure 3-9 presents the sum of the total nitrogen and phosphorus loads for seven land use categories from the thirty-four 12-digit HUCs assessed in the San Fernando Creek watershed. Uplands in the San Fernando Creek watershed are dominated by shrub/scrub and hay/pasture with significant cultivated cropland occurring in a band between Kingsville and Alice. As indicated in Figure 3-9, an estimated 85 and 92 percent of the nutrient load comes from sources associated with pasture/grassland and cropland. Nutrients associated with these two land use types may be influenced by land application of livestock manure and/or commercial fertilizer, wildlife populations, feral hog populations, livestock grazing, and hunting camps. Nutrients deposited on pasture and crop land can be transported to receiving waters by rainfall runoff. The combined acreage of open water, developed land, barren land, forest, and wetlands only accounts for approximately 12 percent of the total acreage in the San Fernando Creek watershed; thus, diminishing the opportunity to apply nutrient reduction strategies in these land use categories. Conversely, targeting the land area that includes shrub/scrub, grassland, hay/pasture and cultivated crops aligns with agricultural related land use activities associated with the 12-digit HUCs contributing the highest nitrogen and phosphorus loads.

Figures 3-10 and Figure 3-11, respectively, show the results of the STEPL modeling in terms of total nitrogen and total phosphorus load. Nitrogen load estimates in the 12-digit HUCs within the San Fernando Creek watershed range, in general, from 1.17 lbs/acre/year to 19.71 lbs/acre/year. Phosphorus load estimates reveal a similar relative loading rate to those in the Lower Guadalupe River watershed ranging from 0.07 to 4.85 lbs/acre/year. The high density of cultivated cropland north of the City of Kingsville and around the City of Alice is related to the HUCs with the highest load estimates.



Nitrogen Loads – San Fernando Creek Watershed



Phosphorus Loads – San Fernando Creek Watershed

Figure 3-9 Percent Distribution of Nutrient Loads Contributed by Landuse Category

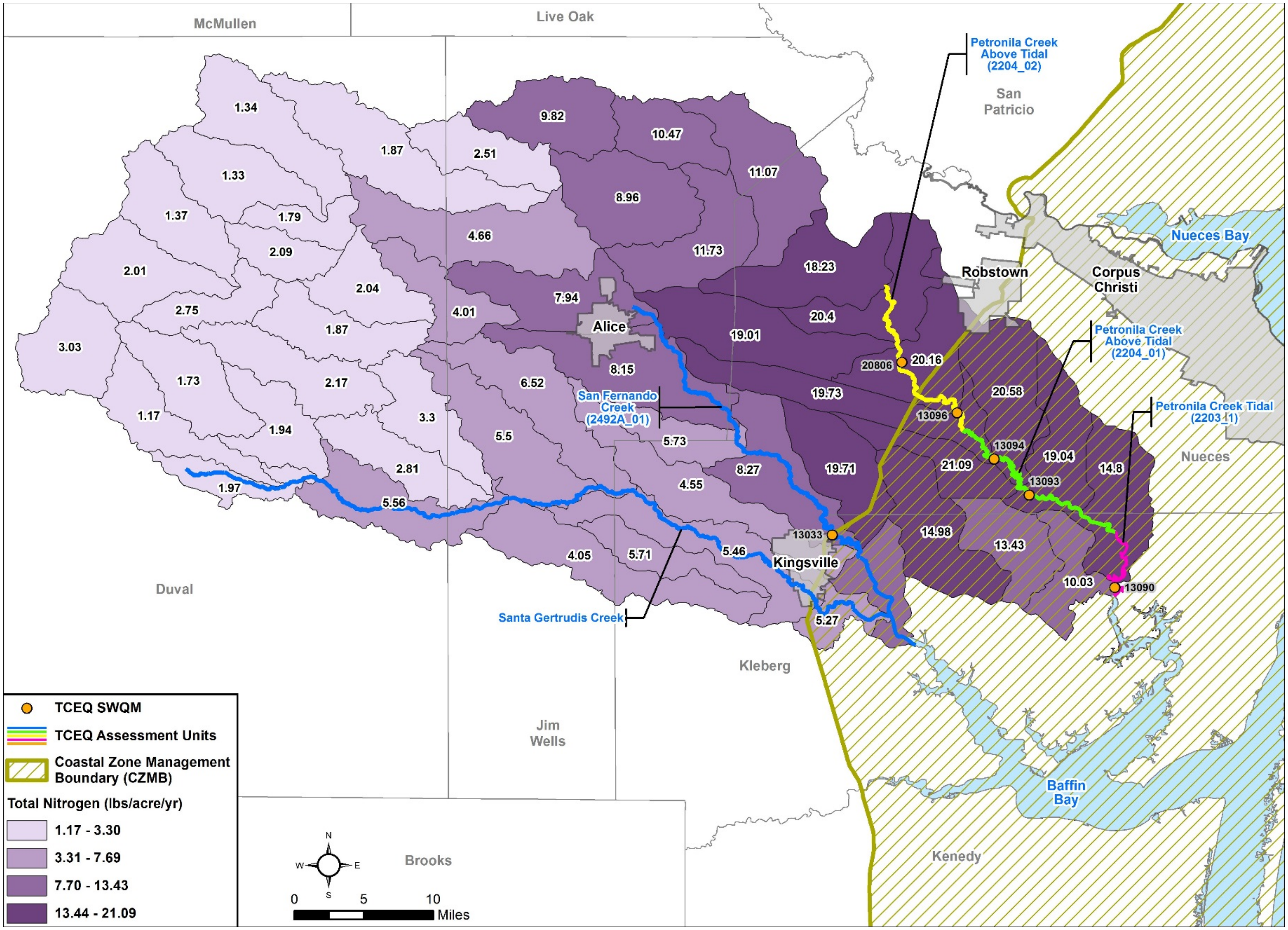


Figure 3-10 San Fernando Creek and Petronila Creek 12-Digit HUCs - Nitrogen Load Estimates

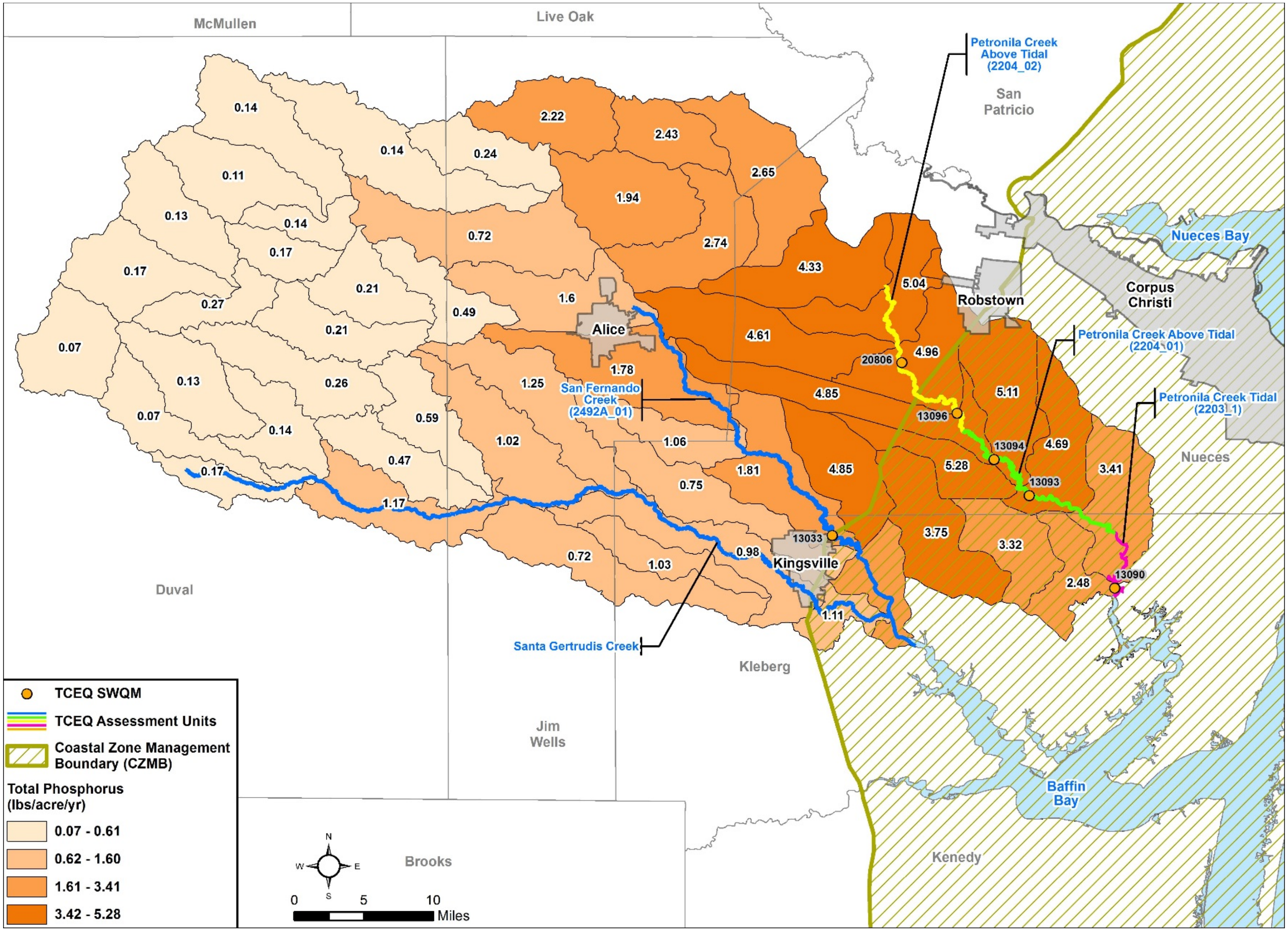


Figure 3-11 San Fernando Creek and Petronila Creek 12-Digit HUCs - Phosphorus Load Estimates

3.9 Petronila Creek Watershed - Nutrient Sources and Load Estimates

Derived from the STEPL analysis, Figure 3-12 presents the sum of the total nitrogen and phosphorus load for seven land use categories from the thirty-four 12-digit HUCs assessed in the Petronila Creek watershed.

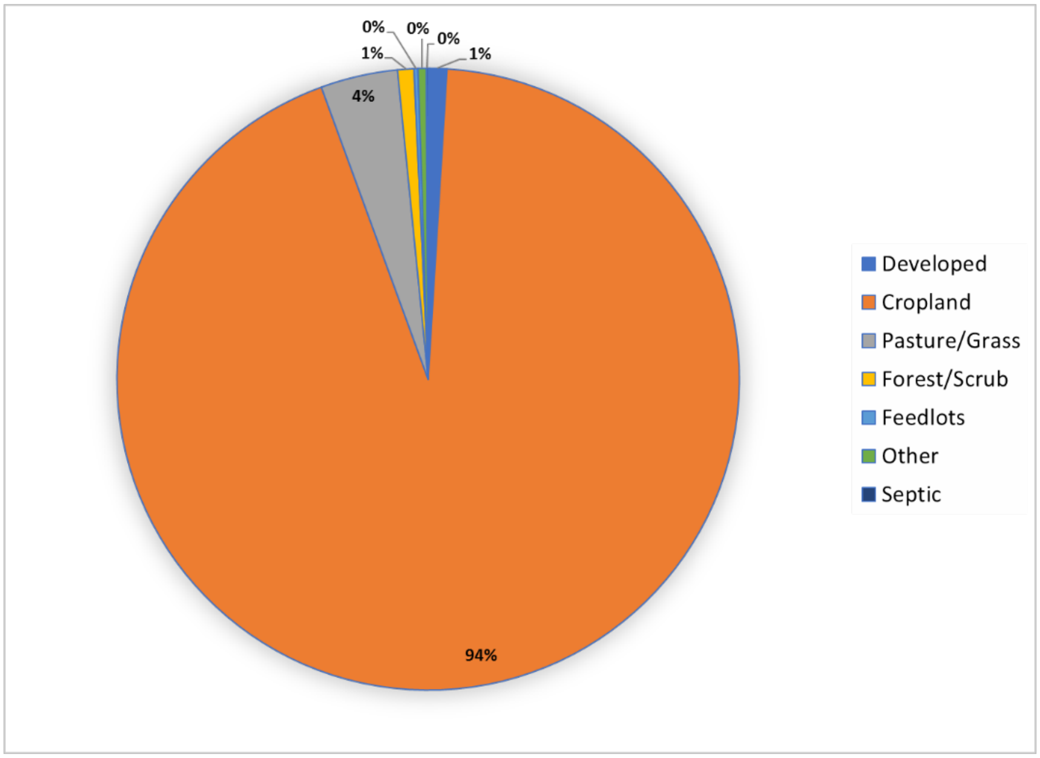
As indicated in Figure 3-12, an estimated 98 percent of the nutrient load comes from sources associated with pasture/grassland and cropland. Nutrients associated with these two land use types may be influenced by land application of livestock manure and/or commercial fertilizer, wildlife populations, feral hog populations, livestock grazing, and hunting camps. Nutrient loads deposited on pasture and crop land can be transported to receiving waters by rainfall runoff. The combined acreage of open water, developed land, barren land, forest, and wetlands only accounts for 8 percent of the total acreage in the Petronila Creek watershed; thus, diminishing the opportunity to apply nutrient reduction strategies in these land use categories. Conversely, targeting the land area that includes shrub/scrub, grassland, hay/pasture and cultivated crops aligns with agricultural related land use activities associated with the 12-digit HUCs contributing the highest nitrogen and phosphorus loads. The Petronila Creek watershed is dominated by cropland (over 70 percent of land cover). Cropland can contribute high levels of nutrients where manure or commercial fertilizers are used to enhance crop production and where soil tillage contributes to soil erodibility. The relatively high EMC measured for cropland in the coastal bend area of Texas (CCBNEP 1996) are the primary factor emphasizing the influence cropland has on nutrient loads.

Figures 3-10 and Figure 3-11 above show the results of the STEPL modeling in terms of total nitrogen and total phosphorus load, respectively. Nitrogen load estimates in the 12-digit HUCs of Petronila Creek watershed range from 8.96 lbs/acre/year to 21.09 lbs/acre/year. Phosphorus load estimates range from approximately 2 to 5 lbs/acre/year.

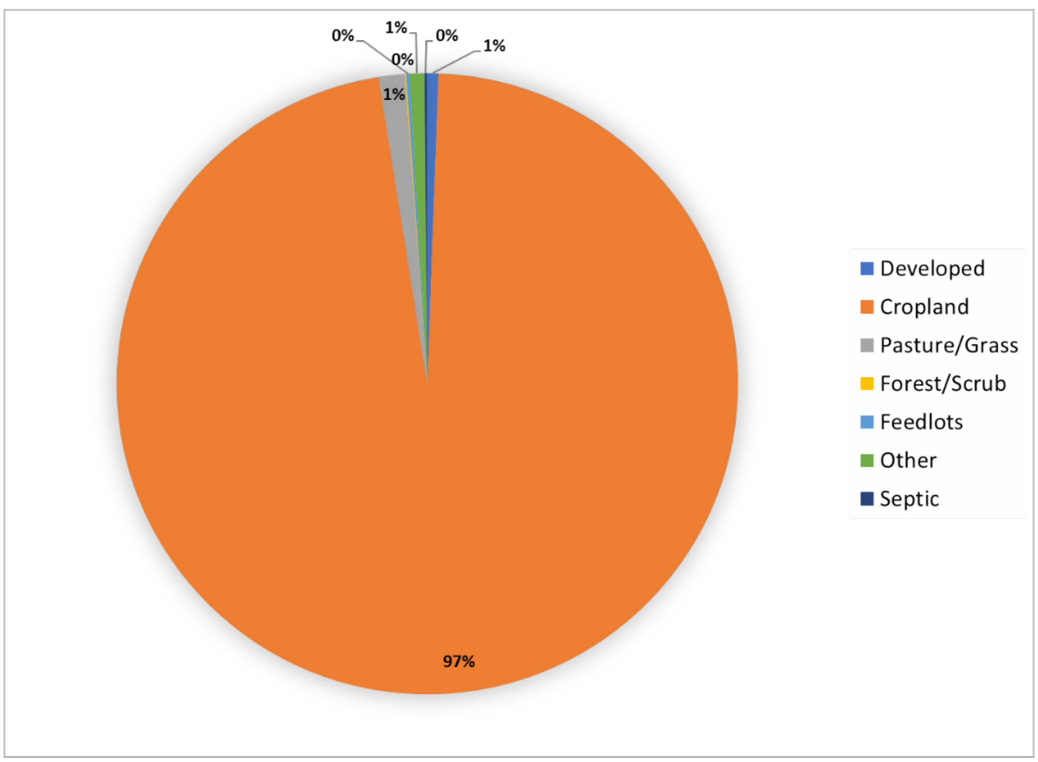
3.10 Watersheds Targeted for Nutrient Reduction Strategies

Using STEPL, pollutant source assessment and best professional judgment, the cumulative outcomes provided in Figures 3-6 through 3-12 set up a prioritization structure for the 12-digit HUCs across all three watersheds. Analyzing the results of nitrogen and phosphorus loads using STEPL is necessary to narrow the focus of implementing nutrient reduction strategies down from sixty-five 12-digit HUCs to a more manageable subset of nine to 18 HUCs. Estimated phosphorus and nitrogen loads from the 12-digit HUCs in the Lower Guadalupe River, San Fernando Creek and Petronila Creek watersheds are strongly correlated (Figure 3-13). Therefore, little value is added by considering both nutrients when comparing the relative contributions of HUCs against each other. It is also interesting to note that the Lower Guadalupe River watershed forms a separate, but parallel line to the San Fernando Creek and Petronila Creek watersheds. In other words, while the relationship between phosphorus and nitrogen is just as strong between the two areas, the Lower Guadalupe River watershed has a slightly lower phosphorus-to-nitrogen ratio.

When looking at each of the watersheds in terms of estimated nitrogen and phosphorus load across Lower Guadalupe River, San Fernando Creek and Petronila Creek watersheds, a clear group of 12-digit HUCs distinguish themselves from the rest as having a higher potential for nonpoint source nutrient loading. This group of nine 12-digit HUCs represents the highest priority (Tier 1) of watersheds that will be targeted for nonpoint source restoration strategies (Figure 3-13). All the Tier 1 12-digit HUCs happen to be adjacent to each other, and all but one is in the Petronila Creek watershed.



Nitrogen Loads – Petronila Creek Watershed



Phosphorus Loads – Petronila Creek Watershed

Figure 3-12 Percent Distribution of Nutrient Loads Contributed by Landuse Category

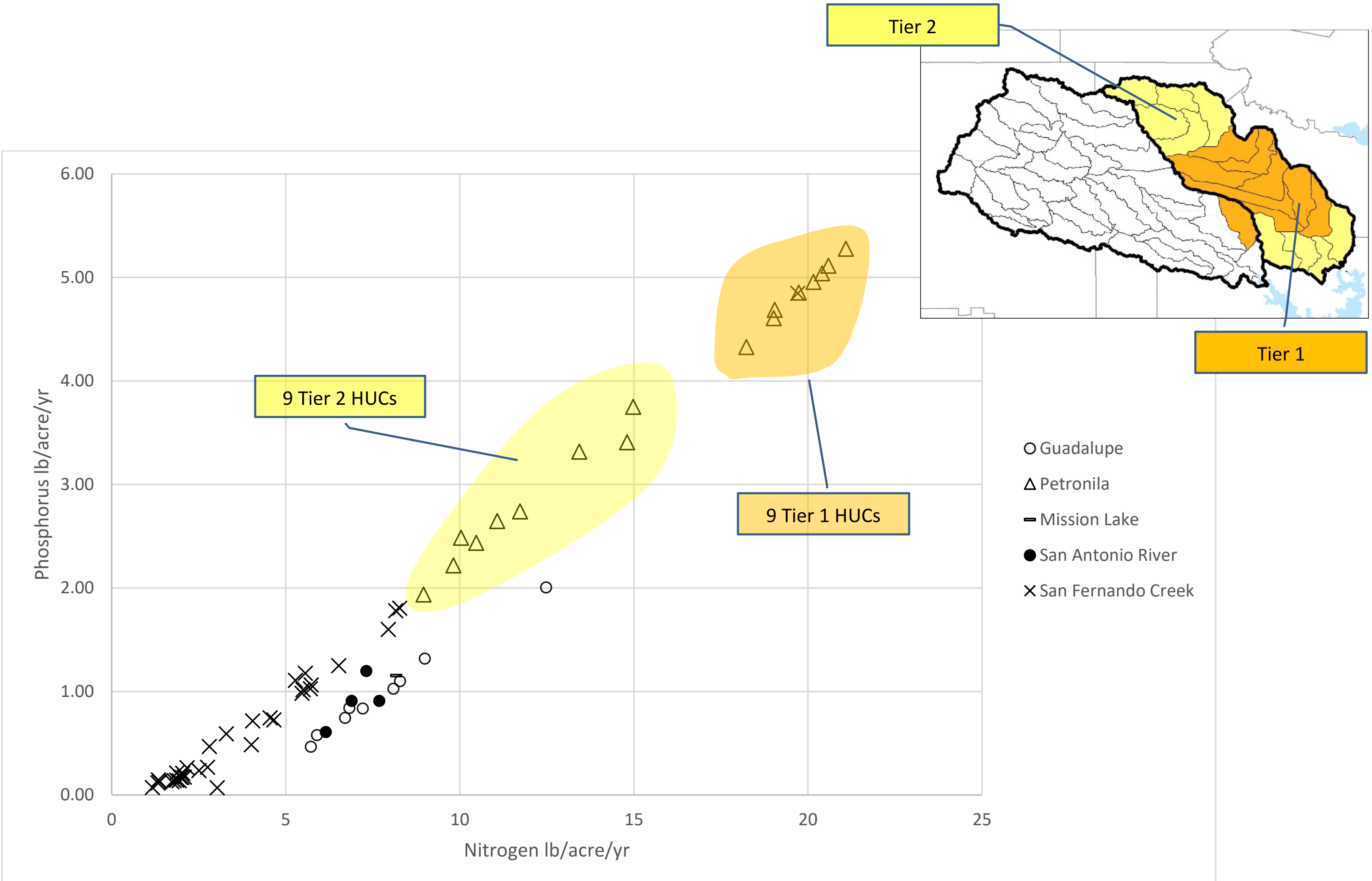


Figure 3-13 Phosphorus/Nitrogen Scatterplot of all HUCs

A second tier (Tier 2) of watersheds targeted for nutrient reduction strategies includes the remainder of the Petronila Creek watershed. Tier 2 represents 12-digit HUCs with significant nonpoint load potential that can serve as areas to target once opportunities in Tier 1 have been exhausted.

Tier 1 HUCs. Nine adjacent HUCs. Eight located on Lower Petronila Creek and one HUC located on San Fernando Creek.

121102050506	Banquete Creek-Agua Dulce Creek
121102050601	Town of Rabb-Petronila Creek
121102050602	Pintas Creek
121102050603	North Clara Driscoll Oil Field-Petronila Creek
121102050604	Town of Driscoll-Petronila Creek
121102050605	City of Concordia-Petronila Creek
121102050606	Gertrude Lubby Lake-Petronila Creek
121102050607	Chapman Ranch Lake-Petronila Creek
121102040408	Carreta Creek

Tier 2 HUCs. Nine HUCs. Five located on Petronila Creek above and four located on Petronila Creek below the Tier 1 HUCs.

121102050501	Headwaters Agua Dulce Creek
121102050502	Reynolds Cemetary-Agua Dulce Creek
121102050503	El Caro Creek-Palo Hueco Creek
121102050504	Rosita Creek-Agua Dulce Creek
121102050505	Quinta Creek-Agua Dulce Creek
121102050801	Upper Chiltipin Creek
121102050802	Lower Chiltipin Creek
121102050803	Tunas Creek
121102050608	Little Tule Lake-Petronila Creek

The percentage of land use categories were summed across the Tier 1 HUCs and compared to the land use in all other HUCs (Figure 3-14). From this comparison, cropland is the clear discriminator between those HUCs that were promoted to Tier 1 status and those that were not.

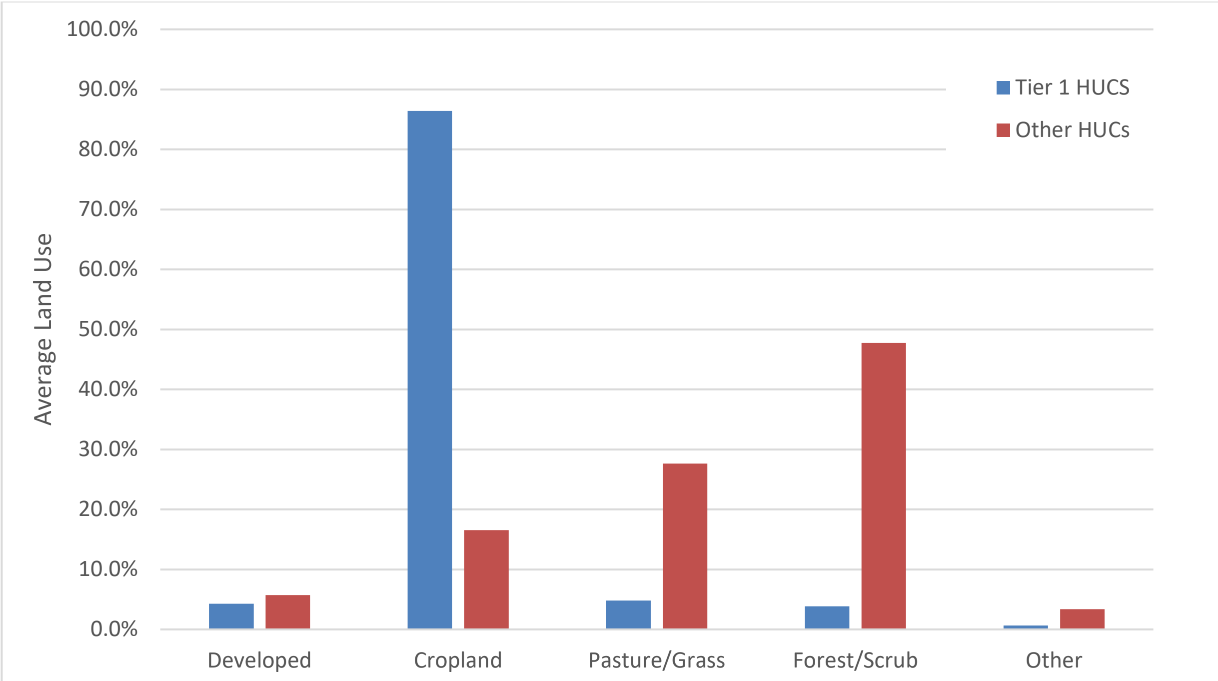


Figure 3-14 Comparison of Land Use between Tier 1 HUCs and Other HUCs in the Evaluation

The STEPL model outputs that inform the conclusions of this evaluation use EMCs based on land cover and soil types and are not calibrated to site-specific conditions such as BMPs, irrigation and fertilizer application rates, and crop types. The values presented in this evaluation are not to be considered accurate absolute values of loads. The primary value of this modeling approach is in comparing 12-digit HUCs to identify those most influenced by nonpoint source pollutant loads associated with agricultural related land uses. Agriculture is a principal source of nutrient loads in the nutrient reduction strategies outlined in PDARP. For this reason, while other nonpoint and point sources are acknowledged and considered, they are not the primary subject of the study.

SECTION 4
EVALUATION OF RESTORATION APPROACHES

The Final PDARP calls for identifying strategies to reduce nutrient loads. The strategies considered depend on the watershed and site characteristics. Cropland is the primary driver of nutrient loads that originate from the Petronila Creek. Understanding how the land in this specific region is used allows the identification of potential voluntary management strategies that can reduce nutrient loads to the creek and ultimately the Baffin Bay estuary. This section identifies a menu of BMPs that may be used to reduce nutrient loads from cropland, pastureland and privately-held off-field areas. Throughout this entire section, the terms management strategy and BMP are used interchangeably. The discussion in this section is not intended to dictate which or how management strategies should be implemented or replace the BMPs individual landowners in the Petronila Creek watershed are currently implementing. The implementation of any management measure(s) designed to reduce nutrient loads can improve water quality in the watershed. Combinations of voluntary management strategies implemented concurrently have synergistic beneficial effects on water quality.

As a reminder, while point sources, atmospheric deposition, groundwater inflows, and wildlife sources may contribute nutrients to Petronila Creek, specific management strategies targeting these sources were not identified and therefore were not incorporated into STEPL. There will always be some sources of nutrient and total suspended solids loading in a watershed that are uncontrollable either because they are background sources or because of legal, funding, or technology limitations. As a result, load reductions for uncontrollable sources are not explicitly estimated in this report. Ultimately, since none of the proposed BMPs can address all nutrient sources, the total effect created by all BMPs is not expected to remove all nutrient loads.

4.1 Petronila Creek Agriculture

The Petronila Creek watershed is located within Kleberg, Jim Wells, and Nueces counties. Farmland in Kleberg and Jim Wells counties are dominated by pasture, while most of the farm acreage in Nueces county is cropland. Table 4-1 summarizes the acres of specific crops by county derived from the 2012 Census of Agriculture (USDA 2014). The proportions of specific crops by county is assumed to be representative of the cropland profile within Petronila Creek watershed. Approximately 40 percent of cropland in the three-county area is within the Petronila Creek watershed. Dryland farming is the primary crop management technique used throughout the Petronila Creek watershed. Dryland farming refers to agricultural operations without irrigation in a climate with a moisture deficiency. It involves raising drought-resistant crops and makes the best use of a limited water supply by maintaining good surface conditions (Gayle Encyclopedia 2000).

Most of the cropland in the watershed is used for sorghum production. Cotton is also a significant crop produced in the area. Grain sorghum fields are planted in late February to early March. Cotton is less cold-tolerant and is planted in late March. Sorghum becomes mature and is ready for harvest in July or August. Rotation of cotton and sorghum, which decreases grassy weed competition, is not uncommon. Sorghum is well-adapted to the coastal Texas climate. It is a drought-tolerant species and can be grown in irrigated or dryland conditions. Conventional tillage, where crop residues are incorporated into the soil following harvest, is the standard practice in coastal Texas. Other agricultural practices include reduced tillage, conservation tillage, strip-till, and no-till. Most sorghum is grown in rows spaced 27 to 40 inches apart, but it can be planted by broadcast.

Commercial inorganic fertilizer is typically used for cropland throughout the watershed. Fertilization practices vary widely and are dependent on site-specific soil factors and farm-specific preferences.

Nitrogen amendments can increase production significantly. Low-phosphorus and potassium conditions are more uncommon in Texas soils but vary from site to site.

Table 4-1 Primary Crop Types by County (acres)

Top Crop Items	Nueces	Kleberg	Jim Wells	Total
Sorghum	147,425	35,870	62,649	245,944
Cotton	65,950	23,082	11,932	100,964
Hay	7,855	2,506	10,872	21,233
Wheat	4,077	1,400	--	5,477
Corn	--	--	15,592	15,592

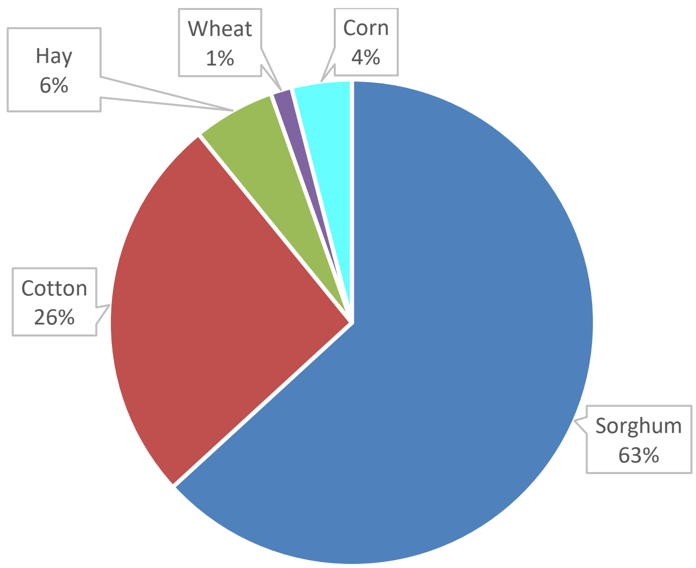


Figure 4-1 Primary Crop Types in the Petronila Creek Watershed

4.2 Cropland Management Strategies

Most of the nutrient loads delivered by the Petronila Creek watershed to Baffin Bay originate from cropland. Therefore, to advance the goals of the Nutrient Reduction Type identified in the PDARP, providing technical and financial assistance to row crop farmers can result in nutrient load reductions to Petronila Creek, its tributaries, and Baffin Bay. There are wide range of agricultural BMPs that row crop farmers have used throughout the Petronila Creek watershed, some of which are very effective at nutrient and sediment management and others that have fallen out of use for various reasons. The following subsections describe BMPs that could potentially reduce nutrient loads from cropland in Nueces, Kleberg, and Jim Wells counties.

Focusing first on addressing nutrient loads from cropland, the Trustees reviewed a list of 20 typical BMP options derived from the NRCS Field Office Technical Guide (FOTG) website:

https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg/.

The Trustees established two criteria to evaluate the 20 cropland BMPs:

- Is the BMP recognized as a practical and commonly executed strategy by agricultural extension specialists and row crop farmers in the watershed; and
- Can the management strategy be modeled in STEPL to estimate nutrient load reductions given readily available information (the STEPL modeling tool is limited on the BMPs for which it can simulate nutrient load reductions).

Through conference calls with NRCS technical specialists, the Trustees discussed these two criteria and how BMPs are typically implemented, whether each BMP is typically used in the Petronila Creek watershed, their cost, and how to evaluate them using the STEPL model. Using local technical expertise from NRCS, information was gleaned allowing the 20 BMPs to be organized into three groups:

1. Group 1: Voluntary cropland BMPs that could be used in the Petronila Creek watershed and that were modeled in STEPL using available data;
2. Group 2: Voluntary cropland BMPs that could be used in the Petronila Creek watershed that were not modeled in STEPL because of lack of field-scale data; and
3. Group 3: Voluntary cropland BMPs not typically used in the Petronila Creek watershed and that were not modeled in STEPL because of lack of field-scale data.

Categorizing the list of 20 BMPs into these three groups provides a qualitative method for considering BMPs individually or cumulatively for future implementation. The level of analysis provided on each BMP in this report is not intended to recommend or prioritize BMPs for any specific field or off-field condition. Site-specific evaluations of soil type, topography, crop type, agribusiness market conditions, planting and harvesting methods, size of operation, costs, annual precipitation, and other field specific factors are necessary for successful implementation of BMPs.

4.2.1 Group 1: Cropland BMPs Modeled in STEPL

The first group presented in Table 4-2 included five cropland BMPs that met both criteria listed above. Detailed evaluation of the commonly used BMPs in Group 1 was conducted using STEPL to estimate the nutrient reduction potential for each BMP, and benefit-to-cost analysis was completed using implementation cost data from the NRCS FOTG. The NRCS FOTG was also used as the reference for characterizing the nutrient and sediment reduction effectiveness of each BMP, which was derived from the Conservation Practice Physical Effect (CPPE) Matrix. Nutrient and sediment reduction effectiveness are just two of 44 criteria NRCS scores each BMP on a scale of one to five for their performance on categories such as soil erosion, soil quality degradation, water quality degradation, plant quality and others. The Conservation Practice Standard from the NRCS FOTG for each BMP is provided in Appendix E.

Table 4-2 Group 1: Management Strategies Typical in Petronila Creek Watershed and Modeled in STEPL

NRCS Practice #	Practice Description	Scenario Descriptions	CPPE Nutrient Reduction Effectiveness[1]	CPPE Sediment Reduction Effectiveness[1]	Annual Cost[2] (per acre)
340	Cover Crop	Basic (organic and non-organic)	2	2	$35.91
345	Reduced Till	Residue and Tillage Management, Reduced Till	2	3	$11.85
393	Filter Strip	Filter Strip, Native or Introduced Species, Forgone Income	5	5	$15.53
412	Grassed Waterway	Base Waterway	2	2	$185.16
327	Conservation Cover (Land Retirement)	Native Species	4	4	$27.26

1 - Scores derived from NRCS FOTG
CPPE Practice Effects:
5-Substantial Improvement
4-Moderate to Substantial Improvement
3-Moderate Improvement
2-Slight to Moderate Improvement
1-Slight Improvement

2 - Costs derived from the NRCS EQIP Texas 2019 Practice Payment Scenarios. Costs are standardized by typical lifespan of a practice.

The five cropland BMPs in Group 1 are summarized in the following cutsheets.

Cover Crops

Definition: Typically, a small grain or legume will be planted as a cover crop immediately after harvest of a row crop, followed by a row crop that uses the residue as a mulch. This practice assumes that seed will be planted with a drill. The cover crop should be allowed to generate as much biomass as possible, without delaying planting of the following crop. The cover crop is terminated using an approved herbicide prior to planting the subsequent crop.

Location: Applies to all cropland and other lands where crops are planted.

Source: Danielle Treadwell, University of Florida

Description: Within 30 days after harvest of the row crop, fields are planted with a cover crop. The cover crop is seeded with a drill. No additional fertilizer is applied with the cover crop. The cover crop provides soil cover by late fall, throughout the winter, and into the early spring. Runoff and erosion are reduced. Wind erosion is reduced by standing residues. The cover crop is terminated with an approved herbicide prior to spring planting as late as feasible to maximize plant biomass production. Over time, soil health is improved due to the additional biomass, ground cover, soil infiltration, and plant diversity introduced to the cropping system. Cover crop residues left on the surface may maximize weed control by increasing allelopathic and mulching effect.

Associated Practices: None

Approximate Load Reduction: Nitrogen Reduction Efficiency ~ 4.3 lbs/acre
Phosphorus Reduction Efficiency ~ 0.8 lbs/acre

Effectiveness:	Low: STEPL modeling analysis demonstrated load reduction potential in the Petronila Creek watershed for TN and TP of 19% and 15%, respectively.
Difficulty:	Medium: There may be up-front costs with acquiring planting equipment. Grass or legume seed is an additional cost. Cover crop seeds can be expensive but can be offset by savings associated with the abandonment of conventional management of winter fallows. Herbicide and spraying expenses may increase due to additional applications.
Certainty:	Medium: In addition to limiting N losses, cover crops can fix atmospheric N; however, the amount of fixation is influenced by many factors.

Reduced Tillage	
Definition: Mulch-till is managing the amount, orientation and distribution of crop and other plant residue on the soil surface year-round while limiting the soil-disturbing activities used to grow crops in systems where the entire field surface is tilled by the planter/drill or tillage tools prior to planting. This practice includes tillage methods commonly referred to as mulch tillage, vertical tillage, chiseling and disking, or the use of high disturbance drills without additional tillage. It applies to stubble mulching on summer-fallowed land and to tillage for annually planted crops, planted crops, and for planting perennial crops.	 Source: American Sorghum
Location: Reduced till can be used on crop types cultivated within the watershed.	
Description: Implementation requirements for this BMP are prepared following the criteria in the FOTG. This practice includes the use of reduced tillage systems and high disturbance drills, such as a hoe drill, air seeder, or no-till drill that disturbs a large percentage of soil surface during the planting operation. The residue that remains on the soil surface provides soil cover during late fall, throughout the winter, and into the early spring. Runoff and water/wind erosion are reduced, and water quality improves. Over time, soil health is improved because of less tillage, the additional biomass, ground cover, soil infiltration, and plant diversity in the cropping system.	
Associated Practices: None	
Approximate Load Reduction:	Nitrogen Reduction Efficiency ~ 3.3 lbs/acre Phosphorus Reduction Efficiency ~ 1.9 lbs/acre
Effectiveness:	Medium: STEPL modeling analysis demonstrated load reduction potential for TP as high as 35 percent; however, it was less effective at reducing TN loads (potential of 15%).
Difficulty:	Low: Studies show that reduced tillage and no-till has the potential to maintain or improve yields, reduce production costs, and improve profitability (Texas A&M AgriLife 2018). There may be up-front costs with equipment transitions. Herbicide and spraying expenses may increase due to additional application requirements.
Certainty:	Medium: Actual results will likely vary by producer and actual cultivation practices.

<table>
<tr><td>Filter Strips</td><td rowspan="3">
Source: Lynn Betts, USDA NRCS</td></tr>
<tr><td>Definition: A strip or area of herbaceous vegetation that removes contaminants from overland flow. Practice includes seedbed preparation and planting of native species.</td></tr>
<tr><td>Location: Cropland without filter strips between cultivated areas and riparian corridors.</td></tr>
<tr><td colspan="2">Description: Implementation requirements for this BMP are customized based on site-specific conditions. The planned filter strip is established and maintained per the practice plan that will maximize nutrient and sediment trapping. Native vegetation species are selected, and the filter strip will have adequate width to filter nutrients. The practice includes seedbed preparation, seeding, and seed. Species selected shall be able to withstand partial burial by sediment and be tolerant of herbicides used on the contribution area while protecting environmentally-sensitive areas. The area of the filter strip is taken out of production.</td></tr>
<tr><td colspan="2">Associated Practices: None</td></tr>
<tr><td colspan="2">Approximate Load Reduction: Nitrogen Reduction Efficiency ~ 7.3 lbs/acre
Phosphorus Reduction Efficiency ~ 2.3 lbs/acre</td></tr>
<tr><td>Effectiveness:</td><td>High: STEPL modeling analysis demonstrated load reduction potential for TN as high as 32 percent using a 35-foot-wide filter strip.</td></tr>
<tr><td>Difficulty:</td><td>Medium: Installation costs, forgone income, and conducting long-term maintenance of healthy native vegetation species can be costly.</td></tr>
<tr><td>Certainty:</td><td>Medium: Filter strips need long-term maintenance. The effectiveness is dependent on the establishment of desired vegetation and commitment to upkeep.</td></tr>
</table>

<table>
<tr><th colspan="2">Grassed Waterways</th><td rowspan="3">
Source: Evrardo, Wikipedia Commons</td></tr>
<tr><td colspan="2">Definition: A grassed waterway is a shaped or graded channel and is established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet.</td></tr>
<tr><td colspan="2">Location: Where practical, in drainage swales associated with cropland.</td></tr>
<tr><td colspan="3">Description: A typical practice is 1200 feet long, 12-foot bottom, 8:1 side slope, 1.5-foot depth. This practice addresses erosion and excessive sediment in surface waters. The waterway construction area includes the excavated width plus the theoretical width for two berms (one on each side) that are calculated based on the excavated area and are 1 foot tall with 5:1 side slopes. The seeding area varies but is typically less than the waterway construction area. Costs include excavation and associated work to construct the overall shape and grade of the waterway. Costs also include vegetation materials, associated vegetation planting work, and foregone income.</td></tr>
<tr><td colspan="3">Associated Practices: Critical Area Planting, Mulching, Subsurface Drains or Underground Outlet</td></tr>
<tr><td colspan="2">Approximate Load Reduction:</td><td>Nitrogen Reduction Efficiency ~ 7.9 lbs/acre
Phosphorus Reduction Efficiency ~ 1.8 lbs/acre</td></tr>
<tr><td>Effectiveness:</td><td colspan="2">Medium: STEPL modeling analysis demonstrated load reduction potential for TN as high as 35 percent when implementing grassed waterways.</td></tr>
<tr><td>Difficulty:</td><td colspan="2">Medium: Installation costs, forgone income, and conducting long-term maintenance of healthy native vegetation species can be costly.</td></tr>
<tr><td>Certainty:</td><td colspan="2">Medium: Grassed waterways need long-term maintenance. The effectiveness is dependent on the establishment of desired vegetation and commitment to upkeep.</td></tr>
</table>

Land Retirement

Definition: Also known as "conservation cover," this practice applies to land that will be retired from agricultural production and on other lands needing permanent protective cover. This practice typically involves conversion from a clean-tilled (conventional tilled) intensive cropping system to permanent native vegetation. This can reduce soil erosion, reduce soil quality degradation, improve water quality, develop wildlife habitat, and reduce air quality impacts.

Location: Cropland that is no longer economically feasible for production.

Source: Wikipedia Commons

Description: The land is covered with permanent native grass vegetation which reduces soil erosion and water/sediment runoff and eliminates dust emissions, thereby improving air quality. Plants sown for conservation cover may provide cover for beneficial insects and wildlife.

Associated Practices: None

Approximate Load Reduction: Nitrogen Reduction Efficiency ~ 19.0 lbs/acre
Phosphorus Reduction Efficiency ~ 4.3 lbs/acre

Effectiveness:	High: STEPL modeling analysis demonstrated load reduction potential for TN and TP of 84% and 79%, respectively.
Difficulty:	High: Conversion costs, forgone income, and conducting long-term maintenance of healthy native vegetation species can be costly. Competing financial incentives.
Certainty:	Low: Following conversion, the reduced soil disturbance, reduced erosion, and reduced nutrient applications will reduce nutrient losses to surface waters.

4.2.2 Group 2: Other Cropland BMPs for Consideration

The second group, presented in Table 4-3, includes five cropland BMPs that could be implemented on some cropland in the Petronila Creek watershed. These five cropland BMPs could not be modeled adequately using STEPL because field-scale cropping practice data from individual farms were not available to develop the model inputs required. While STEPL was not used to estimate the nutrient load reduction potential for these BMPs, a qualitative summary of the nutrient reduction effectiveness and the approximate unit cost was completed using data from the NRCS FOTG. The NRCS FOTG was also used as the reference for characterizing the nutrient and sediment reduction effectiveness of each BMP, which was derived from the CPPE Matrix. Two of the BMPs identified in Table 4-3 (NRCS practices 590 and 587) require highly specialized operation and maintenance at the field-scale level. Nutrient management (BMP 590) requires a field-specific regimented schedule of soil testing to manage seasonal application of inorganic fertilizer to maximize crop production and mitigate nutrient runoff from crop fields. The implementation of this BMP requires examination of land treatment practices, slopes, annual precipitation, other nutrient management BMPs, filter strips, and soil erosion control. Controlled drainage (BMP 587) is also a highly specialized, field-specific BMP that uses various structural controls such as drainage canals, swales, and control gates to help control the duration and volume of runoff from dryland crop fields such as cotton and sorghum. A Conservation Practice Standard from the NRCS FOTG for each BMP in Table 4-3 is provided in Appendix E.

Table 4-3 Group 2: Management Strategies Typical in Petronila Creek Watershed and Are Not Modeled in STEPL

NRCS Practice #	Practice Description	Scenario Descriptions	CPPE Nutrient Reduction Effectiveness[1]	CPPE Sediment Reduction Effectiveness[1]	Annual Cost[2] (per acre)
328	Conservation Crop Rotation	Basic Rotation Organic and Non-Organic	2	2	$9.68
329	Residue and Tillage Management, No-Till	No-Till/Strip-Till	2	4	$18.07
386	Field Border	Field Border, Native or Introduced Species	1	2	$11.28
590	Nutrient Management	Basic Precision NM (Non-Organic/Organic)	5	0	$39.77
587	Controlled Drainage	Various	0	1	Various

1 - Scores derived from NRCS FOTG

CPPE Practice Effects:
5-Substantial Improvement
4-Moderate to Substantial Improvement
3-Moderate Improvement
2-Slight to Moderate Improvement
1-Slight Improvement

2 - Costs derived from the NRCS EQIP Texas 2019 Practice Payment Scenarios. Costs are standardized by typical lifespan of a practice.

4.2.3 Group 3: Cropland BMPs Not Typically Used in Petronila Creek Watershed

The third group, listed in Table 4-4, included 10 cropland BMPs that were identified as not typically being used in the Petronila Creek watershed as a practice on cropland. NRCS technical specialists indicated that there was a combination of reasons that diminish the practicality of implementing these BMPs in the Petronila Creek watershed. Reasons identified ranged from incompatible soil type, flat topography typical of Texas coastal plains, precipitation levels, dryland farming techniques, maintenance, and even cost. It was therefore not practical to consider modeling these BMPs in STEPL. Furthermore, field-scale cropping practice data from individual farms were not available to develop the model inputs required. However, for comparative purposes, Table 4-4 provides the nutrient and sediment reduction effectiveness of each BMP from the CPPE Matrix. The Conservation Practice Standard from the NRCS FOTG for each BMP in Table 4-4 is provided in Appendix E.

While this list of BMPs was not given further consideration for implementation on cropland, some could be implemented as off-field practices. Vegetative cover and riparian buffers, streambank stabilization, and wetland restoration are strategies that could be applied in certain off-field situations. Section 4.4 further discusses potential options for off-field implementation of these other nutrient reduction BMPs, which are often used for stormwater management.

Table 4-4 Group 3: Management Strategies Not Typically Used in Petronila Creek

NRCS Practice #	Practice Description	Scenario Descriptions	CPPE Nutrient Reduction Effectiveness[1]	CPPE Sediment Reduction Effectiveness[1]	Annual Cost[2]
332	Contour Buffer Strips	Native Species, Forgone Income (Organic and Non-Organic)	2	2	$44.28 per acre
390	Riparian Herbaceous Cover	Grass, Cool or Warm Season	5	4	$11.30 per acre
391	Riparian Forest Buffer	Plant Using Cuttings, Seedlings, or Containers	5	5	$9.54 per acre
484	Mulching	Erosion Control Blanket Herbaceous Planting	2	2	$0.12 per square foot
580	Streambank and Shoreline Protection	Shaping, Structural, or Bioengineered	1	2	$1.86 per acre
585	Strip Cropping	Strip cropping - Wind and Water Erosion	2	2	$0.23 per acre
600	Terrace	Broad Based, Contour, Graded	2	2	$0.15 per foot
601	Vegetative Barrier	Vegetative Planting	2	2	$0.38 per foot
603	Herbaceous Wind Barriers	Cool Season Annual/Perennial Species	1	1	$0.06 per linear foot

NRCS Practice #	Practice Description	Scenario Descriptions	CPPE Nutrient Reduction Effectiveness[1]	CPPE Sediment Reduction Effectiveness[1]	Annual Cost[2]
657	Wetland Restoration	Stream Floodplain Restoration	3	2	$24.15 per acre

1 - Scores derived from NRCS FOTG
CPPE Practice Effects:
5-Substantial Improvement
4-Moderate to Substantial Improvement
3-Moderate Improvement
2-Slight to Moderate Improvement
1-Slight Improvement

2 - Costs derived from the NRCS EQIP Texas 2019 Practice Payment Scenarios. Costs are standardized by typical lifespan of a practice.

4.3 Other Agricultural Management Strategies

Pastureland is another agricultural land use in the Petronila Creek watershed where voluntary BMPs could be targeted to reduce nutrient loads. Common BMPs to be considered for mitigating nutrient loads from pastureland include prescribed grazing, streambank stabilization and fencing, and filter strips. Other opportunities may exist in the form of pastureland nutrient management (soil testing) or land use change. Pastureland BMPs were not modeled using STEPL because field-scale data for livestock grazing management from individual farms were not available to develop the model inputs required. Implementation of pastureland BMPs should consider soil type, site-specific topography, size and type of livestock herds, size of pasture fields, forage type, livestock accessibility to a water source, costs, annual precipitation, and other factors. A Conservation Practice Standard from the NRCS FOTG for each of the following pastureland BMPs is provided in Appendix E.

Three pastureland BMPs were identified as feasible in the Petronila Creek watershed: Fencing, Filter Strips, and Prescribed Grazing. These are summarized in the following cutsheets. and the nutrient reduction effectiveness scores cited in the CPPE are presented in Table 4-5.

Table 4-5 Management Strategies for Use in Pastureland

NRCS Practice #	Practice Description	Scenario Descriptions	CPPE Nutrient Reduction Effectiveness[1]	CPPE Sediment Reduction Effectiveness[1]	Annual Cost[2]
382	Fencing	Level, Non-Rocky	0	0	$0.11 per foot
393	Filter Strip	Filter Strip, Native or Introduced Species, Forgone Income	5	5	$15.53 per acre
528	Prescribed Grazing	Standard	1	2	$9.11 per acre

1 - Scores derived from NRCS FOTG
CPPE Practice Effects:
5-Substantial Improvement
4-Moderate to Substantial Improvement
3-Moderate Improvement
2-Slight to Moderate Improvement
1-Slight Improvement

2 - Costs derived from the NRCS EQIP Texas 2019 Practice Payment Scenarios. Costs are standardized by typical lifespan of a practice.

<table>
<tr><td>Fencing</td><td rowspan="3">
Source: Greater Wellington Regional Council</td></tr>
<tr><td>Definition: Installation of multi-strand, barbed or smooth wire fence to exclude animals, people, or vehicles from an area to maintain or improve the quantity and quality of the riparian corridor.</td></tr>
<tr><td>Location: Exclusion of livestock into riparian corridors by targeted installation of fencing in pastureland.</td></tr>
<tr><td colspan="2">Description: Multi-strand, barbed, or smooth wire. Installation of fence on ground that is not excessively steep, rocky, or difficult to work in; fence will allow for implementation of grazing management that allows for an adequate rest and recovery period, protection of sensitive areas, and improved water quality.</td></tr>
<tr><td colspan="2">Associated Practices: Prescribed Grazing, Access Control</td></tr>
<tr><td>Effectiveness:</td><td>Medium: Excluding animals influences vigor and health of vegetation and soil conditions, reducing sediment supply to surface waters. Prevents the direct input of nutrients through livestock excretory waste into surface waters.</td></tr>
<tr><td>Difficulty:</td><td>Medium: Installation costs and conducting long-term maintenance of fencing is inexpensive. Likely needs to be coupled with alternative watering supplies or “hardened” engineered access points for livestock.</td></tr>
<tr><td>Certainty:</td><td>Medium: Dependent on livestock usage prior to controlling access to streambanks.</td></tr>
</table>

Filter Strips	
Definition: A strip or area of herbaceous vegetation that removes contaminants from overland flow. Practice includes seedbed preparation and planting of native species.	 Source: Lynn Betts, USDA NRCS
Location: Targeted installation between pasturelands and riparian corridors or drainageways.	
Description: As with application in croplands, implementation requirements for this BMP are customized based on site-specific conditions. The planned filter strip is established and maintained per the practice plan that will maximize nutrient and sediment trapping. Native vegetation species are selected, and the filter strip will have adequate width to filter nutrients. The practice includes seedbed preparation, seeding, and seed. Species selected shall be able to withstand partial burial by sediment and be tolerant of herbicides used on the contribution area while protecting environmentally-sensitive areas.	
Associated Practices: None	
Effectiveness:	Low: STEPL modeling analysis in croplands demonstrate a load reduction potential for TN as high as 32 percent using a 35-foot-wide filter strip. Effectiveness may be comparable when applied to pastureland.
Difficulty:	Medium: Installation costs and conducting long-term maintenance of healthy native vegetation species can be costly.
Certainty:	Medium: Filter strips need long-term maintenance. The effectiveness is dependent on the establishment of desired vegetation and commitment to upkeep.

<table>
<tr><td>Prescribed Grazing</td><td rowspan="3">
Source: USDA NRCS</td></tr>
<tr><td>Definition: Managing the harvest of vegetation by grazing and/or browsing animals with the intent of achieving specific ecological, economic, and management objectives</td></tr>
<tr><td>Location: Targeted installation where grazing and/or browsing animals are managed.</td></tr>
<tr><td colspan="2">Description: Design and implementation of a grazing system on rangeland or pasture that will enhance ecosystem function, enhance habitat components for the identified wildlife species of concern, and/or improve the plant community while optimizing efficiency and economic return through monitoring. This scenario is for balancing grazing animal numbers with production of forage resulting in a stabilized system that results in decreasing the number of animals on the operating unit(s). Implementation would result in the protection of the resource base and recovery and/or enhancement of the health and vigor of the plant communities that are in place to benefit habitat for targeted wildlife species. Livestock are managed in a way that enhances rangeland health or pasture condition and function through protection of sensitive areas and efficient harvest of forage resources. To have a positive impact on nutrient loads, the system should minimize concentrated livestock areas through grazing management, fencing, alternate water sources, hardened water points, controlled access, supplemental feed placement, and/or shade or cover manipulation. This is to enhance nutrient distribution and ground cover. Grazing system success would be evaluated through short-term monitoring.</td></tr>
<tr><td colspan="2">Associated Practices: Fencing</td></tr>
</table>

Effectiveness:	Low: Prescribed grazing in and of itself will only indirectly improve runoff through increased vegetation density, reduced sediment loss, and increased nutrient attenuation.
Difficulty:	Medium: Costs per acre are nominal; however, feasibility is determined by the availability of land to maintain a favorable grazing schedule and rotation.
Certainty:	High: Once a program and system are in place, recurring costs are nominal. Could be applied in conjunction with other BMPs such as fencing.

4.4 Reducing Nutrient Loading Using Off-Field Management Strategies

After identifying management strategies to reduce nutrients from the dominant land use/land cover types in the Petronila Creek watershed (at least 80 percent of the land area in Petronila Creek is managed for cropland and rangeland uses), the Trustees considered whether there were other voluntary nonpoint source management BMPs that should be investigated. The Trustees acknowledged that implementation of nutrient reduction strategies need not be limited to lands dedicated to agricultural production. Partnerships with willing stakeholders (discussed in Section 5) could present opportunities for nonpoint source management strategies in privately-held, off-field lands and possibly road rights-of-way. NRDA funding opportunities will not differentiate between projects implemented on land in or out of production. Off-field opportunities are an integral consideration in the identification of nutrient reduction strategies.

It was not the intent of this study to undertake an exhaustive investigation to identify and evaluate the feasibility of structural and nonstructural stormwater BMPs that are effective at reducing nutrient loads throughout the Petronila Creek watershed. Acknowledging this, the Trustees set out to only identify if there was a practical group of BMPs for agricultural land use, privately-held off-field land, and road rights-of-way. Limiting the focus to these three areas was also influenced by the:

- Goals of the Nutrient Reduction Type identified in the PDARP;
- Small percentage of publicly-owned land and urban/suburban land use in the watershed;
- Need to focus limited NRDA funding on a narrow set of nutrient reduction strategies that could demonstrate success; and
- Natural characteristics of the Petronila Creek watershed preclude practical consideration of various stormwater BMPs.

4.4.1 Targeting Privately-held Off-field Areas

Using GIS to review aerial imagery of the Petronila Creek watershed, various land features were identified that convey stormwater runoff from cropland. The specific land features identified included man-made conveyance ditches and drainage channels. Conveyance ditches, a critical feature of conventional dryland farming practices throughout the watershed, transport surface runoff from cropland. Most of these small conveyance ditches at the field scale are earthen (i.e., not vegetated) v-shaped ditches that are designed to remove excess water from the field crops. Most of these small ditches flow into off-field drainage channels which are typically vegetated swales that flow into Petronila Creek or its tributaries. Nutrient and sediment loads are delivered through this conveyance system into Petronila Creek or its tributaries. Figure 4-2 displays a typical example of an area in the Petronila Creek watershed that includes numerous, small unvegetated drainage ditches at the field scale that drain to off-field vegetated drainage channels. A portion of the riparian corridor of Petronila Creek is also displayed in Figure 4-2.

Figure 4-2 displays suggestions for identifying opportunities at a regional scale (within 12-digit HUCs) where typical stormwater BMPs such as filter strips, conservation cover, riparian forest buffers, wetland restoration, and riparian vegetation buffers could be implemented. Specifically targeting off-field vegetated drainage channels and degraded areas of the Petronila Creek riparian corridor may present the best opportunities for implementing stormwater BMPs to mitigate nutrient and sediment loading to Petronila Creek in certain 12-digit HUCs.

HUC-level regional planning efforts should identify opportunities to convert some off-field drainage ditches and existing Petronila Creek riparian areas into stormwater treatment systems as suggested in Figure 4-2. Nutrient and sediment retention could be achieved by converting portions of existing drainage channels into a flow-through marsh or constructed wetland. It would be necessary in most cases to expand the width of the channel enough to create a slow, sinuous preferred flow through a vegetated wetland that can capture sediments and allow nutrient attenuation via natural processes. As suggested in Figure 4-2, treatment wetlands outfitted with filter strips and flow cells intercepting cropland drainage channels could be constructed in off-field riparian areas of Petronila Creek and its tributaries. This would reduce the conversion of cropland to constructed stormwater BMPs.

Wetland creation and restoration involves either the establishment of new wetlands from conversion of cropland where practical or the enhancement and permanent protection of existing wetlands as treatment systems for nutrient and sediment reduction. Conservation easements and land acquisition programs could be used to facilitate land-use change on marginally productive land.

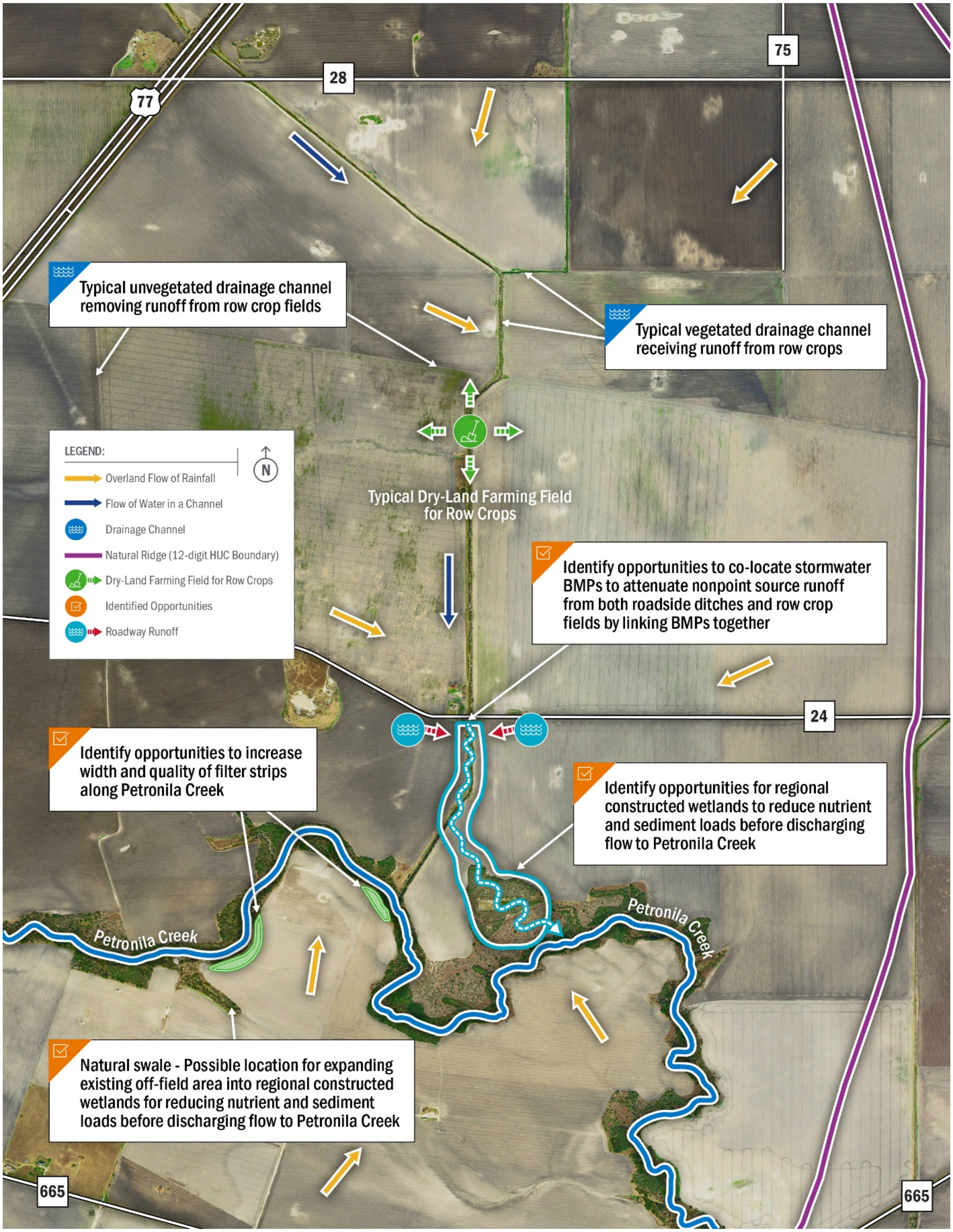


Figure 4-2 Conceptual Targeting of Off-Field BMPs

There are some opportunities for restoration activities within the riparian zone of the main branch of Petronila Creek (S. Sugarik, Nueces River Authority, personal communication). While the riparian buffer in some reaches of Petronila are expansive and in good condition, the vegetative communities and stability in other reaches are degraded. Opportunities should be identified to increase the width and quality of filter strips along both sides of Petronila Creek. Restoration of damaged streambanks along the Petronila Creek riparian corridor not only increases the potential for nutrient attenuation but provides other services as well (wildlife and fishery habitat, recreational opportunities, stabilizing river flows, and improvement of other water quality parameters such as chlorides).

Selection, siting, and application of the best combination of management strategies require consideration of landscape characteristics, flood control needs, the volume and timing of water conveyance, and resources for operations and maintenance. Quantification of the cost and effectiveness of constructing these types of stormwater BMPs has not been done in the Petronila Creek watershed. The successful targeting and implementation of BMPs in off-field drainage swales will require extensive collaboration and support from local landowners.

The feasibility of measures that retard the flow of nonpoint source runoff to Petronila Creek will be influenced by the need to quickly drain rainwater from dryland farming crops. Planning for water retention beyond the scale of individual landowners introduces hydrologic challenges that may require modeling or phased implementation. However, a comprehensive approach to nutrient reduction throughout the watershed has a greater chance of succeeding.

4.4.2 Road Rights-of-Way

The extent of eroding drainage swales running parallel to local, county and state roads that traverse the Petronila Creek watershed is unknown. Drainage swales in road rights-of-way may be conduits for the delivery of nutrient or sediment loads to receiving waters. Only limited opportunities exist to implement practical stormwater BMPs in road rights-of-way because of the:

- Narrow land area along both sides of each road,
- Flat topography of the watershed, and
- Need to ensure no flooding occurs on roads.

The primary focus of targeting BMPs in road rights-of-way would be to maximize the miles of well-maintained grassed and/or tree-lined drainage swales. A variety of factors influence conditions conducive to maintaining such drainage swales in road rights-of-way. Some of these include soil type, climate, slope, flood control needs, the volume and timing of water conveyance, appropriateness and species of trees, and resources for operations and maintenance. Regional approaches must be used when considering where to install stormwater structural controls along roadways to reduce discharge of pollutants to receiving waters. Figure 4-2 provides a simple suggestion to look for opportunities to couple and design stormwater management BMPs for cropland runoff that could also receive roadside channel runoff. These locations would require site-specific field identification and may be very limited in availability.

4.5 Relative Load Reduction Potential

This report did not set out to identify and list all the efforts and stewards that are currently promoting and implementing nutrient reduction strategies throughout the Petronila Creek watershed. This evaluation is meant to support and augment all the important and necessary water quality management efforts that are currently underway in the Petronila Creek watershed at the local, regional, state and federal levels.

The management strategies evaluated in this section are not intended to be prescriptive; rather they are examples of practices that are acceptable (as suggested by local and state NRCS staff), able to be simulated by the STEPL model, and through voluntarily implementation can have a direct beneficial effect on improving water quality. The success of long-term watershed management is dependent on the financial resources and commitment of water resource managers and stakeholders to implement management strategies and verify that water quality has improved. This report offers a guide to water resource managers and stakeholders of the Petronila Creek watershed on the relative benefits of specific management strategies to reduce nutrient loads to Baffin Bay. This report does not attempt to quantify the potential beneficial effect of other implementation strategies such as education, outreach, and technical assistance that are being implemented around the watershed.

Load reductions were estimated for each of the management strategies described in Table 4-2 by simulating in STEPL the effect of only having that individual strategy in place with no other loads reduced (Table 4-6). This BMP load analysis provides some idea of the total load reduction potential from each pollutant source.

Table 4-6 Load Reduction Potential of Select BMPs

BMP Options	Nitrogen Load (lbs/year)	Nitrogen Reduction from Baseline	Phosphorus Load (lbs/year)	Phosphorus Reduction from Baseline
Baseline Loads	*5,884,179*	*0%*	*1,416,062*	*0%*
Filter Strips	3,998,993	32%	810,662	43%
Reduced Till	5,018,116	15%	922,869	35%
Cover Crop	4,767,899	19%	1,206,200	15%
Land Retirement	958,043	84%	294,275	79%
Grassed Waterways	3,828,338	35%	958,162	32%

Figure 4-3 displays the nutrient load reduction potential from baseline for the BMPs listed in Table 4-6 and described in the cutsheets in subsection 4.2.1. All five strategies demonstrate potential for nutrient load reductions. For example, implementing 35-foot filter strips in cropland in the Petronila Creek watershed suggests a 32 percent reduction in TN and a 43 percent reduction in TP may be possible. Complete results for each HUC12 modeled in STEPL are presented in Appendix F.

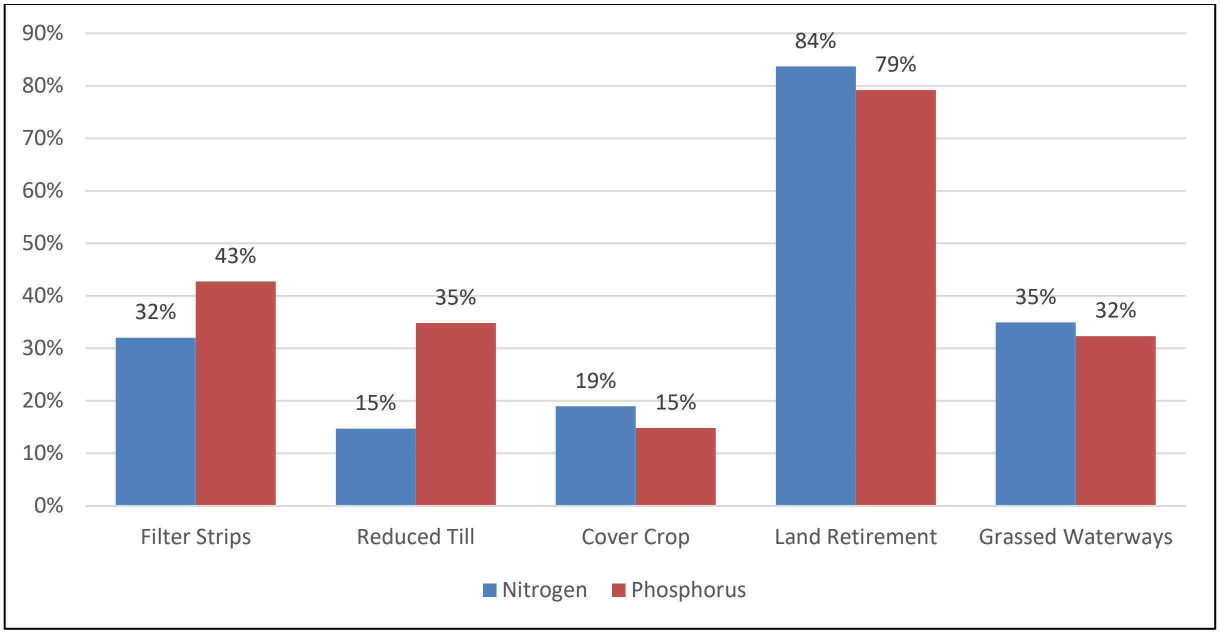


Figure 4-3 BMP Nutrient Load Reduction Potential (Group 1)

4.6 Planning Level Cost Analysis

A cursory investigation was conducted to develop planning level cost estimates to present an approximate cost comparison for implementation of the recommended management strategies. Average unit costs were established and applied to each management strategy to help provide an order of magnitude of an approximate cost per pound of nutrient load reduced as a tool to prioritize the most cost-effective approaches.

Table 4-7 summarizes how cost information was compiled for the suite of recommended management strategies that were modeled in Petronila Creek.

Table 4-7 Cost Estimate Summary Data

BMP Scenario	Unit	Unit Cost[1]	Calculating Quantity[2]	Annual Cost
327-Conservation Cover (Land Retirement), Native Species	acre	$136.31	Applied over entire cropland acreage. Cost amortized over five years.	$7,711,889
340-Cover Crops, Basic (Organic and Non-Organic)	acre	$35.91	Applied over entire cropland acreage.	$9,583,483
345-Residue and Tillage Management, Reduced Till	acre	$11.85	Applied over entire cropland acreage.	$3,162,469
393-Filter Strips, Native or Introduced Species, Forgone Income	acre	$155.29	Filter Strips applied to all cropland; estimated 3% of land needed. Cost amortized over 10 years.	$141,506

BMP Scenario	Unit	Unit Cost[1]	Calculating Quantity[2]	Annual Cost
412-Grassed Waterway, Base Waterway	acre	$1,851.58	Grassed Waterways applied to all cropland; estimated 2% of land needed. Cost amortized over 10 years.	$1,124,822

[1] Unit Costs derived from the NCRS Environmental Quality Incentives Program rate sheet for fiscal year 2019.
[2] Cropland in the study area of the Petronila Creek watershed is 259,102 acres.

Cost data for cropland BMPs were derived from the NRCS Financial Assistance website: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/?cid=nrcseprd1328414/. From the Environmental Quality Incentives Program (EQIP) payment schedule for fiscal year 2019, a unit cost for each BMP was obtained using the Historically Underserved (HU) client rates. Each BMP is assumed to be applied on every tract of cropland; however, some strategies are applied to a percentage of the total cropland. For example, reduced till can be applied to every acre of cropland in the watershed. Filter strips are only applied to a small percentage of cropland (in this case 3 percent). Assumptions on the percent of cropland each BMP would be applied are included in Table 4-6.

Each practice has a predetermined lifespan before additional funding is necessary to renew the practice. An amortization rate of 3 percent was applied for practices with lifespans greater than a year as noted in Table 4-6. Using the per-acre cost, the acreage of application, and the lifespan of the practice and amortization rate, an annual cost was determined to represent the capital investments.

The implementation of each of BMP scenario achieved simultaneous but different load reductions for TN and TP. Therefore, separate benefits for the same dollar investment were estimated. While not included in the costs presented in this report, future planning efforts should consider incorporating an additional 10% inflation rate to projected costs.

The costs management strategies are compared to aid decision makers in prioritizing the implementation of the greatest effect management strategies and obtaining an order of magnitude of the required financial resources needed. Figure 4-4 compares daily load reduction to dollars invested for TN and TP. The amortized cost on the x-axis is the same for both TN and TP because the investment is expected to achieve both TN and TP reduction simultaneously. The variation is in the amount of nutrient load reduced. BMPs falling further to right on the x-axis are costlier than those to the left. Conversely, those further up the y-axis achieve a larger load reduction than those on the bottom. Therefore, the BMPs in the upper left corner of the graph achieve the greatest benefit for the investment. As demonstrated, some strategies could be more effective at nutrient load reduction than others.

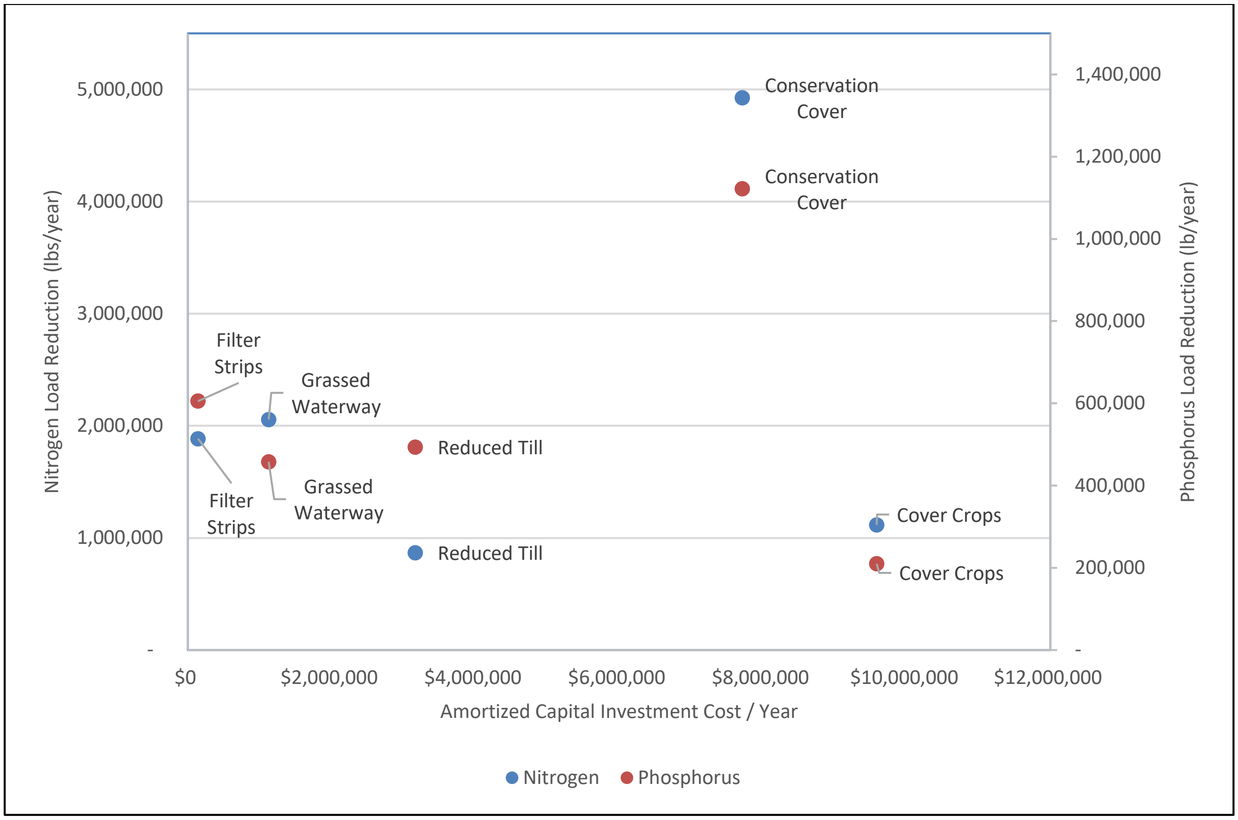


Figure 4-4 Benefit-Cost Analysis of Management Strategies

SECTION 5
IDENTIFICATION OF NUTRIENT REDUCTION STAKEHOLDERS

It is critical to engage local stakeholders in the assessment and evaluation of a watershed's water quality impairments and concerns and in the development and implementation of necessary management strategies to abate nonpoint source pollution (TCEQ 2017). Cooperation from local stakeholders will be crucial to promoting a sense of equitable responsibility. Achieving buy-in from private entities and local governments will be required to implement these recommendations and may require some public engagement either directly or through steering committees and/or technical advisory groups. Successful implementation of all nutrient reduction management strategies will require technical and financial support. These are available to varying degrees from federal, state, and local governments, universities, NGOs, and trade organizations. The key to acquiring technical and financial assistance that will advance the actions outlined here is to have knowledge of where to obtain this assistance, when it is available, and investing the time and energy necessary to obtain and use it. Leveraging similar objectives with funding agencies through grant programs can reduce the unit costs to affordable levels, expedite implementation, and serve as an incentive to participants. Other watersheds around Texas have implemented various institutional strategies dedicated to the improvement of water quality in surface waters. Some of these include establishing watershed management plans and watershed stakeholder committees. Other institutional strategies include education and outreach or technical assistance programs.

This section serves as an inventory of current and potential stakeholders engaged in water quality issues related to Petronila Creek and the greater Baffin Bay watershed. Agency and organization mission statements are summarized below.

5.1 Federal Partners

United States Department of Agriculture – Natural Resources Conservation Service

The NRCS is the federal agency that works with private landowners to prevent erosion, improve water quality and promote sustainable agriculture. NRCS experts help landowners develop conservation plans, create and restore wetlands, and restore and manage other natural ecosystems. While farmers and ranchers remain NRCS's primary customers, the agency also provides technical assistance to city planners, watershed groups, state and local governments and civic organizations. The EQIP authorized in the Conservation Title of the 2014 Farm Bill is a voluntary conservation program established to provide financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, improved water conservation, reduced soil erosion, and improved wildlife habitat. EQIP is administered by the USDA-NRCS, but the priorities are identified by the local work groups that are chaired by soil and water conservation districts (SWCDs) and the statewide resource concerns identified by the State Technical Advisory Committee that is composed of representatives from federal and state resource agencies and organizations that are associated with agriculture. The committee and local work groups recommend the practices eligible for cost share. Eligible persons may select to apply in the county-based program recommended by the local work group or in one of the Statewide Resource Concerns recommended by the committee. From this plan, landowners and operators will choose the practices and evaluation systems that they are willing and able to implement. Additionally, EQIP has several national priorities and landscape initiatives, such as the National Water Quality Initiative, in place to address high-priority resource concerns (TCEQ 2017). The NRCS Corpus Christi office would be an instrumental partner in working with farmers and ranchers throughout the Baffin Bay watershed to reduce nutrient runoff from their lands.

United States Environmental Protection Agency

The EPS's mission is to protect human health and the environment. EPA offers numerous free tools and resources that simplify the watershed planning process and provide access to needed resources. Water quality standards, set by the EPA, are the foundation of the water quality-based pollution control program mandated by the CWA. In partnership with state, regional, local, and volunteer resources, the EPA compiles and reports on surface water quality. EPA also has several programs for wetland conservation, restoration, and monitoring. EPA, along with the U.S. Army Corps of Engineers, establishes environmental standards for reviewing permits for discharges that affect wetlands, such as residential development, roads, and levees. Permitted facilities discharging to Petronila Creek and Baffin Bay are regulated by the EPA. In addition, the CWA established the Section 319 Nonpoint Source Management Program to grant funds to states, territories, and tribes to support nonpoint source efforts.

United States Department of Agriculture - Farm Service Agency

The Farm Service Agency (FSA) serves farmers, ranchers, and agricultural partners through the delivery of agricultural programs. FSA's responsibilities are organized into five areas: Farm Programs, Farm Loans, Commodity Operations, Management, and State Operations. FSA also implements ad hoc disaster programs and the Conservation Reserve Program. The agency provides credit to agricultural producers who are unable to receive private, commercial credit. The Conservation Reserve Program is a voluntary program administered by the FSA that offers annual rental payments, incentive payments, annual maintenance payments for certain activities, and cost-share assistance to establish approved cover on eligible cropland. The program encourages farmers to plant long-term, resource-conserving cover to improve soil, water, and wildlife resources. These practices can reduce nonpoint source pollution from agricultural lands (TCEQ 2017). The FSA can serve as a distributor of funding for nutrient reduction projects on agricultural lands.

National Oceanic and Atmospheric Administration

NOAA's mission is to understand climate, weather, ocean, and coast science, share that information, and conserve and manage coastal and marine ecosystems and resources. The agency exercises its direct authority to regulate and sustain marine fisheries and their ecosystems, protect endangered marine and anadromous species, protect and restore habitats and ecosystems, conserve marine sanctuaries and other protected places, respond to environmental emergencies, and aid in disaster recovery. NOAA has resources that can be applied to monitoring and assessing nutrient reduction goals in Baffin Bay as management strategies are applied throughout the Baffin Bay watershed.

United States Army Corps of Engineers

The U.S. Army Corps of Engineers is a worldwide organization that provides engineering services, environmental restoration, and construction support for a wide variety of civil and military projects. The Corps' primary civil mission is developing and managing the nation's water resources. The Corps develops projects to reduce flood damage; improves navigation channels and harbors; protects wetlands; and preserves, safeguards, and enhances the environment (TCEQ 2017).

United States Geological Survey

The USGS provides scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect quality of life. USGS collects, monitors, analyzes, and provides science about natural resource conditions, issues, and problems. The agency carries out large-scale, multidisciplinary investigations and provides scientific information to resource managers, planners, and other customers. Like NOAA, the USGS can use its monitoring and evaluation resources to assess progress toward meeting nutrient reduction goals, specifically in the freshwater reaches of Petronila Creek.

5.2 State Partners

Texas A&M University – Corpus Christi (Harte Research Institute)

The Harte Research Institute (HRI) employs a unique interdisciplinary way of working that integrates science with economic, policy, and sociological expertise. HRI scientists are encouraged to think broadly and pursue partnerships to identify and advance solutions to environmental and economic challenges facing the Gulf of Mexico. These scientists would continue to play an important role in identifying unique nutrient reduction strategies and modeling water quality in Petronila Creek and the Baffin Bay watershed.

Texas Water Resources Institute

The Texas Water Resources Institute (TWRI), part of Texas AgriLife Research, the Texas AgriLife Extension Service, and the College of Agriculture and Life Sciences at Texas A&M University, provides science-based, community-supported solutions for the state's pressing water quantity and quality challenges through internal expertise and external collaborations. Many of the TWRI's projects address agricultural and urban BMPs to reduce or prevent nonpoint source pollution. The TWRI assists communities with water quality monitoring and assessment, bacterial source tracking of pollution sources in watersheds, and evaluation of innovative BMPs. Through its watershed planning and implementation projects, the TWRI works with stakeholders to identify, develop, and implement effective watershed-based management strategies to address local water quality concerns (TCEQ 2017).

Texas State Soil and Water Conservation Board

The TSSWCB is the state agency that administers Texas' soil and water conservation law and offers technical assistance to the state's SWCDs. The TSSWCB coordinates conservation and nonpoint source water pollution abatement programs throughout the state, including the Water Quality Management Plan (WQMP) Program and the Nonpoint Source Grant Program. The WQMP Program provides a voluntary, incentive-based, natural resource conservation planning mechanism to agricultural producers and other rural landowners who choose to implement BMPs that prevent and abate nonpoint source pollution. The WQMP Program includes technical assistance to participants for the development of WQMPs, as well as financial incentives to participants to assist with the installation of specific BMPs prescribed in WQMPs. The WQMP Program is the state's primary BMP implementation program for agricultural lands (TCEQ 2017). Similarly, nonpoint source pollution prevention and abatement activities can be funded through the Nonpoint Source Grant Program. These activities include: implementation of WPPs and the nonpoint source portion of TMDL I-Plans, surface water quality monitoring, demonstration of innovative BMPs, technical assistance and financial incentives for the development and implementation of TSSWCB-certified WQMPs, public outreach and education, development of WPPs, and monitoring activities to determine the effectiveness of specific pollution prevention methods (TCEQ 2017).

Texas Parks and Wildlife Department

TPWD's mission is to manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations. TPWD coordinates with landowners to manage their land to the benefit of fish and wildlife. Specific programs that support nonpoint source nutrient management include the Kills and Spills Team, the Private Lands and Habitat Program, the Texas Farm and Ranch Lands Conservation Program, the Conserving Texas Rivers Initiative, and the Coastal Habitat Restoration and Protection program. For example, under the Conserving Texas Rivers Initiative, TPWD staff engage private landowners and promote the implementation of watershed-based BMPs for the conservation of riparian and aquatic species. Technical guidance is provided to facilitate land stewardship that results in benefits to aquatic species. Additionally, staff work with landowners to develop riparian and upland restoration projects that are ultimately funded by the TPWD Landowner Incentive Program, National Fish and Wildlife Foundation, Southeast Aquatic Resources Partnership, and U.S. Fish and Wildlife Partners (TCEQ 2017).

Texas A&M University AgriLife Extension

The Texas A&M AgriLife Extension Service is an education agency with a statewide network of professional educators, trained volunteers, and county offices. Major efforts include mitigating drought impacts; conserving water use in homes, landscapes, and production agriculture; improving emergency management; enhancing food security; and protecting human health through education about diet, exercise, and disease prevention and management. One of its primary goals is to help consumers, homeowners, agricultural producers, communities, and irrigation districts understand and adopt BMPs to protect water quality and enhance conservation so water supplies will meet future water needs in Texas that are essential for expanding agricultural growth, jobs, and the economy in both rural and urban areas. AgriLife Extension also demonstrates the latest technology and best practices to improve the state's food and fiber system. Staff and resources from AgriLife would play a critical function in evaluating lands for BMP implementation.

Texas General Land Office

The GLO is the state agency responsible for the management of state-owned public lands not specifically purchased by or deeded to other agencies. The GLO is also the state's lead agency for coordinating the Coastal Management Program (CMP) designed to help preserve public beach access, protect coastal wetlands and other coastal natural resources, and respond to beach erosion along the Texas coast. The GLO primarily serves the schoolchildren, veterans, and the environment of Texas. The agency does so by preserving our history, maximizing state revenue through innovative administration, and through the prudent stewardship of state lands and natural resources. The Texas CMP and the Texas Coastal Nonpoint Source Program, funded by NOAA and managed by the GLO, focuses on the state's coastal natural resource areas. The document discusses the coastal nonpoint source management area; provides an overview of program implementation and coordination; presents specific nonpoint source categories, the CZMA §6217 management measures, and the state rules and programs which address pollution sources and meet the federal requirements; provides information on additional management measures, technical assistance, and public participation; and describes program monitoring and evaluation.

Texas Commission on Environmental Quality

The TCEQ strives to protect our state's public health and natural resources consistent with sustainable economic development. The agency establishes surface water quality standards for rivers, lakes, and estuaries; monitors and assesses their status; and implements pollution control projects to protect or restore natural waterways. The goal of TCEQ's Nonpoint Source Program is to protect water bodies from nonpoint source pollution and restore water quality through assessment, implementation, and educational activities. The agency works with stakeholders to develop and implement programs and practices that minimize nonpoint source pollution at the source and manage nonpoint source pollution. Program activities include the Nonpoint Source Management Program, CWA §319(h) grant allocation, the Nonpoint Source Annual Report, development of WPPs, and CWA §604(b) grant allocation (TCEQ 2017).

Texas Department of Agriculture

The Texas Department of Agriculture's (TDA) key objectives are to promote production agriculture, consumer protection, economic development and healthy living. TDA is a diversified state agency that provides value-added services through regulatory and marketing initiatives. TDA's mission is to make Texas a leader in agriculture, fortify the economy, empower rural communities, promote healthy lifestyles, and cultivate winning strategies for rural, suburban, and urban Texas. While the TDA is the state's lead regulatory agency for agricultural, structural, and vector pesticide regulation, the agency is also working on issues involving risks from other contaminants as well as state water conservation and planning efforts. The TDA can provide farm interests support in linking landowners to qualified and affordable vendors and services needed to reduce nutrient runoff.

Texas Water Development Board

The Texas Water Development Board (TWDB) is the state's water planning and water project financing agency. It is responsible for collecting and disseminating water related data, assisting with regional water planning, preparing the State Water Plan and financing water and wastewater projects throughout the state. Under the Clean Water State Revolving Fund (CWSRF), most loans administered by the TWDB are made to publicly-owned wastewater treatment and collection systems. Loans for nonpoint source pollution abatement projects can also be provided through the CWSRF. Some of the activities that are eligible for funding include agricultural, rural, and urban runoff control; estuary improvement; nonpoint source education; and wet weather flow control including stormwater and sewer overflows that are not associated with a TPDES permit. Other programs the TWDB administers for financing potential nonpoint source activities include the Texas Water Development Fund, the Rural Water Assistance Fund, the Agricultural Loan Program, and the Economically Distressed Areas Program (TCEQ 2017).

Texas Department of Transportation

The Texas Department of Transportation (TxDOT) aims to deliver a safe, reliable, and integrated transportation system that enables the movement of people and goods. They are the lead state agency for construction and maintenance of state roads, which includes responsibility for the management of potential pollution from road and highway operations. TxDOT has a comprehensive state-wide stormwater management effort to ensure water quality throughout the state. Some nutrient reduction management strategies could be applied to road rights-of-way. TxDOT designs stormwater structural controls in a manner to reduce the discharge of pollutants to the maximum extent practicable. TxDOT's manual entitled *Storm Water Management Guidelines for Construction Activities* provides guidelines to prevent erosion and pollutants from projects from flowing into the waters of the U.S. The manual provides guidelines for each structural control device, including height, width, depth, and drainage area design requirements for each device. In addition to the construction guidelines manual, TxDOT maintains stringent design specifications, ensuring structural goals meet water quality requirements (TCEQ 2017). TxDOT could self-implement projects that foster nutrient assimilation in roadside drainage channels (e.g., vegetating ditches, holding ponds).

5.3 Regional Partners

Coastal Bend Bays & Estuaries Program

The CBBEP is a local non-profit organization dedicated to researching, restoring and protecting the bays and estuaries of the Texas Coastal Bend. This 515 square mile area of water includes all bays, estuaries and bayous in the Copano, Aransas, Corpus Christi, Nueces, Baffin and upper Laguna Madre bay systems. CBBEP’s mission is the implementation of the Coastal Bend Bays Plan, which is to protect and restore the health and productivity of the bays and estuaries while supporting continued economic growth and public use of the bays. The plan identifies specific actions that will benefit the bay system and the users of the bays. The CBBEP can promote the use of nutrient reduction strategies with willing partners whether they are landowners, public agencies, or other NGOs.

Nueces River Authority

The NRA was created by the Texas legislature in 1935. Unlike typical government agencies, NRA does not tax, issue permits, or regulate. NRA receives no state or federal tax or appropriations revenue. The agency’s income is mainly from contracted services. NRA has broad authority to preserve, protect, and develop water resources; provide for flood control, irrigation, and navigation; develop parks and recreational facilities; finance water supply, water treatment, and pollution control projects; and receive state and federal grants and loans. The NRA supports surface water quality studies and watershed management projects implemented throughout the watershed. Examples of these include the riparian evaluation of Baffin Bay tributaries to identify priority areas for riparian/wetland restoration and conservation efforts. The NRA's Farming Out Pollutants project would provide farmers incentive payments to replace seasonal crops or invasive grasses along waterways with herbaceous buffers designed to improve water quality.

Baffin Bay Watershed Study Group

The Baffin Bay Watershed Study Group was formed by the local community to bring together scientists, natural resource managers, and various stakeholders who are committed to restoring the health and productivity of Baffin Bay, which has been in decline for some time. Baffin Bay is a Texas icon, a significant contributor to the economy of the area and to the wellbeing of our citizens. Since the first meeting, the group has grown to include not only researchers and state agencies, but commercial fisherman, recreational fisherman, hotel/B&B owners, citizens living on Baffin Bay, ranchers, business owners, federal and local agencies, local government representatives, and other interested stakeholders. The group's charge is to identify the issues that are contributing to a decline in the health of Baffin Bay, characterize the problems, and develop solutions. The group also serves as a communications platform between all stakeholders in the watershed to maintain transparency and monitor progress toward nutrient reduction goals.

5.4 Local Government Partners

Kleberg-Kenedy Soil and Water Conservation District

The Texas soil and water conservation districts have working mutual agreements with the USDA to provide grassroots input to USDA through NRCS. Local soil and water conservation district boards of supervisors are composed of five elected officials. They are organized statewide, often following county boundaries and are generally collocated with NRCS in USDA Service Centers. The district can serve as a resource for farmers and ranchers to obtain technical assistance with developing a custom plan for reducing nutrient runoff associated with their specific agricultural activities.

Kleberg County and Nueces County

Kleberg County public figures should be involved in representing the interests of the public as projects are formulated and implemented. Counties in Texas have numerous environmental responsibilities including OSSF management, solid waste management, and stormwater management. OSSF management programs are implemented in accordance with rules established by TCEQ which include site plan approval, construction inspection, and complaint response.

City of Kingsville

The City of Kingsville is the largest metropolitan area in the Baffin Bay watershed. Cities in Texas have numerous environmental responsibilities including water and wastewater services, solid waste management, and stormwater management. There may be opportunities for the city to implement public works projects to help achieve water quality goals.

5.5 Local Partners

Private Landowners

Ranchers and farmers with active operations will be critical partners in reducing nutrient loads to Baffin Bay. In coordination with the other listed stakeholders, these landowners will need to be fully vested into the planning, funding, implementation, and monitoring process.

King Ranch

The King Ranch owns and operates 825,000 acres of land for cattle ranching, farming, and recreational hunting purposes. The prominence of the King Ranch gives them regional leadership status in agribusiness industry. Their practices and conservation programs serve as industry standard and a model for other ranchers.

Gulf Coast Cooperative

The Gulf Coast Cooperative is a farmer-owned cooperative allowing for cost sharing and combined buying power for seed and feed purchase and storage. Facilities are located throughout the coastal bend region; however, the original facility is in Ricardo, Kleberg County, Texas. Representing many of the farmers and ranchers in the region, the cooperative can serve as a conduit between area stakeholders.

Chamber of Commerce - Kingsville

The mission of the Kingsville Chamber of Commerce is to improve the Kingsville business environment through voluntary partnerships with economic, civic, commercial, industrial, and educational interests by capitalizing on the strengths of its community and businesses. The Chamber of Commerce would represent business and economic interests.

5.6 Non-Governmental Organizations

The Nature Conservancy

The mission of The Nature Conservancy (TNC) is to conserve the lands and waters on which all life depends. TNC's vision is a world where the diversity of life thrives, and people act to conserve nature for its own sake and its ability to fulfill our needs and enrich our lives. The TNC is able to acquire and manage large tracts of land to restore and use as natural nutrient filters within the watershed.

Holistic Management International

Holistic Management International (HMI) educates family farmers and ranchers and pastoralists in regenerative agricultural practices that empower them to strengthen their businesses, produce healthier food, improve local wildlife habitats, and protect the environment. HMI's mission is to educate people in regenerative agriculture for healthy land and thriving communities. HMI can provide services to farmers and ranchers to help evaluate their land for nutrient runoff reduction opportunities.

Texas Farm Bureau

The Texas Farm Bureau represents agricultural and agribusiness interests in shaping policies at a state government level. It advocates on behalf of its members in law and policy decision-making. With support from the Texas Farm Bureau, farmers and ranchers will also have support from state lawmakers and resources to implement BMPs aimed at improving water quality.

Ducks Unlimited

Ducks Unlimited conserves, restores, and manages wetlands and associated habitats for North America's waterfowl. The organization aims to address the challenges of degradation and elimination of wetlands and other habitats across the continent. As a leader in conservation, Ducks Unlimited can offer resources in the acquisition and restoration of natural lands in the watershed.

Gulf of Mexico Alliance

The mission of the Gulf of Mexico Alliance is to enhance the ecological and economic health of the Gulf of Mexico through increased regional collaboration. The five U.S. Gulf States (Alabama, Florida, Louisiana, Mississippi, and Texas) face similar challenges and concerns regarding the Gulf Coast and its waters. Through the Alliance, the Gulf States can manage the Gulf with a comprehensive, ecosystem approach. The Gulf of Mexico Alliance structure allows state and federal agency partners to focus funding priorities on the needs of the Gulf. Equally important, the Alliance provides a forum to share knowledge and expertise as well as an opportunity to collaborate to reduce duplication of effort. Involving the Alliance is necessary to incorporate Baffin Bay watershed plans into the larger Gulf of Mexico planning effort.

Texas Sea Grant

The Texas Sea Grant College Program is a collaboration of NOAA, the State of Texas and universities across the state. Texas Sea Grant is part of NOAA's National Sea Grant College Program, a network of 33 university-based programs. Texas Sea Grant is headquartered at Texas A&M University in College Station and has staff members located at Texas A&M University at Galveston and Texas A&M University-Corpus Christi. Texas Sea Grant’s competitive research grant program draws on the expertise of the state’s top scientists. At the same time, its coastal extension agents and specialists working in the field translate and communicate research results to stakeholders in ways that meet the real-world needs of Texans. Living in coastal communities themselves, Texas Sea Grant personnel are a conduit to the industries, local governments and citizens there to help identify additional issues that would benefit from scientific study. Texas Sea Grant can provide funding opportunities to study and monitor progress toward meeting nutrient reduction goals.

SECTION 6
SUMMARY OF FINDINGS

The Nutrient Reduction Strategies Report was prepared to assist the TIG with identifying opportunities to invest NRDA funding in projects that will improve coastal waters degraded by nonpoint source nutrients. This report describes the approach for identifying a high-priority coastal watershed to target the NRDA funding to achieve nutrient load reductions and demonstrate coastal water quality improvements. The findings of this study are summarized below.

- Based on historical data assessments completed between 2006 and 2014, 85 Texas coastal waterbodies demonstrated water quality impacts associated with nutrient concentrations compared to state screening levels. The primary sources of degraded water quality vary by waterbody. This report focused specifically on evaluating and prioritizing coastal water quality impacts caused by excessive nutrients. Waterbodies that were impacted primarily by nonpoint source pollution were given the highest priority.
- Three coastal watersheds were identified with significant nutrient loads that are relatively devoid of point sources: the lower Guadalupe River, San Fernando River, and Petronila Creek. The last two both empty into the Baffin Bay estuary.
- Petronila Creek was singled out as having the greatest opportunity for implementing nonpoint source nutrient reduction strategies because most of the watershed is considered agricultural land use. The Petronila Creek watershed is almost exclusively agricultural, with approximately 72 percent of the entire watershed area in use as cropland and 20 percent in pastureland.
- Modeling of nutrient loads using watershed-specific variables such as land use, slopes, and hydrology in the STEPL model confirmed that nonpoint sources in Petronila Creek are the primary contributor to nutrient loads. It is estimated that 98 percent of the nutrients in Petronila Creek comes from sources associated with pasture/grassland and cropland. Nutrient loads associated with these two land use types are influenced by land application of commercial fertilizer and direct deposition of manure from livestock.
- Most of the cropland in the watershed is used for sorghum production. Cotton is also a significant crop. These crops are produced using dryland farming techniques that require maintaining low-moisture soil conditions by draining rainfall as efficiently as possible.
- Nutrient management strategies to consider in Petronila Creek are numerous and should be evaluated on a case-by-case basis depending on cost effectiveness, landowner willingness, soil type, topography, crop type, agribusiness market conditions, planting and harvesting methods, livestock type, size of operation, annual precipitation, and other field-specific factors. While all options should be considered, some BMPs are more likely to be implemented than others given the area land use and topography.
- Of the more feasible options, some practices may be more cost effective than others to apply. A benefit-cost analysis was applied to a limited number of practices for which it was practical to estimate the cost and effectiveness of nutrient reduction. For example, land retirement, while extremely effective in reducing nutrient loads, especially if converted to lands that actively retain sediment and attenuate nutrients, is also relatively expensive on a per acre basis (high cost/high benefit). Cover crops represented a high cost/low benefit option. Filter strips represented a low cost/moderately high benefit option.
- Opportunities exist to reduce nutrient loads throughout the Petronila Creek watershed. For example, riparian restoration and wetland creation within Petronila Creek and its tributaries

would provide nutrient sinks for nonpoint source runoff from cropland while also providing other ecosystem services such as wildlife and fishery habitat. Implementing voluntary BMPs in pasturelands and improving road rights-of-way should also be considered, although those opportunities may be relatively limited.

- Engaging local, regional, state, and federal stakeholders in identifying specific opportunities to fund and implement nutrient reduction strategies will be paramount to meeting water quality improvement objectives. This report lists potential stakeholders that can serve as active partners to advance implementation of voluntary nutrient BMPs.
- The TIG recognizes that coordination and communication between landowners, ranchers, farmers and local, regional, state, and federal land and water resource management agencies will be paramount to taking the next step to advance Nutrient Reduction Strategies in Petronila Creek Watershed.

SECTION 7
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APPENDIX A
COASTAL SEGMENTS WITH NUTRIENT CONCERNS

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Coastal Segments with Nutrient Concerns

Row Number	Segment Number	Segment Name	Segment Type	Nutrient Integrated Level of Support				
				2006	2008	2010	2012	2014
1	0501B	Little Cypress Bayou	Tidal Stream	CS	CS	CS	CS	**CS***
2	0508C	Hudson Gully	Tidal Stream	CS	CS	CS	CS	**CS***
3	0511E	Terry Gully	Freshwater Stream	CS	CS	CS	CS	**CS***
4	0701	Taylor Bayou/North Fork Taylor Bayou Above Tidal	Freshwater Stream	CS	CS	CS	CS	CS
5	0702	Intracoastal Waterway Tidal	Tidal Stream	NC	NC	CS	CS	CS
6	0702A	Alligator Bayou and Main Canals A, B, C, and D	Freshwater Stream	CS	CS	CS	CS	CS
7	0704	Hillebrandt Bayou	Freshwater Stream	CS	CS	CS	CS	CS
8	0801	Trinity River Tidal	Tidal Stream	NC	NC	CS	CS	CS
9	0801B	Old River	Tidal Stream	CS	CS	CS	CS	CS
10	0801C	Cotton Bayou	Tidal Stream	ID	ID	CS	CS	CS
11	0901	Cedar Bayou Tidal	Tidal Stream	NC	NC	CS	CS	CS
12	1002	Lake Houston	Reservoir	CS	CS	CS	CS	CS
13	1005	Houston Ship Channel/San Jacinto River Tidal	Tidal Stream	NC	CS	CS	CS	CS
14	1006	Houston Ship Channel Tidal	Tidal Stream	CS	CS	CS	CS	CS
15	1007	Houston Ship Channel/Buffalo Bayou Tidal	Tidal Stream	NC	CS	CS	CS	CS
16	1007F	Berry Bayou Above Tidal	Freshwater Stream	CS	CS	CS	CS	CS
17	1007H	Pine Gully Above Tidal	Freshwater Stream	NA	NA	CS	CS	CS
18	1007I	Plum Creek Above Tidal	Freshwater Stream	NA	NA	CS	CS	CS
19	1007O	Unnamed Tributary of Buffalo Bayou	Freshwater Stream	NA	NA	CS	CS	CS
20	1007R	Hunting Bayou Above Tidal	Freshwater Stream	CS	CS	CS	CS	CS
21	1013	Buffalo Bayou Tidal	Tidal Stream	CS	CS	CS	CS	CS
22	1013C	Unnamed Non-Tidal Tributary of Buffalo Bayou Tidal	Freshwater Stream	NA	NA	CS	CS	CS
23	1014	Buffalo Bayou Above Tidal	Freshwater Stream	CS	CS	CS	CS	CS

Row Number	Segment Number	Segment Name	Segment Type	Nutrient Integrated Level of Support				
				2006	2008	2010	2012	2014
24	1017	Whiteoak Bayou Above Tidal	Freshwater Stream	CS	CS	CS	CS	CS
25	1101	Clear Creek Tidal	Tidal Stream	CS	CS	CS	CS	CS
26	1102	Clear Creek Above Tidal	Freshwater Stream	CS	CS	CS	CS	CS
27	1103	Dickinson Bayou Tidal	Tidal Stream	NC	NC	CS	CS	CS
28	1111	Old Brazos River Channel Tidal	Estuary	CS	CS	CS	CS	CS
29	1113	Armand Bayou Tidal	Tidal Stream	CS	CS	CS	CS	CS
30	1113B	Horsepen Bayou Tidal	Tidal Stream	CS	CS	CS	CS	CS
31	1201	Brazos River Tidal	Tidal Stream	CS	CS	CS	CS	CS
32	1301	San Bernard River Tidal	Tidal Stream	CS	CS	CS	CS	CS
33	1401	Colorado River Tidal	Tidal Stream	CS	CS	CS	CS	CS
34	1402	Colorado River Below La Grange	Freshwater Stream	CS	CS	CS	CS	CS
35	1501	Tres Palacios Creek Tidal	Tidal Stream	CS	CS	CS	CS	CS
36	1604	Lake Texana	Reservoir	CS	CS	CS	CS	CS
37	1701	Victoria Barge Canal	Estuary	ID	CS	CS	CS	CS
38	1801	Guadalupe River Tidal	Tidal Stream	ID	CS	CS	CS	CS
39	1802	Guadalupe River Below San Antonio River	Freshwater Stream	NA	CS	CS	CS	CS
40	1901	Lower San Antonio River	Freshwater Stream	NA	CS	CS	CS	CS
41	2101	Nueces River Tidal	Tidal Stream	ID	CS	CS	CS	CS
42	2102	Nueces River Below Lake Corpus Christi	Freshwater Stream	ID	CS	CS	CS	CS
43	2201	Arroyo Colorado Tidal	Tidal Stream	ID	CS	CS	CS	CS
44	2201A	Harding Ranch Drainage Ditch Tributary (A) to the Arroyo Colorado Tidal	Freshwater Stream	ID	ID	CS	CS	CS
45	2201B	Unnamed Drainage Ditch Tributary (B) in Cameron County Drainage District #3	Tidal Stream	ID	ID	CS	CS	CS
46	2202	Arroyo Colorado Above Tidal	Freshwater Stream	ID	CS	CS	CS	CS

Row Number	Segment Number	Segment Name	Segment Type	Nutrient Integrated Level of Support				
				2006	2008	2010	2012	2014
47	2203	Petronila Creek Tidal	Reservoir	ID	CS	CS	CS	CS
48	2204	Petronila Creek Above Tidal	Freshwater Stream	NA	CS	CS	CS	CS
49	2301	Rio Grande Tidal	Tidal Stream	ID	CS	CS	CS	CS
50	2421	Upper Galveston Bay	Estuary	ID	CS	CS	CS	CS
51	2421A	Clear Lake Channel	Estuary	NC	NC	CS	CS	CS
52	2422	Trinity Bay	Estuary	ID	CS	CS	CS	CS
53	2423	East Bay	Estuary	ID	CS	CS	CS	CS
54	2423A	Oyster Bayou	Tidal Stream	NC	NC	CS	CS	CS
55	2424A	Highland Bayou	Tidal Stream	NC	NC	CS	CS	CS
56	2424B	Lake Madeline	Estuary	NC	NC	CS	CS	CS
57	2424D	Offatts Bayou	Estuary	NC	NC	CS	CS	CS
58	2424E	English Bayou	Estuary	NC	NC	CS	CS	CS
59	2425	Clear Lake	Estuary	ID	CS	CS	CS	CS
60	2426	Tabbs Bay	Estuary	ID	CS	CS	CS	CS
61	2427	San Jacinto Bay	Estuary	ID	CS	CS	CS	CS
62	2428	Black Duck Bay	Estuary	ID	CS	CS	CS	CS
63	2429	Scott Bay	Estuary	ID	CS	CS	CS	CS
64	2430	Burnett Bay	Estuary	ID	CS	CS	CS	CS
65	2430A	Crystal Bay	Estuary	ID	ID	CS	CS	CS
66	2431	Moses Lake	Estuary	ID	NC	CS	CS	CS
67	2436	Barbours Cut	Estuary	ID	CS	CS	CS	CS
68	2437	Texas City Ship Channel	Estuary	ID	CS	CS	CS	CS
69	2438	Bayport Channel	Estuary	ID	CS	CS	CS	CS
70	2439	Lower Galveston Bay	Estuary	ID	CS	CS	CS	CS

Row Number	Segment Number	Segment Name	Segment Type	Nutrient Integrated Level of Support				
				2006	2008	2010	2012	2014
71	2452A	Tres Palacios Harbor	Estuary	CS	CS	CS	CS	CS
72	2453	Lavaca Bay/Chocolate Bay	Estuary	ID	CS	CS	CS	CS
73	2454A	Cox Lake	Estuary	CS	CS	CS	CS	CS
74	2456	Carancahua Bay	Estuary	ID	CS	CS	CS	CS
75	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	Estuary	ID	CS	CS	CS	CS
76	2471A	Little Bay	Estuary	ID	ID	CS	CS	CS
77	2484	Corpus Christi Inner Harbor	Estuary	ID	CS	CS	CS	CS
78	2485	Oso Bay	Estuary	ID	CS	CS	CS	CS
79	2485A	Oso Creek	Tidal Stream	CS	CS	CS	CS	CS
80	2485B	Unnamed tributary of Oso Creek	Tidal Stream	ID	ID	CS	CS	CS
81	2485D	West Oso Creek	Tidal Stream	ID	ID	CS	CS	CS
82	2491	Laguna Madre	Estuary	ID	CS	CS	CS	CS
83	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	Estuary	ID	CS	CS	CS	CS
84	2492A	San Fernando Creek	Tidal Stream	CS	CS	CS	CS	CS
85	2501	Gulf of Mexico	Ocean	ID	NC	CS	CS	CS

*CS = Insufficient data to remove from concerns list, but was not reported as a carryforward by SWQM

Code	Description
NS	Non-Supporting
CN	Concern for Near Non-Attainment
CS	Concern for Screening Level
NC	No Concern
FS	Fully Supporting
NA	Not Assessed
ID	Insufficient Data; either from assessment data gaps or lack of data to evaluate for assessment.

APPENDIX B
DISSOLVED OXYGEN ASSESSMENT STATUS HISTORY FOR SIGNIFICANT NUTRIENT IMPACTED COASTAL WATERS

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Dissolved Oxygen Assessment Status History for Significant Nutrient Impacted Coastal Waters

Row Number	Segment Number	Segment Name	Segment Type	Dissolved oxygen Integrated Level of Support: Impairment Category				
				2006	2008	2010	2012	2014
1	0501B	Little Cypress Bayou	Tidal Stream	NS: 5c	NS: 5c	NS: 5c	NS: 5c	NS: 5c
2	0701	Taylor Bayou/North Fork Taylor Bayou Above Tidal	Freshwater Stream	NS: 5a	NS: 5a	NS: 5b	NS: 5b	NS: 5b
3	0702A	Alligator Bayou and Main Canals A, B, C, and D	Freshwater Stream	NC	NC	NC	NC	NC
4	0704	Hillebrandt Bayou	Freshwater Stream	NS: 5a	NS: 5a	NS: 5b	NS: 5b	NS: 5b
5	0801C	Cotton Bayou	Tidal Stream	NS: 5b	NS: 5b	NS: 5b	CS	CN
6	1002	Lake Houston	Reservoir	NC	NC	NC	NC	NC
7	1006	Houston Ship Channel Tidal	Tidal Stream	NS: 5c	NS: 5c	NS: 5c	NC	NC
8	1007	Houston Ship Channel/Buffalo Bayou Tidal	Tidal Stream	NC	CN	NC	NC	NC
9	1007F	Berry Bayou Above Tidal	Freshwater Stream	NA	NA	NC	NC	NC
10	1007H	Pine Gully Above Tidal	Freshwater Stream	NA	NA	NS: 5c	NS: 5c	NS: 5c
11	1007I	Plum Creek Above Tidal	Freshwater Stream	NA	NA	NS: 5c	NS: 5c	NS: 5c
12	1007O	Unnamed Tributary of Buffalo Bayou	Freshwater Stream	NS: 5c	NS: 5c	NS: 5c	NS: 5c	NS: 5c
13	1013	Buffalo Bayou Tidal	Tidal Stream	NC	NC	NC	NC	NC
14	1013C	Unnamed Non-Tidal Tributary of Buffalo Bayou Tidal	Freshwater Stream	NC	NC	CS	CN	NS: 5c
15	1014	Buffalo Bayou Above Tidal	Freshwater Stream	NC	NC	NC	NC	NC
16	1017	Whiteoak Bayou Above Tidal	Freshwater Stream	NC	NC	NC	NC	NC
17	1101	Clear Creek Tidal	Tidal Stream	CS	CS	CS	CS	NC
18	1103	Dickinson Bayou Tidal	Tidal Stream	NS: 5a	NS: 5a	NS: 5a	NS: 5b	NS: 5b
19	1113	Armand Bayou Tidal	Tidal Stream	N: 5b	NS: 5b	NS: 5b	NS: 5b	NS: 5b
20	1113B	Horsepen Bayou Tidal	Tidal Stream	NC	NC	CS	CN	CN
21	1301	San Bernard River Tidal	Tidal Stream	NC	NC	NC	NC	NC

Row Number	Segment Number	Segment Name	Segment Type	Dissolved oxygen Integrated Level of Support: Impairment Category				
				2006	2008	2010	2012	2014
22	1402	Colorado River Below La Grange	Freshwater Stream	NC	NC	NC	NC	NC
23	1501	Tres Palacios Creek Tidal	Tidal Stream	NS: 5b	NS: 5b	NS: 5b	NS: 5b	NS: 5b
24	1701	Victoria Barge Canal	Estuary	ID	NC	NC	NC	NC
25	1801	Guadalupe River Tidal	Tidal Stream	FS	CS	CN	CN	NC
26	1901	Lower San Antonio River	Freshwater Stream	NA	NC	NC	NC	NC
27	2101	Nueces River Tidal	Tidal Stream	ID	NC	NC	NC	NC
28	2201	Arroyo Colorado Tidal	Tidal Stream	NA	NS: 5a	NS: 5a	NS: 5c	NS: 5a
29	2201A	Harding Ranch Drainage Ditch Tributary (A) to the Arroyo Colorado Tidal	Freshwater Stream	ID	ID	NC	ID	ID
30	2201B	Unnamed Drainage Ditch Tributary (B) in Cameron County Drainage District #3	Tidal Stream	ID	ID	NC	NC	ID
31	2202	Arroyo Colorado Above Tidal	Freshwater Stream	NA	NC	NC	NC	NC
32	2203	Petronila Creek Tidal	Reservoir	NA	NC	NC	NC	NC
33	2204	Petronila Creek Above Tidal	Freshwater Stream	NA	NC	NC	NC	NC
34	2301	Rio Grande Tidal	Tidal Stream	ID	NC	NC	NC	NC
35	2421	Upper Galveston Bay	Estuary	ID	NC	NC	NC	NC
36	2422	Trinity Bay	Estuary	ID	NC	NC	NC	NC
37	2423A	Oyster Bayou	Tidal Stream	NC	NC	CN	CN	NC
38	2424B	Lake Madeline	Estuary	NC	NC	NC	CS	NS: 5c
39	2425	Clear Lake	Estuary	ID	NC	NC	NC	NC
40	2426	Tabbs Bay	Estuary	ID	NC	NC	NC	NC
41	2427	San Jacinto Bay	Estuary	ID	NC	NC	NC	NC
42	2428	Black Duck Bay	Estuary	ID	NC	NC	NC	NC
43	2429	Scott Bay	Estuary	ID	NC	NC	NC	NC
44	2430	Burnett Bay	Estuary	ID	NC	NC	NC	NC
45	2430A	Crystal Bay	Estuary	ID	ID	NC	NC	NC
46	2436	Barbours Cut	Estuary	ID	NC	NC	NC	NC
47	2437	Texas City Ship Channel	Estuary	ID	NC	NC	NC	NC

Row Number	Segment Number	Segment Name	Segment Type	Dissolved oxygen Integrated Level of Support: Impairment Category				
				2006	2008	2010	2012	2014
48	2438	Bayport Channel	Estuary	ID	NC	NC	NC	CS
49	2454A	Cox Lake	Estuary	NC	NC	NC	CS	CS
50	2456	Carancahua Bay	Estuary	ID	NC	NC	NC	NC
51	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	Estuary	ID	NC	NC	NC	NC
52	2471A	Little Bay	Estuary	ID	ID	NC	NC	NC
53	2484	Corpus Christi Inner Harbor	Estuary	ID	NC	NC	NC	NC
54	2485	Oso Bay	Estuary	ID	NS: 5b	NS: 5b	NS: 5b	NS: 5b
55	2485A	Oso Creek	Tidal Stream	NC	NC	CS	CS	NC
56	2491	Laguna Madre	Estuary	ID	NS: 5b	NS: 5b	NS: 5b	NS: 5b
57	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	Estuary	ID	NC	NC	NC	NC
58	2492A	San Fernando Creek	Tidal Stream	NC	NC	NC	NC	NC

Code	Description
NS	Non-Supporting
CN	Concern for Near Non-Attainment
CS	Concern for Screening Level
NC	No Concern
FS	Fully Supporting
NA	Not Assessed
ID	Insufficient Data; either from assessment data gaps or lack of data to evaluate for assessment.

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APPENDIX C
TPDES PERMITTED OUTFALLS DISCHARGING TO 15 CANDIDATE SEGMENTS

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TPDES Permitted Outfalls Discharging to 15 Candidate Segments

Segment	Type	Outfall ID	Permittee	County	Measure of Flow	Average Flow (MGD)
1301	Minor Municipal	12819	8 MILE PARK LP	BRAZORIA	DAILY AVERAGE	0.0072
1301	Minor Municipal	15841	COLUMBIA BRAZORIA ISD	BRAZORIA	DAILY AVERAGE	0.01
1301	Minor Municipal	12346	TEXAS DEPT OF CRIMINAL JUSTICE	BRAZORIA	DAILY AVERAGE	0.54
1301	Minor Municipal	12647	CITY OF BRAZORIA	BRAZORIA	DAILY AVERAGE	0.75
1301	Minor Municipal	12593	CITY OF SWEENY	BRAZORIA	DAILY AVERAGE	0.975
1501	Minor Municipal	14933	TIDEHAVEN INDEPENDENT SCHOOL DISTRICT	MATAGORDA	DAILY AVERAGE	0.01
1501	Minor Municipal	15777	TIDEHAVEN INDEPENDENT SCHOOL DISTRICT	MATAGORDA	DAILY AVERAGE	0.02
1501	Minor Municipal	12511	MIDFIELD WATER SUPPLY CORPORATION	MATAGORDA	DAILY AVERAGE	0.03
1501	Minor Municipal	18707	MARKHAM MUD	MATAGORDA	DAILY AVERAGE	0.3
1701	Industrial	13613	UNION CARBIDE CORP	CALHOUN	DAILY AVERAGE	
1701	Industrial	14973	AIR LIQUIDE LARGE INDUSTRIES US LP	VICTORIA	DAILY AVERAGE	0.13
1701	Minor Municipal	13450	ARROWHEAD RANCH UTILITY COMPANY LLC	CALHOUN	DAILY AVERAGE	0.15
1701	Industrial	13516	SEADRIFT COKE LP	CALHOUN	DAILY AVERAGE	0.202
1701	Minor Municipal	12945	VICTORIA COUNTY WCID 1	VICTORIA	DAILY AVERAGE	0.3
1701	Minor Municipal	14863	ARROWHEAD RANCH UTILITY COMPANY LLC	CALHOUN	DAILY AVERAGE	0.3
1701	Minor Municipal	14864	ARROWHEAD RANCH UTILITY COMPANY LLC	CALHOUN	DAILY AVERAGE	0.6
1701	Industrial	13085	INEOS USA LLC	CALHOUN	DAILY AVERAGE	1.2
1701	Major Municipal	13014	CITY OF VICTORIA	VICTORIA	ANNUAL AVERAGE	9.6
1701	Industrial	Unknown	UNION CARBIDE CORP	CALHOUN	Unknown	Unknown
2204	Minor Municipal	10677	BISHOP CONSOLIDATED ISD	NUECES	DAILY AVERAGE	0.008
2204	Minor Municipal	15650	TEEN CHALLENGE OF TEXAS	NUECES	DAILY AVERAGE	0.009
2204	Minor Municipal	15913	CITY OF DRISCOLL	NUECES	DAILY AVERAGE	0.1
2204	Minor Municipal	17497	NUECES COUNTY WCID NO 5	NUECES	DAILY AVERAGE	0.1

Segment	Type	Outfall ID	Permittee	County	Measure of Flow	Average Flow (MGD)
2204	Minor Municipal	15409	LCS CORRECTIONS SERVICES INC	NUECES	DAILY AVERAGE	0.15
2204	Minor Municipal	18974	CITY OF AGUA DULCE	NUECES	DAILY AVERAGE	0.16
2422	Minor Municipal	15757	DICK WILLIAM STREET	CHAMBERS	DAILY AVERAGE	0.0075
2422	Minor Municipal	12540	3180 MAVERICK INVESTMENTS LLC	CHAMBERS	DAILY AVERAGE	0.015
2422	Minor Municipal	9326	COTTON BAYOU MANOR MOBILE HOME PARK INC	CHAMBERS	DAILY AVERAGE	0.032
2422	Minor Municipal	12726	TRINITY BAY CONSERVATION DISTRICT	CHAMBERS	DAILY AVERAGE	0.1
2422	Minor Municipal	12728	TRINITY BAY CONSERVATION DISTRICT	CHAMBERS	DAILY AVERAGE	0.1
2422	Minor Municipal	9221	TRINITY BAY CONSERVATION DISTRICT	CHAMBERS	DAILY AVERAGE	0.1
2422	Minor Municipal	11894	AQUA UTILITIES INC	CHAMBERS	DAILY AVERAGE	0.3
2422	Minor Municipal	11904	AQUA UTILITIES INC	CHAMBERS	DAILY AVERAGE	0.3
2422	Minor Municipal	11905	AQUA UTILITIES INC	CHAMBERS	DAILY AVERAGE	0.6
2422	Minor Municipal	11906	AQUA UTILITIES INC	CHAMBERS	DAILY AVERAGE	0.6
2422	Minor Municipal	9319	CITY OF ANAHUAC & TRINITY BAY CONSERV DIST	CHAMBERS	DAILY AVERAGE	0.6
2422	Industrial	7765	NRG TEXAS POWER LLC	CHAMBERS	DAILY AVERAGE	1616
2456	Municipal	Unknown	TRI-COUNTY POINT PROPERTY OWNERS ASSOCIATION	JACKSON	Unknown	Unknown
2456	Minor Municipal	14688	JESSE CARL WOOD	CALHOUN	DAILY AVERAGE	0.025
2462	Municipal	Unknown	CITY OF SEADRIFT	CALHOUN	Unknown	Unknown
2462	Minor Municipal	14784	CITY OF AUSTWELL	REFUGIO	DAILY AVERAGE	0.06
2462	Minor Municipal	12243	REFUGIO COUNTY WCID 1	REFUGIO	DAILY AVERAGE	0.075
2462	Minor Municipal	15032	CITY OF SEADRIFT	CALHOUN	DAILY AVERAGE	0.3
2462	Industrial	13051	AUSTWELL AQUA FARM INC	REFUGIO	DAILY AVERAGE	3.7
2491	Municipal	Unknown	VALLEY MUD NO 2	CAMERON	Unknown	Unknown

Segment	Type	Outfall ID	Permittee	County	Measure of Flow	Average Flow (MGD)
2491	Municipal	Unknown	SOUTHMOST REGIONAL WATER AUTHORITY AND BROWNSVILLE PUBLIC UTILITIES	CAMERON	Unknown	Unknown
2491	Municipal	Unknown	MILITARY HWY WSC	CAMERON	Unknown	Unknown
2491	Industrial	12226	BROWNSVILLE PUBLIC UTILITIES	CAMERON	DAILY AVERAGE	
2491	Minor Municipal	15423	US DEPT OF THE INTERIOR	KLEBERG	DAILY AVERAGE	0.025
2491	Minor Municipal	15455	BROWNSVILLE NAVIGATION DISTRICT	CAMERON	DAILY AVERAGE	0.098
2491	Minor Municipal	10960	EAST RIO HONDO WATER SUPPLY CO	CAMERON	DAILY AVERAGE	0.1
2491	Minor Municipal	16039	BROWNSVILLE NAVIGATION DISTRICT	CAMERON	DAILY AVERAGE	0.1
2491	Industrial	18160	TEXAS PACK INC	CAMERON	ANNUAL AVERAGE	0.15
2491	Minor Municipal	14750	US DEPT OF JUSTICE	CAMERON	DAILY AVERAGE	0.16
2491	Minor Municipal	15087	PORT MANSFIELD PUD AND WILLACY CO NAVIGATION DISTRICT	WILLACY	DAILY AVERAGE	0.221
2491	Industrial	15620	BROWNSVILLE NAVIGATION DISTRICT	CAMERON	DAILY AVERAGE	0.25
2491	Industrial	12224	BROWNSVILLE PUBLIC UTILITIES	CAMERON	DAILY AVERAGE	0.39
2491	Minor Municipal	15907	VALLEY MUNICIPAL UTILITY DISTRICT NO 2	CAMERON	DAILY AVERAGE	0.4
2491	Minor Municipal	14581	OLMITO WSC	CAMERON	DAILY AVERAGE	0.5
2491	Minor Municipal	14791	MILITARY HIGHWAY WSC	CAMERON	DAILY AVERAGE	0.51
2491	Minor Municipal	14942	LAGUNA MADRE WATER DISTRICT	CAMERON	DAILY AVERAGE	0.65
2491	Minor Municipal	14582	OLMITO WSC	CAMERON	DAILY AVERAGE	0.75
2491	Major Municipal	12436	CITY OF LOS FRESNOS	CAMERON	ANNUAL AVERAGE	1
2491	Major Municipal	16709	LAGUNA MADRE WATER DISTRICT	CAMERON	ANNUAL AVERAGE	1.1
2491	Major Municipal	16710	LAGUNA MADRE WATER DISTRICT	CAMERON	ANNUAL AVERAGE	1.1
2491	Major Municipal	14211	LAGUNA MADRE WATER DISTRICT	CAMERON	ANNUAL AVERAGE	1.5
2491	Industrial	11793	TAIWAN SHRIMP VILLAGE ASSOC INC & ...	CAMERON	DAILY AVERAGE	100
2491	Industrial	11794	TAIWAN SHRIMP VILLAGE ASSOC INC & ...	CAMERON	DAILY AVERAGE	100

Segment	Type	Outfall ID	Permittee	County	Measure of Flow	Average Flow (MGD)
2491	Major Municipal	15095	BROWNSVILLE PUBLIC UTILITIES BOARD	CAMERON	ANNUAL AVERAGE	12.8
2491	Major Municipal	14714	BROWNSVILLE PUBLIC UTILITIES BOARD	CAMERON	ANNUAL AVERAGE	14.5
2491	Major Municipal	13914	CITY OF LOS FRESNOS	CAMERON	ANNUAL AVERAGE	2
2491	Industrial	16394	TENASKA BROWNSVILLE PARTNERS LLC	CAMERON	DAILY AVERAGE	2.3
2491	Major Municipal	11899	CITY OF CORPUS CHRISTI	NUECES	ANNUAL AVERAGE	2.5
2491	Major Municipal	14741	LAGUNA MADRE WATER DISTRICT	CAMERON	ANNUAL AVERAGE	2.6
2491	Industrial	15019	KAAPA AQUA VENTURES ALLIANCE LLC	CAMERON	ANNUAL AVERAGE	8
2492	Minor Municipal	14683	TEXAS DEPT OF TRANSPORTATION	KENEDY	DAILY AVERAGE	0.013
2492	Minor Municipal	15070	KLEBERG COUNTY	KLEBERG	DAILY AVERAGE	0.033
2492	Minor Municipal	16515	KLEBERG COUNTY	KLEBERG	DAILY AVERAGE	0.0485
2492	Minor Municipal	15880	RIVIERA WCID	KLEBERG	DAILY AVERAGE	0.06
2423A	Minor Municipal	14867	STYN LLC	CHAMBERS	DAILY AVERAGE	0.01
2471A	Major Municipal	17794	CITY OF ROCKPORT	ARANSAS	ANNUAL AVERAGE	2.5
2492A	Industrial	14577	TICONA POLYMERS INC	NUECES	DAILY AVERAGE	
2492A	Minor Municipal	11603	CITY OF BISHOP	NUECES	DAILY AVERAGE	0.32
2492A	Minor Municipal	15780	US DEPT OF THE NAVY	KLEBERG	DAILY AVERAGE	0.4
2492A	Major Municipal	14657	CITY OF KINGSVILLE	KLEBERG	ANNUAL AVERAGE	1
2492A	Major Municipal	14886	CITY OF ALICE	JIM WELLS	ANNUAL AVERAGE	2.02
2492A	Major Municipal	15364	CITY OF ALICE	JIM WELLS	ANNUAL AVERAGE	2.6
2492A	Major Municipal	14655	CITY OF KINGSVILLE	KLEBERG	ANNUAL AVERAGE	3
2492A	Industrial	Unknown	TICONA POLYMERS INC	NUECES	Unknown	Unknown

APPENDIX D
STEPL RESULTS: ESTIMATED NUTRIENT LOADS FOR 12-DIGIT HUCS

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HUC12	County	Loads in lb/ac/year (except sediment in tons/ac/yr)			
		Total Nitrogen	Total Phosphorus	BOD	Sediment
121102050605	Nueces	21.09	5.28	32.96	0.22
121102050606	Nueces	20.58	5.11	32.23	0.19
121102050601	Nueces	20.40	5.04	32.28	0.20
121102050603	Nueces	20.16	4.96	31.79	0.11
121102050604	Nueces	19.73	4.85	31.65	0.18
121102040408	Nueces	19.71	4.85	32.56	0.11
121102050607	Nueces	19.04	4.69	30.17	0.19
121102050602	Nueces	19.01	4.61	30.29	0.10
121102050506	Nueces	18.23	4.33	30.40	0.09
121102050801	Kleberg	14.98	3.75	23.16	0.14
121102050608	Nueces	14.80	3.41	25.04	0.15
121102050802	Kleberg	13.43	3.32	20.97	0.14
121002040403	Victoria	12.48	2.01	29.21	0.110
121102050504	Jim Wells	11.73	2.74	20.11	0.22
121102050505	Jim Wells	11.07	2.65	19.22	0.22
121102050502	Jim Wells	10.47	2.43	18.37	0.22
121102050803	Kleberg	10.03	2.48	15.89	0.45
121102050501	Jim Wells	9.82	2.22	17.06	0.15
121002040108	Victoria	8.99	1.32	32.36	0.063
121102050503	Jim Wells	8.96	1.94	16.69	0.14
121002040401	Victoria	8.28	1.10	21.03	0.061
121102040407	Kleberg	8.27	1.81	15.43	0.08
121004030100	Calhoun	8.17	1.15	19.46	0.045
121102040405	Jim Wells	8.15	1.78	16.56	0.11
121002040404	Victoria	8.09	1.03	19.76	0.052
121102040404	Jim Wells	7.94	1.60	18.64	0.13
121003030605	Goliad	7.69	0.91	20.83	0.074
121003030607	Refugio	7.31	1.20	15.72	0.036
121002040106	Victoria	7.21	0.84	19.12	0.048
121003030608	Refugio	6.89	0.91	17.13	0.028
121002040105	Victoria	6.83	0.84	17.72	0.071
121002040107	Victoria	6.70	0.75	24.50	0.045
121102040202	Jim Wells	6.52	1.25	13.28	0.12

HUC12	County	Loads in lb/ac/year (except sediment in tons/ac/yr)			
		Total Nitrogen	Total Phosphorus	BOD	Sediment
121003030606	Goliad	6.15	0.61	16.55	0.047
121002040305	Victoria	5.90	0.58	15.77	0.037
121102040406	Jim Wells	5.73	1.06	11.62	0.08
121002040402	Victoria	5.72	0.47	15.39	0.031
121102040204	Kleberg	5.71	1.03	12.15	0.07
121102040109	Duval	5.56	1.17	10.12	0.12
121102040201	Jim Wells	5.50	1.02	11.12	0.09
121102040205	Kleberg	5.46	0.98	12.21	0.06
121102040206	Kleberg	5.27	1.11	13.56	0.11
121102040403	Jim Wells	4.66	0.72	9.71	0.05
121102040409	Kleberg	4.55	0.75	12.97	0.05
121102040203	Jim Wells	4.05	0.72	8.01	0.06
121102040310	Duval	4.01	0.49	11.67	0.05
121102040107	Duval	3.30	0.59	6.16	0.07
121102040101	Duval	3.03	0.07	2.12	0.01
121102040108	Duval	2.81	0.47	5.41	0.06
121102040303	Duval	2.75	0.27	7.37	0.04
121102040402	Jim Wells	2.51	0.24	5.92	0.03
121102040106	Duval	2.17	0.26	4.64	0.03
121102040308	Duval	2.09	0.17	5.53	0.03
121102040309	Duval	2.04	0.21	4.94	0.03
121102040301	Duval	2.01	0.17	5.25	0.03
121102040103	Duval	1.97	0.17	5.37	0.03
121102040105	Duval	1.94	0.14	4.29	0.03
121102040401	Duval	1.87	0.14	4.55	0.02
121102040304	Duval	1.87	0.21	3.99	0.03
121102040307	Duval	1.79	0.14	4.46	0.02
121102040104	Duval	1.73	0.13	4.20	0.02
121102040302	Duval	1.37	0.13	3.65	0.03
121102040305	Duval	1.34	0.14	3.30	0.02
121102040306	Duval	1.33	0.11	3.50	0.02
121102040102	Duval	1.17	0.07	2.31	0.01

APPENDIX E
SCENARIO DESCRIPTIONS OF BMPS FROM THE NRCS FIELD OFFICE TECHNICAL GUIDE

The unit prices in the following practice payment scenarios were not used in Section 4 of the Report

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APPENDIX F
STEPL RESULTS: ESTIMATED NUTRIENT LOAD REDUCTIONS FOR SELECT STRATEGIES IN PETRONILA CREEK

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				340 - Cover Crops				393 - Filter Strip				345 - Residue and Tillage Management, Reduced Till			
Waterbody	**Primary County**	**Watershed (HUC12)**	**Cropland**	**N Reduction**	**P Reduction**	**N Reduction Efficiency**	**P Reduction Efficiency**	**N Reduction**	**P Reduction**	**N Reduction Efficiency**	**P Reduction Efficiency**	**N Reduction**	**P Reduction**	N Reduction Efficiency	P Reduction Efficiency
			Acres	**lb/year**	**lb/year**	**lb/acre**	**lb/acre**	**lb/year**	**lb/year**	**lb/acre**	**lb/acre**	**lb/year**	**lb/year**	**lb/acre**	**lb/acre**
Petronila Creek	Nueces	121102050506	22,808	102,033	18,858	4.47	0.83	170,709	54,541	7.48	2.39	77,125	44,531	3.38	1.95
Petronila Creek	Nueces	121102050601	21,216	96,198	18,038	4.53	0.85	162,225	52,055	7.65	2.45	74,337	42,422	3.50	2.00
Petronila Creek	Nueces	121102050602	27,413	122,576	22,644	4.47	0.83	205,024	65,495	7.48	2.39	92,582	53,478	3.38	1.95
Petronila Creek	Nueces	121102050603	23,954	107,210	19,826	4.48	0.83	179,422	57,334	7.49	2.39	81,103	46,808	3.39	1.95
Petronila Creek	Nueces	121102050604	25,097	113,614	21,268	4.53	0.85	191,416	61,391	7.63	2.45	87,568	50,041	3.49	1.99
Petronila Creek	Nueces	121102050605	14,185	64,551	12,150	4.55	0.86	109,085	35,043	7.69	2.47	50,171	28,544	3.54	2.01
Petronila Creek	Nueces	121102050606	25,207	114,160	21,379	4.53	0.85	192,383	61,709	7.63	2.45	88,048	50,297	3.49	2.00
Petronila Creek	Nueces	121102050607	19,311	87,572	16,423	4.53	0.85	147,689	47,393	7.65	2.45	67,684	38,621	3.50	2.00
Petronila Creek	Nueces	121102050608	15,419	69,854	13,086	4.53	0.85	117,742	37,771	7.64	2.45	53,906	30,784	3.50	2.00
Petronila Creek	Jim Wells	121102050505	20,474	64,737	12,597	3.16	0.62	111,444	36,157	5.44	1.77	52,911	29,326	2.58	1.43
Petronila Creek	Jim Wells	121102050504	14,326	56,885	11,059	3.97	0.77	97,877	31,747	6.83	2.22	46,430	25,752	3.24	1.80
Petronila Creek	Jim Wells	121102050503	11,347	44,514	8,551	3.92	0.75	76,079	24,589	6.70	2.17	35,683	19,976	3.14	1.76
Petronila Creek	Jim Wells	121102050502	7,970	31,685	6,167	3.98	0.77	54,553	17,701	6.84	2.22	25,907	14,356	3.25	1.80
Petronila Creek	Jim Wells	121102050501	10,375	40,692	7,815	3.92	0.75	69,538	22,474	6.70	2.17	32,608	18,258	3.14	1.76
Petronila Creek			259,102	1,116,281	209,862	4.31	0.81	1,885,187	605,400	7.28	2.34	866,064	493,193	3.34	1.90

				600 - Terrace				412 - Grassed Waterway				327 - Conservation Cover			
Waterbody	Primary County	Watershed (HUC12)	Cropland	N Reduction	P Reduction	N Reduction Efficiency	P Reduction Efficiency	N Reduction	P Reduction	N Reduction Efficiency	P Reduction Efficiency	N Reduction	P Reduction	N Reduction Efficiency	P Reduction Efficiency
			Acres	lb/year	lb/year	lb/acre	lb/acre	lb/year	lb/year	lb/acre	lb/acre	lb/year	lb/year	lb/acre	lb/acre
Petronila Creek	Nueces	121102050506	22,808	127,788	38,689	5.60	1.70	190,939	42,528	35.21	33.04	449,715	101,182	19.72	4.44
Petronila Creek	Nueces	121102050601	21,216	121,444	36,980	5.72	1.74	177,612	39,560	36.56	32.97	424,441	96,474	20.01	4.55
Petronila Creek	Nueces	121102050602	27,413	153,475	46,457	5.60	1.69	229,490	51,115	36.53	33.58	540,244	121,507	19.71	4.43
Petronila Creek	Nueces	121102050603	23,954	134,311	40,672	5.61	1.70	200,533	44,665	37.20	33.70	472,553	106,359	19.73	4.44
Petronila Creek	Nueces	121102050604	25,097	143,295	43,605	5.71	1.74	210,102	46,796	36.36	32.92	501,219	113,789	19.97	4.53
Petronila Creek	Nueces	121102050605	14,185	81,663	24,904	5.76	1.76	118,751	26,450	37.04	32.98	284,888	64,929	20.08	4.58
Petronila Creek	Nueces	121102050606	25,207	144,019	43,833	5.71	1.74	211,022	47,001	36.98	33.15	503,644	114,376	19.98	4.54
Petronila Creek	Nueces	121102050607	19,311	110,562	33,668	5.73	1.74	161,664	36,008	36.24	32.80	386,384	87,832	20.01	4.55
Petronila Creek	Nueces	121102050608	15,419	88,142	26,830	5.72	1.74	129,081	28,750	32.84	31.77	308,187	70,006	19.99	4.54
Petronila Creek	Jim Wells	121102050505	20,474	83,440	25,782	4.08	1.26	115,237	25,667	5.63	1.25	286,416	66,841	13.99	3.26
Petronila Creek	Jim Wells	121102050504	14,326	73,281	22,635	5.12	1.58	101,351	22,574	7.07	1.58	251,656	58,692	17.57	4.10
Petronila Creek	Jim Wells	121102050503	11,347	56,959	17,511	5.02	1.54	80,276	17,880	7.07	1.58	196,751	45,496	17.34	4.01
Petronila Creek	Jim Wells	121102050502	7,970	40,845	12,622	5.12	1.58	56,385	12,559	7.07	1.58	140,185	32,722	17.59	4.11
Petronila Creek	Jim Wells	121102050501	10,375	52,062	16,004	5.02	1.54	73,399	16,348	7.07	1.58	179,854	41,582	17.34	4.01
Petronila Creek			**259,102**	**1,411,285**	**430,191**	**5.45**	**1.66**	**2,055,841**	**457,900**	**7.93**	**1.77**	**4,926,136**	**1,121,787**	**19.01**	**4.33**