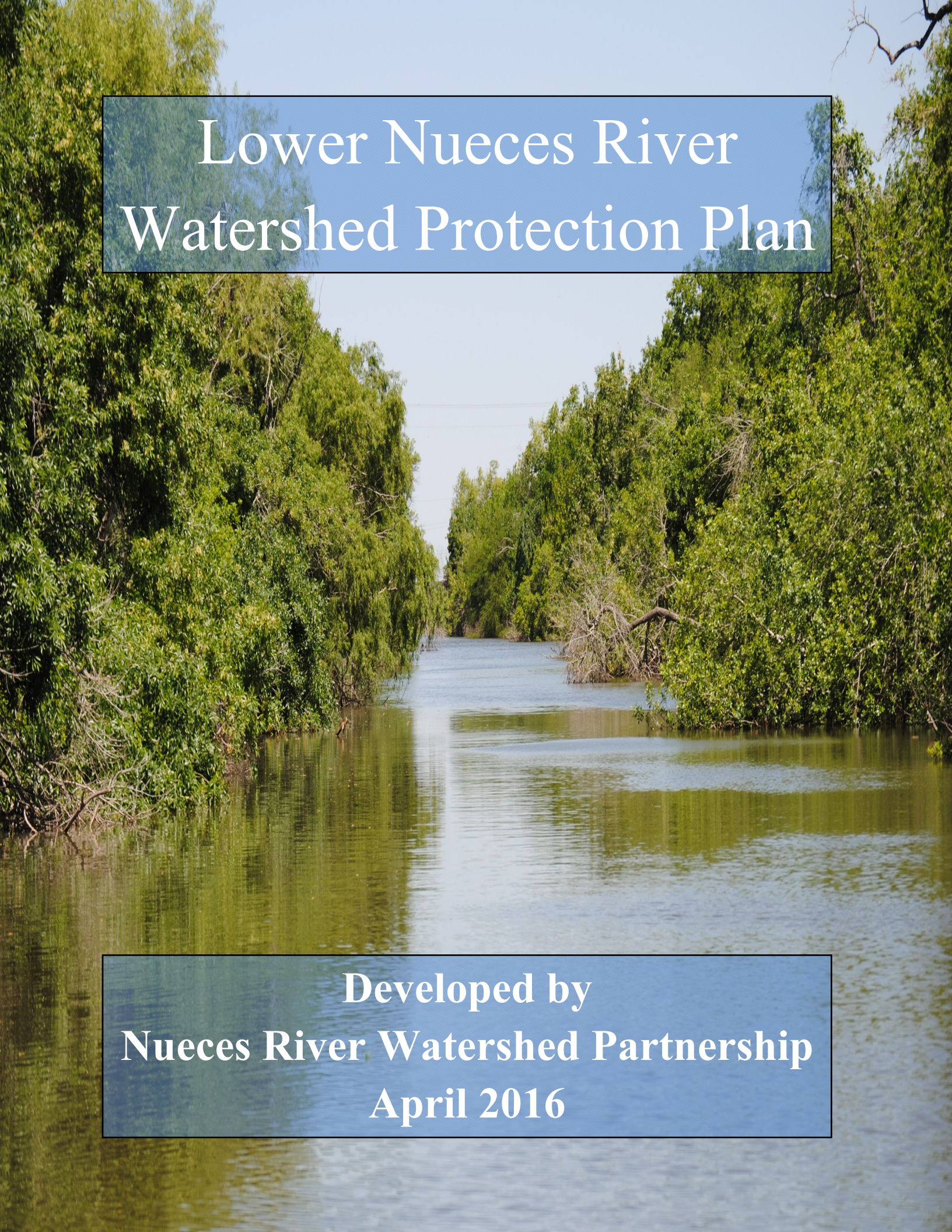

Lower Nueces River Watershed Protection Plan

Developed by
Nueces River Watershed Partnership
April 2016

Cover photo of the Lower Nueces River between Nueces County Hazel Bazemore Park and the saltwater barrier dam, courtesy of Jana Lloyd, Texas State Soil and Water Conservation Board

Lower Nueces River Watershed Protection Plan

Prepared for the
Nueces River Watershed Partnership
by

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Funding for the development of this Watershed Protection Plan was provided through a federal Clean Water Act §319(h) grant to the Nueces River Authority, administered by the Texas State Soil and Water Conservation Board from the U.S. Environmental Protection Agency

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This document and the efforts behind its completion are the result of collaboration and cooperation between many different groups and individuals. Each has played an important role in the Nueces River Watershed Partnership.

First and foremost, the Partnership wishes to express thanks to members of the Steering Committee for their investments of time and energy in participating throughout the process. Without their direction and support, development of this plan would not have been possible. Through the Lower Nueces River Watershed Protection Plan, their efforts serve as an example to all stakeholders of the importance of active stewardship of water resources.

The Nueces River Watershed Partnership also would like to thank the members of the Utilities / Nonpoint Source, Agricultural, Education and Outreach, and Large Debris work groups. Their specialized knowledge and expertise were key ingredients for a stakeholder developed plan. The Partnership would also like to thank members of the Technical Advisory Group for their assistance, advice, and online reference materials:

- Coastal Bend Bays and Estuaries Program
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- San Patricio Soil and Water Conservation District
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- Texas Commission on Environmental Quality
- Texas Department of Agriculture
- Texas Department of Transportation
- Texas Farm Bureau
- Texas General Land Office
- Texas Parks and Wildlife Department
- Texas Soil and Water Conservation Board
- Texas Water Development Board
- U. S. Department of Agriculture – Natural Resources Conservation Service
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

We are especially grateful to the Texas State Soil and Water Conservation Board and the Environmental Protection Agency for funding support. Funding provided through these agencies provided for the development of this Watershed Protection Plan and established a solid foundation for watershed stewardship in the Lower Nueces River.

Statement of Purpose

The Lower Nueces River is the conduit of water from Lake Corpus Christi to the City of Corpus Christi, which supplies drinking water to approximately 500,000 people and to industries in the Coastal Bend. In November 2009, the City of Corpus Christi experienced a sudden, unexpected increase in turbidity levels at the O. N. Stevens Water Treatment Plant that resulted in a drinking water violation. The City of Corpus Christi hired the Nueces River Authority to develop a source water protection plan to help prevent future turbidity issues and identify and prevent other possible threats to the water supply. The Nueces River Authority based the source water protection plan on the US Environmental Protection Agency's *Nine Elements of Successful Watershed Plans* with the goal of developing a full watershed protection plan for the Lower Nueces River.

Although at the time the Lower Nueces River was not listed on the Texas 303(d) List of impaired waters, the Texas State Soil and Water Conservation Board acknowledged the stakeholders' interest and efforts in protecting the river and selected it for development of the Lower Nueces River Watershed Protection Plan – a voluntary, non-regulatory alternative to addressing water quality issues. The segment has been listed as having a concern for chlorophyll-*a* since the 2008 Water Quality Inventory. It was listed as being impaired for TDS in the 2012 Integrated Report.

The Lower Nueces River Watershed Protection Plan incorporates an analysis of existing water quality data and an investigation into potential pollutant sources based on local knowledge and experience to develop a strategy for addressing concerns related to water quality and watershed health.

Stakeholders are any individual or group that may be directly or indirectly affected by activities implemented to protect water quality, such as citizens, businesses, municipalities, county governments, river authorities, nonprofit organizations, and state agencies. This document is a means by which stakeholders can become more familiar with the Lower Nueces River Watershed and actively make a difference in the quality and health of their streams through voluntary management practices. It is a starting point to focus restoration efforts and enable financial and technical assistance to facilitate improvements in the Lower Nueces River. This Watershed Protection Plan is intended to be a living document, adjusted to include new data and modified as conditions in the watershed change over time. It will evolve as needs and circumstances dictate and will be guided by the stakeholders as they undertake active stewardship of the watershed.

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Executive Summary

The Lower Nueces River is listed as impaired for Total Dissolved Solids (TDS) in the 2012 and Draft 2014 Integrated Reports and has had nutrient enrichment (chlorophyll-*a*) concerns since the 2008 assessment. The average of the TDS measurements exceeded water quality standards for general use, and chlorophyll-*a* concentrations exceeded screening levels resulting in the nutrient enrichment concern. Elevated levels of TDS may affect the permeability of ions in aquatic organisms, affect the aesthetic quality of the water, corrode plumbing fixtures, add to the expense of treating the water for human consumption, and reduce its reuse efficiency for refineries. Elevated chlorophyll-*a* levels are related to excessive growth of aquatic plants and algae that can lead to degradation of aquatic habitat, loss of recreation, and low dissolved oxygen levels which could lead to fish kills.

The Lower Nueces River forms the county line between Jim Wells and San Patricio counties and between Nueces and San Patricio counties. The 183-square-mile watershed is the most downstream, fresh water, section of the Nueces River Basin and is comprised of five subwatersheds at the 12-digit hydrologic unit code (HUC 12) level:

121101110701 – Sixmile Creek
121101110702 – Bayou Creek
121101110703 – Javelin Creek
121101110704 – Sandy Hollow
121101110705 – Cayamon Creek

This segment of the Nueces River begins at Wesley E. Seale Dam at Lake Corpus Christi and flows southeast through primarily rural lands, and a few unincorporated population areas, before it reaches the City of Corpus Christi and the saltwater barrier dam in Calallen. The Corpus Christi city limits extends upstream within a few miles of the Jim Wells County line, so that the lower half of the watershed lies almost completely within the extra-territorial jurisdiction of Corpus Christi. The riparian zone along the river is largely intact and is functioning as nature designed. Implementation of the Lower Nueces River Watershed Protection Plan (WPP) will help preserve the riparian zone and help restore and protect the water quality in the watershed.

The Texas State Soil and Water Conservation Board (TSSWCB) selected the Lower Nueces River for development of a WPP based on the potential for success, ongoing activities, and level of stakeholder interest: the City of Corpus Christi and the Nueces River Authority (NRA) were working on a source water protection plan for the watershed along the guidelines of the United States Environmental Protection Agency's *Nine Elements of Successful Watershed Plans*. Public meetings were held in Corpus Christi and the Nueces River Watershed Partnership was formed to guide the WPP development process. Led by the Steering Committee, the Partnership is working with citizens, businesses, public officials, and state and federal agencies in the watershed to restore and protect the health of the Lower Nueces River. The Partnership recognizes that success in improving and protecting water resources depends on the people who live and work in the watershed. The Lower Nueces River WPP that was created through these efforts will serve as a guidance document for restoring and protecting the local water source that provides drinking water to approximately 500,000 people and process water for numerous refineries and industries in the area.

Executive Summary

The Steering Committee, along with topical work groups created by the Partnership, dedicated time to the identification and locations of potential sources of pollutants in the watershed. Agricultural runoff, urban runoff, failing septic systems, improperly plugged and abandoned oil and gas wells, and leaking oil and gas pipelines were identified as potential sources for TDS, with the latter three being the more likely candidates. Sources for chlorophyll-*a* include agricultural runoff, failing septic systems, and an over-abundance of hyacinth. Although the river is not impaired for bacteria for contact recreation, increasing trends of *E. coli* concentrations have been identified. Therefore, the WPP also addresses potential sources of bacteria in order to prevent a future impairment. These potential sources were identified as dogs, cattle, goats, horses, deer, feral hogs, urban runoff, and failing septic systems. Most potential sources that contribute to bacteria loading also contribute to nutrient loading. While not of primary concern in this watershed, "other" pollutants such as sediment and illegal dumping have been identified by the stakeholders.

Through scientific analysis, the Partnership determined to what degree TDS and chlorophyll-*a* in the Lower Nueces should be reduced to meet the water quality standard, and to what degree bacteria should be reduced to insure it continues to meet the water quality standard. The goal over the next ten years is reduce TDS averages by 32%, reduce chlorophyll-*a* exceedances by 57%, and reduce the *E. coli* geometric mean by 14.5%.

Based on an evaluation of existing water quality data and watershed characteristics, the work groups and stakeholders recommended voluntary management measures needed to reduce TDS, chlorophyll-*a,* and bacteria levels and to address illegal dumping activities in the Lower Nueces River. Key recommendations adopted by the Steering Committee include the following:

- Agricultural Nonpoint Source Management Measures to develop additional Water Quality Management Plans (WQMP) and conduct status review of existing WQMPs. Successful implementation should result in the reduction of TDS, chlorophyll-*a,* and bacteria numbers.
- Riparian Habitat Conservation Management Measures to develop conservation easements within the riparian zone. Successful implementation should result in preserving the existing riparian areas and prevent additional TDS, chlorophyll-*a,* and bacteria loadings.
- Wastewater and Urban Management Measures to replace, repair, and remove septic systems; to create conveniently located solid waste transfer stations, and to encourage the creation of storm water retention ponds when and where feasible. Successful implementation should result in the reduction of TDS and bacteria numbers.
- Wildlife Management Measures to provide opportunities to deliver education programs for wildlife management to landowners. Successful implementation could result in the reduction of bacteria numbers.
- Feral Hog Management Measures to provide opportunities to deliver education programs for feral hog control to landowners. Successful implementation could result in the reduction of bacteria numbers.
- Cleanup Management Measures to address hyacinth management; the removal of submerged, large man-made debris that is potentially hazardous to water quality and/or recreation safety; and the investigation of oil and gas wells and pipelines. Successful implementation should result in the reduction of TDS and chlorophyll-*a* numbers.

As the recommended management measures of the Lower Nueces River WPP are put into action, it will be essential to monitor water quality and make any needed adjustments to the implementation strategy. Routine water quality monitoring at SH 359, FM 666, and Nueces County Hazel Bazemore Park will continue throughout the implementation phase. Adaptive Management will be utilized throughout the process to provide flexibility and enable adjustments to monitoring and implementation activities. This on-going, cyclic implementation and evaluation process serves to focus project efforts and optimize impacts. Adaptive Management relies on constant input of watershed information and the establishment of intermediate and final water quality targets. Pollutant concentration targets for the Lower Nueces River were developed based on complete implementation of the WPP, with interim goals, and assume full accomplishment of pollutant load reductions by the end of the 10-year project period. The Partnership will evaluate progress towards achieving programmatic and water quality goals at years 3, 6, and 10 and make critical decisions at those year milestones. However, it can be assumed that reductions in the loadings will be tied to the implementation of management measures throughout the watershed. Thus, projected pollutant targets will serve as benchmarks of progress, indicating the need to maintain or adjust planned activities. While water quality conditions likely will change and may not precisely follow the projections indicated in the WPP, these estimates serve as a tool to facilitate stakeholder evaluation and decision-making based on Adaptive Management.

The Nueces River Watershed Partnership will continue to meet on a quarterly, or as needed, basis to receive updates on the progress of implementation efforts and guide the program through adaptive management actions. Ultimately, it is the goal of the Partnership and this plan to improve and protect water quality in the Lower Nueces River so that it is restored and preserved for present and future generations.

1. WATERSHED MANAGEMENT

WATERSHED DEFINITION

A watershed is an area of land that water flows across, through, or under on its way to a single common point in a stream, river, lake, or ocean. Watersheds include not only water bodies such as streams and lakes, but also all the surrounding lands that contribute water to the system as runoff during and after rainfall events. Relationships between the quality and quantity of water affect the function and health of a watershed. Thus, significant water removals (such as for irrigation, municipal, and industrial use) or water additions (such as wastewater discharges) are important. Watersheds can be extremely large, covering many thousands of acres and often are separated into smaller subwatersheds for the purposes of study and management. Figure 1.1 is an aerial view of a portion of the Lower Nueces River watershed.

Figure 1.1. Lower Nueces River Watershed below SH 359

WATERSHEDS AND WATER QUALITY

Watershed stewardship is caring for the water, air, and biodiversity in an entire watershed, while acknowledging that all resources are connected and all are affected by natural and human activities. Water is the most critical component of life. Without clean water resources, we cannot survive. The quality and quantity of water within our watersheds are greatly affected by the way we choose to live on the land. Each of us lives in a watershed, so good watershed stewardship is crucial to ensuring the

sustainability of our water resources for generations to come. If we become educated about our watersheds and understand how our activities affect them, we will act more responsibly to preserve, protect, and enhance these vital resources.

Point source pollution is discharged from a defined location or a single point, such as a pipe or drain. It includes any pollution that may be traced back to a single point of origin. Point source pollution is typically discharged directly into a waterway and often contributes flow across all stream conditions, from low flow to high flow. In Texas, dischargers holding a permit through the Texas Pollutant Discharge Elimination System are considered point sources, and their effluent is permitted with specific pollutant limits to reduce their impact on the receiving stream.

Figure 1.2 Neighborhood along the Nueces River

Nonpoint source pollution (NPS), (see Appendix A for a complete list of acronyms) on the other hand, comes from a source that does not have a single point of origin. The pollutants are generally carried off the land by runoff from storm water following rainfall events. As runoff moves over the land, it can pick up both natural and human-related pollutants, depositing them into water bodies such as creeks, rivers, and lakes. Figure 1.2 shows an area along the Lower Nueces River that is inundated during floods, resulting in loose items being swept into the river. Ultimately, the types and amounts of pollutants entering a water body will determine the quality of water it contains and whether it is suitable for irrigation, fishing, swimming, or drinking.

BENEFITS OF A WATERSHED APPROACH

State and federal water resource management and environmental protection agencies have embraced the watershed approach for managing water quality. The watershed approach involves assessing sources and causes of impairments at the watershed level and utilizing this information to develop and implement watershed management plans. Watersheds are determined by the landscape and not political borders, and thus often cross municipal, county, and state boundaries (Figure 1.3). By using a watershed perspective, all potential sources of pollution entering a waterway can be better identified and evaluated. Just as important, all stakeholders in the watershed can be involved in the process. A watershed stakeholder is anyone who lives, works, or engages in recreation in the watershed. They have a direct interest in the quality of the watershed and will be affected by planned efforts to address water quality issues. Individuals, groups, and organizations within a watershed can become involved as stakeholders.

Stakeholder involvement is critical for selecting, designing, and implementing management measures to successfully improve water quality.

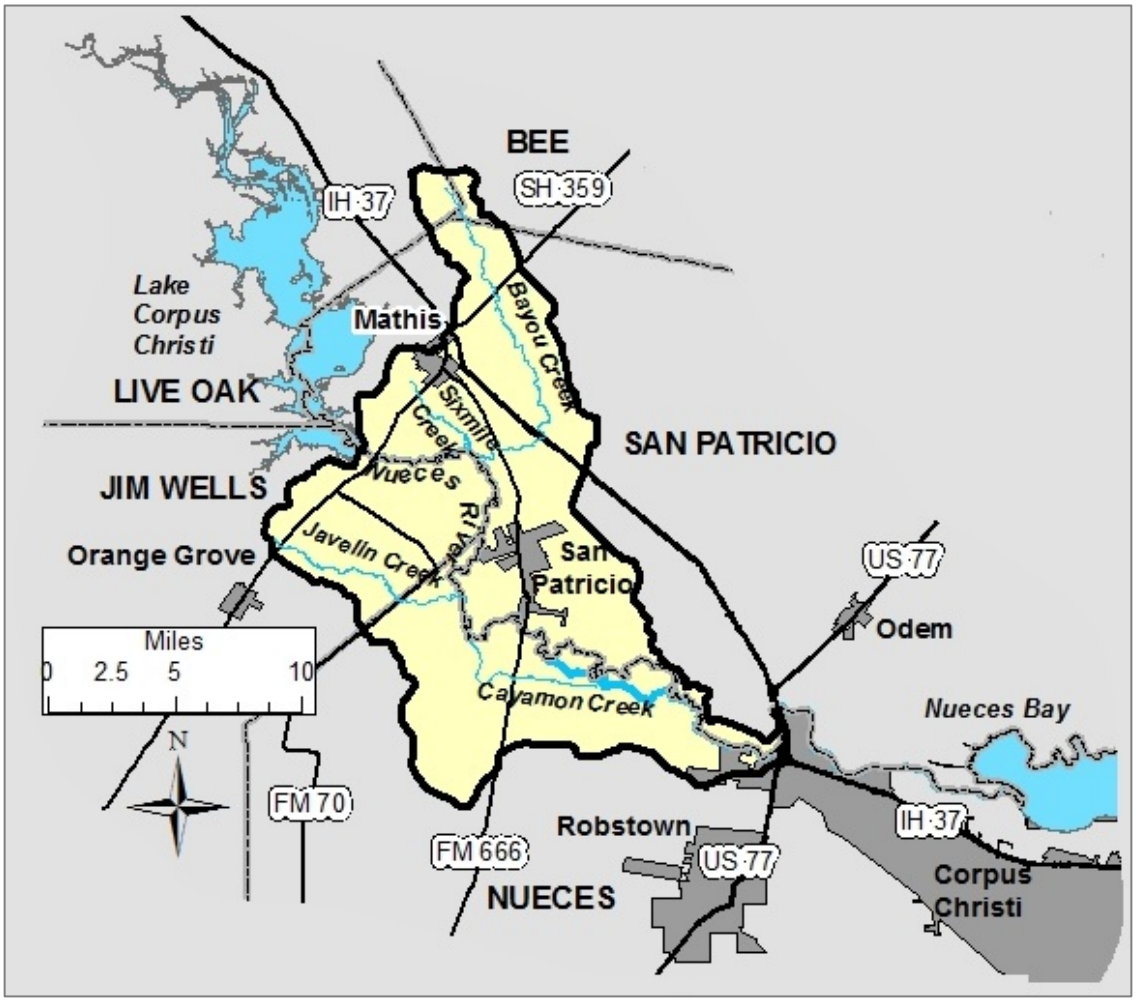


Figure 1.3. Map of the Lower Nueces River Watershed

WATERSHED PROTECTION PLANNING

A Watershed Protection Plan (WPP) is typically developed according to the United States Environmental Protection Agency's (USEPA) *Nine Elements of Successful Watershed Plans* (see Appendix B for a description of the elements and where each element is addressed in this WPP) by local stakeholders with the primary goal being to restore and/or protect water quality and designated uses of a water body through voluntary, non-regulatory water resource management. Public participation is critical throughout plan development and implementation, as ultimate success of any WPP depends on stewardship of the land and water resources by landowners, businesses, elected officials, and residents of the watershed. The Lower Nueces River WPP defines a strategy and identifies opportunities for stakeholders across the watershed to work together and as individuals to implement voluntary practices and programs that restore and protect water quality.

2. Overview of the Watershed

GEOGRAPHY

The 39 mile Lower Nueces River segment begins at the Wesley E. Seale Dam at Lake Corpus Christi (Figure 2.1) and ends at the saltwater barrier dam at Labonte Park in the City of Corpus Christi. It forms the county line between Jim Wells and San Patricio counties and between Nueces and San Patricio counties. Its 183 square mile watershed includes a very small portion of Bee and Live Oak counties and is comprised of five subwatersheds at the 12-digit hydrologic unit code (HUC 12) level (See Figure 4.1).

- 121101110701 – Sixmile Creek
- 121101110702 – Bayou Creek
- 121101110703 – Javelin Creek
- 121101110704 – Sandy Hollow
- 121101110705 – Cayamon Creek

Figure 2.1: Wesley E. Seale Dam at Lake Corpus Christi

The city limits of Corpus Christi extend upriver to a point about 3.6 miles downstream of Farm to Market Road (FM) 666. An additional 5 miles upstream and most of the lower half of the watershed are included in the City's extra territorial jurisdiction. The Lower Nueces River serves as the delivery system of water from Lake Corpus Christi to three water treatment plants (WTP) and two industrial users' intakes near the lower end of the segment. The river is perennial given that water is always being released from the lake to meet the downstream water rights.

PHYSICAL AND NATURAL FEATURES

Ecoregion[1]

The Lower Nueces River lies entirely within the Gulf Coast Prairies and Marshes ecoregion zone (Figure 2.2). This zone is a nearly level, slowly drained plain less than 150 feet in elevation, dissected by streams and rivers flowing into the Gulf of Mexico. The region includes barrier islands along the coast, salt grass marshes surrounding bays and estuaries, remnant tallgrass prairies, oak parklands, and oak mottes scattered along the coast, and tall woodlands in the river bottomlands. The average rainfall in this area is about 30 inches per year. The growing season is usually more than 300 days, with high humidity and warm temperatures.

Native vegetation consists of tallgrass prairies and live oak woodlands. Brush species such as mesquite and acacias are more common now than in the past. Although much of the native habitat has been lost to agriculture and urbanization, the region still provides important habitat for migratory birds and spawning areas for fish and shrimp. Millions of hawks have been spotted within the Lower Nueces River watershed at Nueces County Hazel Bazemore Park during the fall migration period. Animals native to the area

[1] Ecoregion description from http://tpwd.texas.gov/education/hunter-education/online-course/wildlife-conservation/texas-ecoregions

include white-tailed deer, javelina, bobcat, coyote, skunk, raccoon, squirrel, turkey, alligator, and a diverse array of other small mammals and birds. Feral hog (non-native, invasive species) are also common in the watershed.

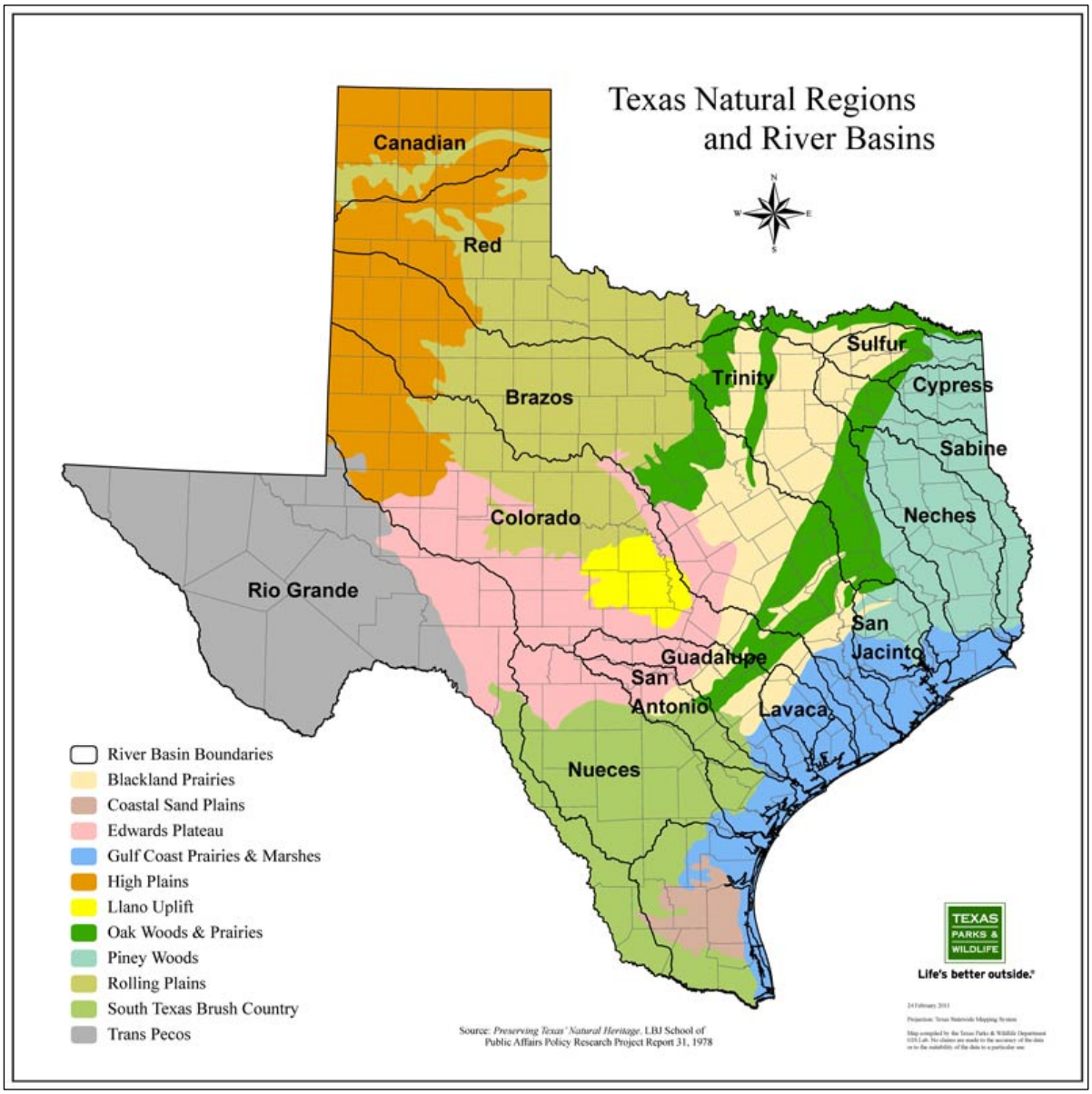


Figure 2.2: Ecoregions of Texas (Image courtesy of TPWD)

Soils[2]

The majority of the soils, nearly 78%, are clays and sandy loams (Figure 2.3). The area of the watershed within Jim Wells County is dominated by Rio Grande Plain Delmita-Pernitas-Randado soils. These soils formed on a broad coastal plain consisting of sediments of Tertiary and Quaternary age. Pernitas soils are deep and very deep, well-developed, loamy soils that occur on nearly level to moderately sloping plains and broad ridges. Delmita, and Randado soils, shallow to a root-restrictive layer of cemented caliche

[2] Soil descriptions form USDA-NRCS General Soil Map of Texas, http://www.lib.utexas.edu/maps/texas/texas-general_soil_map-2008.pdf

(CaCO), formed in gravelly Pleistocene sediments. The area of the watershed within Nueces and San Patricio counties is dominated by Gulf Coast Prairie soils. These soils formed in alluvial and marine sediments of (primarily) Quaternary age that were deposited under fluctuating sea-level conditions. The area is characterized by low local relief and dissection by rivers that flow to the Gulf of Mexico. Victoria and Edroy, soils are well-developed, clayey soils with high shrink-swell properties. Orelia, soils have loamy surface textures and loamy and clayey subsoilhorizons, and they differ primarily on drainage class and mineralogy.

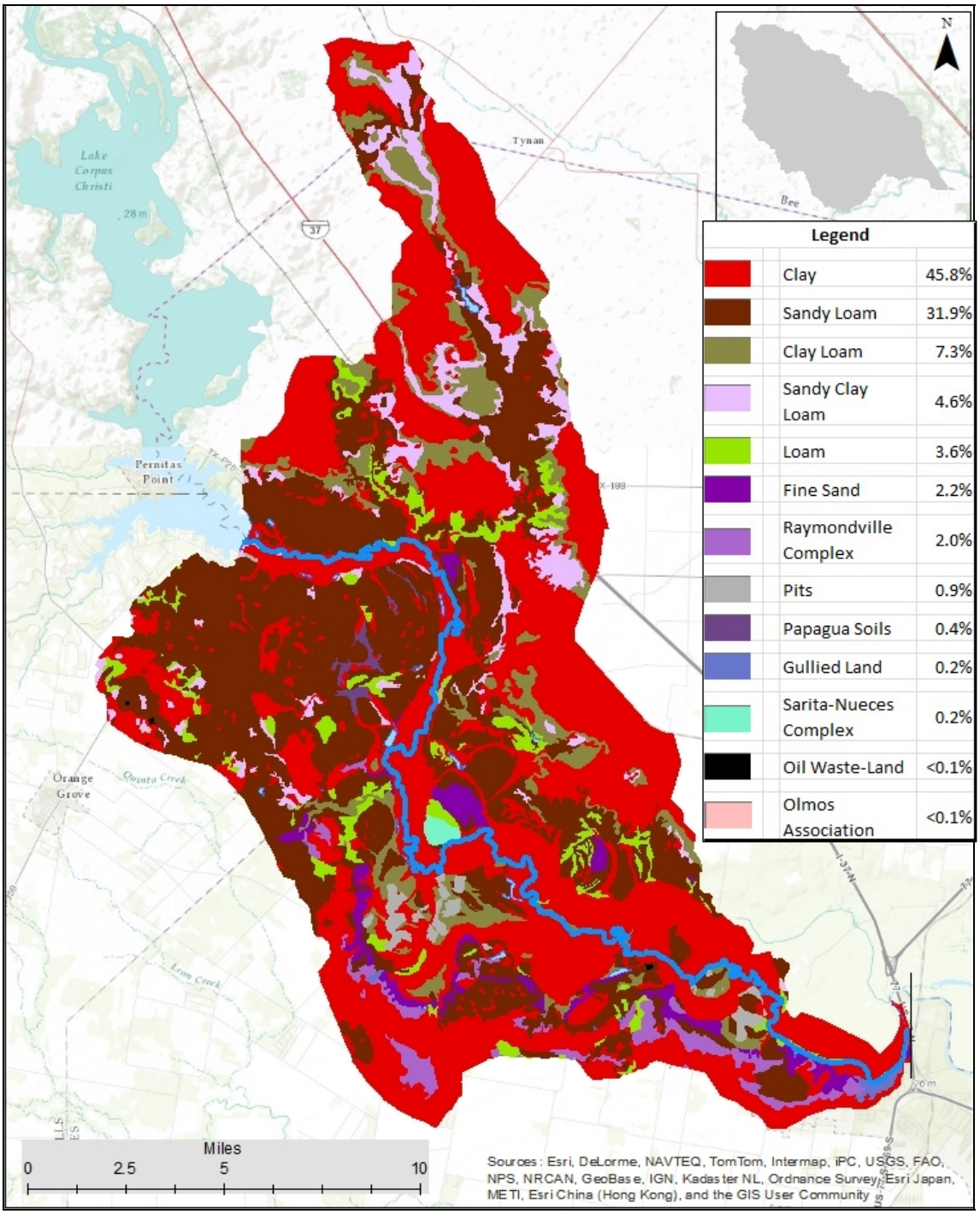


Figure 2.3: Soils of the Lower Nueces River Watershed

Water Resources

Surface Water

The Choke Canyon / Lake Corpus Christi Reservoir System supplies water to cities and industries in the Coastal Bend. The City of Corpus Christi owns and operates Lake Corpus Christi. Choke Canyon Reservoir is a US Bureau of Reclamation Project, operated by the City of Corpus Christi. Its water rights are owned by the City of Corpus Christi (78%), NRA (20%), and the City of Three Rivers (2%).

The City of Three Rivers diverts water directly out of Choke Canyon Reservoir. The cities of Alice, Beeville, and Mathis divert water directly out of Lake Corpus Christi. The City of Corpus Christi, the primary wholesale water provider for the region, diverts its water from near the downstream end of the Lower Nueces River known as the Calallen Pool. Entities that buy raw water from the City, but have their own diversions in the Calallen Pool, include Flint Hills Resources, Celanese, and San Patricio Municipal Water District (SPMWD). Nueces County Water Control and Improvement District (WCID) #3 has its own water right and also diverts water from the Calallen Pool. SPMWD and Nueces County WCID #3, in turn, provide water to a number of municipal and industrial customers.

The water for these raw water diversions from the Calallen Pool is released from Lake Corpus Christi and flows 39 miles down the Nueces River to the intakes. This water is the primary source of fresh drinking water for nearly 500,000 people in the Coastal Bend region and is the reason a WPP is being developed for the Lower Nueces River Watershed.

The City of Corpus Christi and SPMWD also receive raw surface water from Lake Texana in Jackson County via the 101-mile Mary Rhodes Pipeline. By the end of 2015, the City of Corpus Christi will add water from the Colorado River in Matagorda County near Bay City, via a 42-mile Mary Rhodes Phase II Pipeline to the pump station at Lake Texana. SPMWD diverts its portion from the pipeline in San Patricio County, and the City of Corpus Christi's portion is piped directly into the O.N. Stevens WTP in northwest Corpus Christi. This diversity of water supply is a safety net for drought conditions and contamination.

Groundwater

The Lower Nueces River Watershed overlays the Gulf Coast Aquifer, which yields moderate to large amounts of both fresh and slightly saline water. This groundwater is used for agricultural needs in Jim Wells, Nueces, and San Patricio counties. It is also used for municipal and industrial needs for the cities of Orange Grove, Lake City, and Sinton which are not connected to the water supply network. Of the total water supplies, groundwater makes up approximately 63% of the supplies for Jim Wells County, approximately 5% of the supplies for Nueces County, and approximately 29% of the supplies for San Patricio County.[3]

[3] 2016 Coastal Bend (Region N) Regional Water Plan

Oil and Gas Production

Oil and gas production began in the 1920s in Nueces County[4] and in the 1930s in Jim Wells[5] and San Patricio[6] counties. The Railroad Commission of Texas (RRC) online database[7] shows numerous oil and gas wells and production fields throughout the watershed. While many wells are still producing, a majority appear to no longer be active.

Ecologically Significant Stream Segment

Texas Parks and Wildlife Department (TPWD) has identified the Lower Nueces River as an ecologically significant stream segment.[8,9] The ecological significance of this segment is based upon the following criteria:

- Biological function - Riparian forested habitat occurs along most of the length of this segment. The lower portion of the segment also has freshwater marsh on the floodplain.[10] These habitats support a wide variety of fish and wildlife, and contribute nutrients to the Nueces and Corpus Christi Bay estuarine ecosystem.
- Hydrologic function - The riparian forest on the floodplain performs a host of important hydrologic functions such as: downstream flood control and mitigation of storm damage; regulation of baseflows and protection of fisheries habitat; protection of public and private water supplies through pollution filtration; and regulation and protection of groundwater and baseflows in the river.
- Riparian conservation areas - At the upstream end of the segment is the 258-acre City of Corpus Christi Wildlife Sanctuary. The sanctuary is also site Central Texas Coast (CTC) 079 on the Great Texas Coastal Birding Trail. At the downstream end of the segment is Hazel Bazemore Park - site CTC 078 on the Great Texas Coastal Birding Trail.[11]
- High water quality/exceptional aquatic life/high aesthetic value - The segment has high aesthetic and economic value for outdoor recreation, especially birdwatching. Hazel Bazemore Park is a world-class hawk migration site. Birders come to the area from around the world to observe the fall hawk migration moving down the Nueces River.[10]
- Threatened or endangered species/unique communities - The following rare species are State Threatened species associated with aquatic or riparian habitats occur in or along this segment: black spotted newt, South Texas siren (large form), white-faced ibis, wood stork, and the indigo

[4] https://tshaonline.org/handbook/online/articles/hcn05
[5] https://tshaonline.org/handbook/online/articles/hcj07
[6] http://txsanpatricio.eppygen.org/Landmarks/HM/Plymouth_Oil_Co_HM.htm
[7] http://wwwgisp.rrc.state.tx.us/GISViewer2
[8] Nueces River and Corpus Christi and Baffin Bays Basin and Bay Expert Science Team Environmental Flows Recommendation Report, 2011 http://www.tceq.state.tx.us/assets/public/permitting/watersupply/water_rights/eflows/20111028nuecesbbest_recommendations.pdf
[9] Ecologically Significant River & Stream Segments of Coastal Bend Water Planning Area (Region N) http://tpwd.texas.gov/publications/pwdpubs/pwd_rp_t3200_1059f/media/nueces_downstream.pdf
[10] U.S. Fish and Wildlife Service. 2000. Wetlands interactive mapper. National wetlands inventory, St. Petersburg, Florida. http://www.fws.gov/wetlands_interactive_mapper_tool.htm
[11] Texas Parks and Wildlife Department and Texas Department of Transportation. 1999-2000. The great Texas coastal birding trail. http://www.tpwd.state.tx.us/birdingtrails/index.htm#

snake.[12] The riparian forests are important foraging and roosting habitat for neotropical migratory songbirds. The City of Corpus Christi Wildlife Sanctuary supports some tropical birds such as the green jay[6].

CLIMATE[13]

Corpus Christi lies on Corpus Christi Bay, an inlet of the Gulf of Mexico. Corpus Christi has a subtropical climate, enjoying similar temperatures to those of other Gulf coast regions, but lower precipitation as it is located in a semi-arid region. The moderating influence of the Gulf can make temperatures in the city substantially different from inland areas during calm winter mornings and summer afternoons. The Gulf also keeps humidity high throughout the year and produces a high average number of days (108) with fog. Average annual precipitation is 30.13 inches, but has ranged from <12 inches in 2011 to 48.07 inches in 1991. Peak rainfall months are May and September and winter is the driest season. The hurricane season from June to November can greatly affect rainfall totals. Main hurricane months are August and September. Corpus Christi has been brushed or hit by hurricanes 34 times from 1874-2009, for an average of once every 4.09 years. A direct hit by a hurricane averages every 15.44 years. Hurricane Celia, reported to be the costliest in the state's history, hit Corpus Christi on August 3, 1970. Winds up to 161 miles an hour and gusts to 180 miles an hour were reported in the area.

Temperatures can be warm, even during mid-winter. The average high in January is 65 °F and low 45 °F. The record low occurred on February 11, 1899 with a temperature of 11 °F. Nueces Bay completely froze over at this time. The city's largest snowstorm occurred in December 2004 with 4.4 inches. December and January skies are normally cloudy to partly cloudy an average of 24 days and only 7 days with clear skies. Summers can be hot with very high humidity. The record high occurred on September 5, 2000 with a temperature of 109 °F. The average morning humidity during the summer months is 93%. Corpus Christi is one the ten most humid cities in the U.S. with an annual average humidity of 76%. From June-August, high temperatures exceed 90 °F 83% of the time and December-February low temperatures dip below freezing only 11% of the time.

HISTORY

Early Settlement[14]

The Karankawa Indians made their appearance around 1400 A.D. and survived until forced to leave the area in 1848 by white settlers. It is apparent that known inhabitants of the Corpus Christi area suffered water shortages from time to time and resorted to mass relocation as a solution. The Karankawa Indians, like other settlers, used the natural water resources that were available. Their fresh water was obtained from rain water trapped in earth depressions, shallow ground water that was a few feet below the surface, and the Nueces River.

During exploration along the Nueces River, the Spanish encountered many pecan trees and Cabeza de Vaca, in 1529, described it as the river of nuts, “Rio de las Nueces”. Don Jose de Escandon was

[12] Texas Parks and Wildlife Department. 2000. Annotated County Lists of Rare Species. Wildlife Diversity Program, Wildlife Division, Austin, Texas.

[13] Average and historical weather data are for the City of Corpus Christi, the closest source to the Lower Nueces River Watershed: http://web2.airmail.net/danb1/texas_climate_descriptions.htm

[14] Atlee Cunningham: “Corpus Christi Water Supply Documented History 1852-1997,” 2nd Edition

commissioned in 1746 by the Spanish Government to explore and settle the Gulf Coast region. Escandon probably made the first survey of the Corpus Christi area and its water supply in October 1747 when he reported that advantages included "an abundance of grass, water for irrigation, salt, fish, timber and stone." Escandon also described the land along the Nueces River as being fertile and suitable for irrigation from the river.

In 1828 John McMullen and James McGloin established an Irish colony near the Nueces River some twenty-file miles from the present site of Corpus Christi. The colony, known as San Patricio, depended on supplies landed at Corpus Christi Bay and the nearby Nueces River for water.

The City of Mathis was founded in 1887 when the San Antonio and Aransas Pass Railroad was laying tracks across San Patricio County. Thomas H. Mathis received naming rights when he donated 300 acres for a town site and school. Mathis and his brother, J. M. Mathis, held 37,000 acres in the vicinity. Thomas Mathis owned an additional 60,000 acres around Mathis and built a fence enclosing the town. As late as 1906, Mathis was enclosed and arriving and departing trains had to be let in and out.[15]

Fort Lipantitlan[16]

Fort Lipantitlan was established by the Spanish along the south side of the Nueces River in 1734, one hundred years before the Texas Revolution (Figure 2.4). The entrance to the site is marked by one of the ubiquitous, gray, granite markers erected by the State of Texas for the State Centennial which reads: "*On This Site Stood Fort Lipantitlán. Occupied in 1831 by soldiers of the mexican army to prevent further anglo-american colonization in Texas captured November 4, 1835 by volunteers under Captain Ira Westover. Unsuccessfully attacked June 7, 1842 by 700 men under Gen. Antonio Canales while defended by 192 men under General James Davis. Five acres of land surrounding the site of the Fort were generously donated to the State of Texas by the heirs of J.C. Bluntzer in 1937.*"

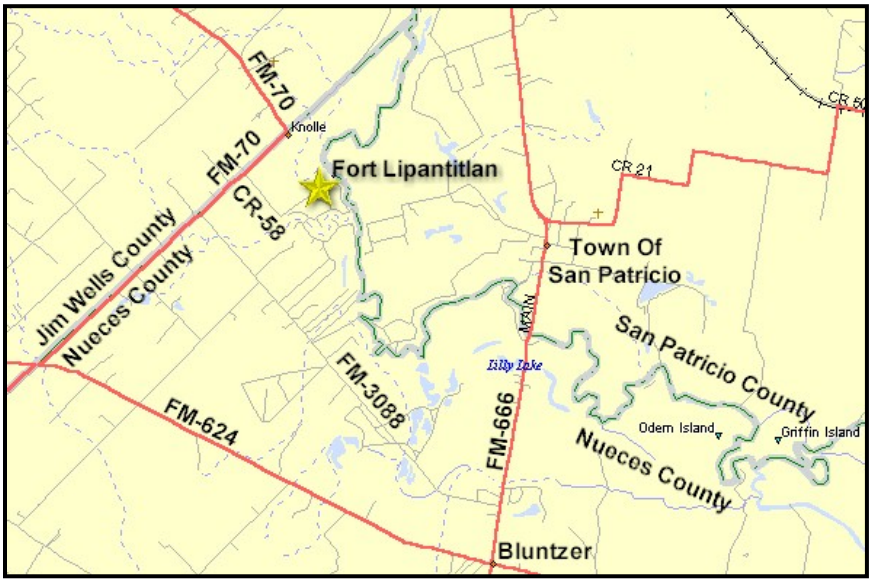


Figure 2.4 Location of Fort Lipantitlan

Some interesting reading about the history of the fort and the Battle for the Nueces in 1835 can be found at http://www.tamu.edu/faculty/ccbn/dewitt/adp/archives/feature/lipantitlan/lipanframe.html.

[15] https://en.wikipedia.org/wiki/Mathis,_Texas
[16] http://www.texianlegacy.com/lipan.html

LAND USES

Urban areas are located in the very upper and very lower ends of the Lower Nueces River Watershed: 83% of the City of Mathis and 1% of the City of Corpus Christi, respectively. Sandia, San Patricio, and several unincorporated communities lie within the area. Approximately 75% of the entire watershed is comprised of farms and ranches. Except for some westward expansion of the City of Corpus Christi, land use has not changed significantly as compared to the National Land Cover Data (NLCD) 1992 land use map.[17] See Figure 4.1 for the 2011 land use /land cover map.

PERMITTED DISCHARGES

There are no permitted municipal Wastewater Treatment Facilities (WWTF) in the Lower Nueces River Watershed. Wright Materials, a sand and gravel operation, has a no-discharge permit. The permit allows for overflow during flood events. The discharge location is into Cayamon Creek west FM 666.

WATER QUALITY

Two locations on the Lower Nueces River have been monitored by NRA since 1998 as part of the Clean Rivers Program (CRP). A third site was added beginning in Fiscal Year (FY) 2011. Station 12965 is located towards the upper end of segment at State Highway (SH) 359. The Texas Commission on Environmental Quality (TCEQ) uses this station to assess assessment unit (AU) 02, the upper half the segment. Station 12964 is located about mid-way in segment at FM 666. TCEQ uses this station to assess AU_01, the lower half the segment. Station 20936, at the boat ramp in Hazel Bazemore Park, was added to provide better information for AU_01. Once enough data have been collected at this site, the data from both Station 12964 and Station 12965 will most likely be used to assess AU_02. See Figure 8.1 for monitoring locations.

Chlorophyll-*a* was first listed as being a concern on AU_01 in the 2008 Water Quality Inventory. Chlorophyll-*a* for AU_02 was added in the 2012 Integrated Report.[18] Total dissolved solids (TDS) are assessed on the entire segment as opposed to individual AUs. NRA noted an increasing trend in TDS in the CRP 2008 Basin Summary Report, and the segment was listed as being impaired for TDS as of the 2012 Integrated Report. As of the Draft 2014 Integrated Report, *E. coli* concentrations are currently meeting water quality standards. However, the CRP 2013 Basin Summary Report identified an increasing trend at Station 12964. Therefore, this WPP also addresses bacteria loadings to try and prevent an additional impairment for contact recreation.

WATERSHED SELECTION

The Lower Nueces River is the conduit of water from Lake Corpus Christi to the City of Corpus Christi, which supplies drinking water to approximately 500,000 people and to industries in the Coastal Bend.

In November 2009, the City of Corpus Christi experienced a sudden, unexpected increase in turbidity levels at the O. N. Stevens WTP that resulted in a drinking water violation. The City of Corpus Christi hired NRA to develop a source water protection plan (SWPP) to help prevent future turbidity issues and identify and prevent other possible threats to the water supply. NRA based the SWPP on the USEPA's

[17] http://edcftp.cr.usgs.gov/pub/data/landcover/states/

[18] TCEQ assessments prior to 2010 were called the Water Quality Inventory, 2010 and forward are called the Integrated Report.

Nine Elements of Successful Watershed Plans with the goal of developing a full WPP for the Lower Nueces River.

Although at the time the Lower Nueces River was not listed as impaired, the TSSWCB acknowledged the stakeholders' interest and efforts in protecting the river and selected it for development of the Lower Nueces River WPP.

Beginning October 2012, funding for the development of the Lower Nueces River WPP was provided through a federal Clean Water Act §319(h) grant to the NRA, administered by the TSSWCB through the USEPA. The TSSWCB is the lead agency for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural NPSs of water pollution. The agency also coordinates the programs and activities of the state's 216 soil and water conservation districts, administers a water supply enhancement program for the selective control of water-depleting brush, and facilitates the Texas Invasive Species Coordinating Committee.

3. The Nueces River Watershed Partnership

PARTNERSHIP FORMATION AND MISSION

Local public involvement is critical for successful development and implementation of a WPP. To inform and educate citizens from across the watershed and engage them in the planning process, stakeholders were identified and mailing lists and e-mail notification lists were developed. Stakeholders were defined as those who make and implement decisions, those who are affected by the decisions made, or those who have the ability to assist with implementation of the decisions.

These notification lists are updated on a regular basis. There are over 300 people / businesses that receive information via U.S. Mail and approximately 150 that receive information via e-mail. They include:

- Elected state representatives of Jim Wells, Nueces, and San Patricio counties
- Federal, state, and local resource agencies representatives
- Local county and city officials or their designated representatives
- Jim Wells, Nueces, and San Patricio Soil and Water Conservation Districts (SWCD) Board members
- Property owners along the river
- Interested citizens

A website, http://www.nuecesriverpartnership.org/, was developed to provide access to information related to the development of the Lower Nueces River WPP. Press releases were developed and posted in the Corpus Christi Caller Times, a local newspaper that is distributed throughout the watershed, to announce stakeholder meetings. Meeting invitations and agendas were mailed / e-mailed to everyone on the notification lists and posted on the website. Periodic newsletters highlighting the studies conducted in support of the development of the WPP were developed, distributed, and posted on the website.

Between January 2011 and July 2012, six stakeholder meetings were held in conjunction with the SWPP. By the time the WPP is completed and submitted for approval, an additional 14 stakeholder meetings, between March 2013 and November 2015, will have occurred.

The goal of the Nueces River Watershed Partnership, through the development of the WPP, is to address all sources of current and potential pollutants to restore the water quality and prevent any further degradation. The Partnership, with the support of local, state, and federal partners, works with all stakeholders and citizens in the watershed, towards achieving this goal.

PARTNERSHIP STRUCTURE

To guide the overall watershed protection plan development and implementation, the Partnership adopted the following structure.

Steering Committee

A Steering Committee was formed to represent the key stakeholder interests in the watershed and be the decision-making body for the Nueces River Watershed Partnership. The process of identifying and inviting stakeholders to serve on the Steering Committee included identifying all relevant interests and

soliciting nominations and volunteers to represent those interests. This discussion took place over the first three stakeholder meetings and the members were appointed at a meeting in January 2014.

The interests and representatives are:

Water Right Permit Holders	City of Corpus Christi Nueces County WCID #3
Industries	Flint Hills Resources Celanese San Patricio Municipal Water District
Homeowners	Corpus Christi Resident CR 73 Resident San Patricio Resident Sandia Resident
Counties	Jim Wells Nueces San Patricio
Large / Rural Landowner	Angelina Ranch
Agriculture	Ag Producer – Jim Wells County
Environmental Stewardship	Coastal Bend Bays and Estuaries Program
Recreation	Resident
Outreach and Education	Nueces River Authority
Soil and Water Conservation Districts	Jim Wells County SWCD

The Nueces River Watershed Partnership operates under ground rules approved by the Steering Committee (Appendix C). As part of the Partnership, the Steering Committee, some of whom are pictured below in Figure 3.1, is a facilitated group that met approximately quarterly during the first two and one half years of the WPP development process and bi-monthly during the completion of specific WPP chapters. The primary objectives of the Steering Committee are to:

- identify desired water quality conditions and measurable goals,
- prioritize programs and practices to achieve those goals,
- assist in the development of the WPP document,
- lead implementation of the WPP at the local level, and
- communicate goals and objectives of the WPP to other interested groups within the watershed.

The Steering Committee, working together and with support from topical work groups (described below), led the development of the Lower Nueces River WPP and will guide the implementation phase of the plan. While formation of the Steering Committee was coordinated by the NRA and the TSSWCB, the Committee functions as an independent group of watershed stakeholders, including both organized entities and individuals, with an interest in restoring and protecting the designated uses and overall health of the Lower Nueces River Watershed.

Figure 3.1 Members of the Steering Committee

Work Groups

Work groups were created to focus on specific topical issues and areas of concern and to make recommendations to the Steering Committee. Work groups were composed of Steering Committee members and any other members of the Nueces River Watershed Partnership with expertise or a vested interest in that topic. Work group meetings were facilitated by the NRA and held on an as-needed basis to study specific issues, identify and make recommendations on implementation strategies, and support development of the WPP. Between the SWPP and WPP, the following work groups have met on at least one occasion to provide input on:

- Water Quality: water quality sampling and parameters
- Utilities / NPS: storm water and on-site sewage facility concerns
- Agricultural: agricultural issues and programs available through the SWCDs, TSSWCB and the Natural Resources Conservation Service (NRCS)
- Recreation: recreational use and public access concerns
- Education and Outreach: strategies to inform and engage stakeholders, decision makers, and the public
- Large Debris: management plan for items identified by a side-scan sonar survey
- Hyacinth: management plan for control for hyacinth infestation

Technical Advisory Group

A Technical Advisory Group (TAG) was identified which consists of state and federal agencies with water quality responsibilities that are able to provide guidance to the Steering Committee and work groups, and answers questions related to matters falling under the jurisdiction of each TAG entity. The TAG includes the following agencies and organizations:

- Coastal Bend Bays and Estuaries Program (CBBEP)
- Coastal Bend Bays Foundation (CBBF)
- Coastal Bend Council of Governments (CBCOG)
- Railroad Commission of Texas (RRC)
- Jim Wells County Soil and Water Conservation District (SWCD)
- Nueces SWCD
- San Patricio SWCD
- Texas A&M University – Corpus Christi (TAMUCC)
- Texas A&M AgriLife Extension Service
- Texas Commission on Environmental Quality (TCEQ)
- Texas Department of Agriculture (TDA)
- Texas Department of Transportation (TxDOT)
- Texas Farm Bureau (TFB)
- Texas General Land Office (TGLO)
- Texas Parks and Wildlife Department (TPWD)
- Texas State Soil and Water Conservation Board (TSSWCB)
- Texas Water Development Board (TWDB)
- U. S. Department of Agriculture (USDA) – NRCS
- U.S. Environmental Protection Agency (USEPA)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Geological Survey (USGS)

4. Methods of Analysis and Estimate of Pollutant Loads and Required Load Reductions

The Nueces River Watershed Partnership utilized a variety of approaches to interpret water quality patterns in the watershed, identify pollutant sources, and assist in making decisions regarding necessary management measures.

LAND USE CLASSIFICATIONS

The Lower Nueces River Watershed was delineated using 12-digit hydrologic unit codes (HUC-12) to determine the size and characteristics of lands contributing to the river along its course. A 2011 land use/land cover (LULC) dataset was downloaded from the National Geospatial Management Center for the development of NRA's 2013 Basin Summary Report. The watershed was divided into 5 subwatersheds to enable closer examination of possible pollutant sources and to aid in targeting implementation efforts. (Figure 4.1)

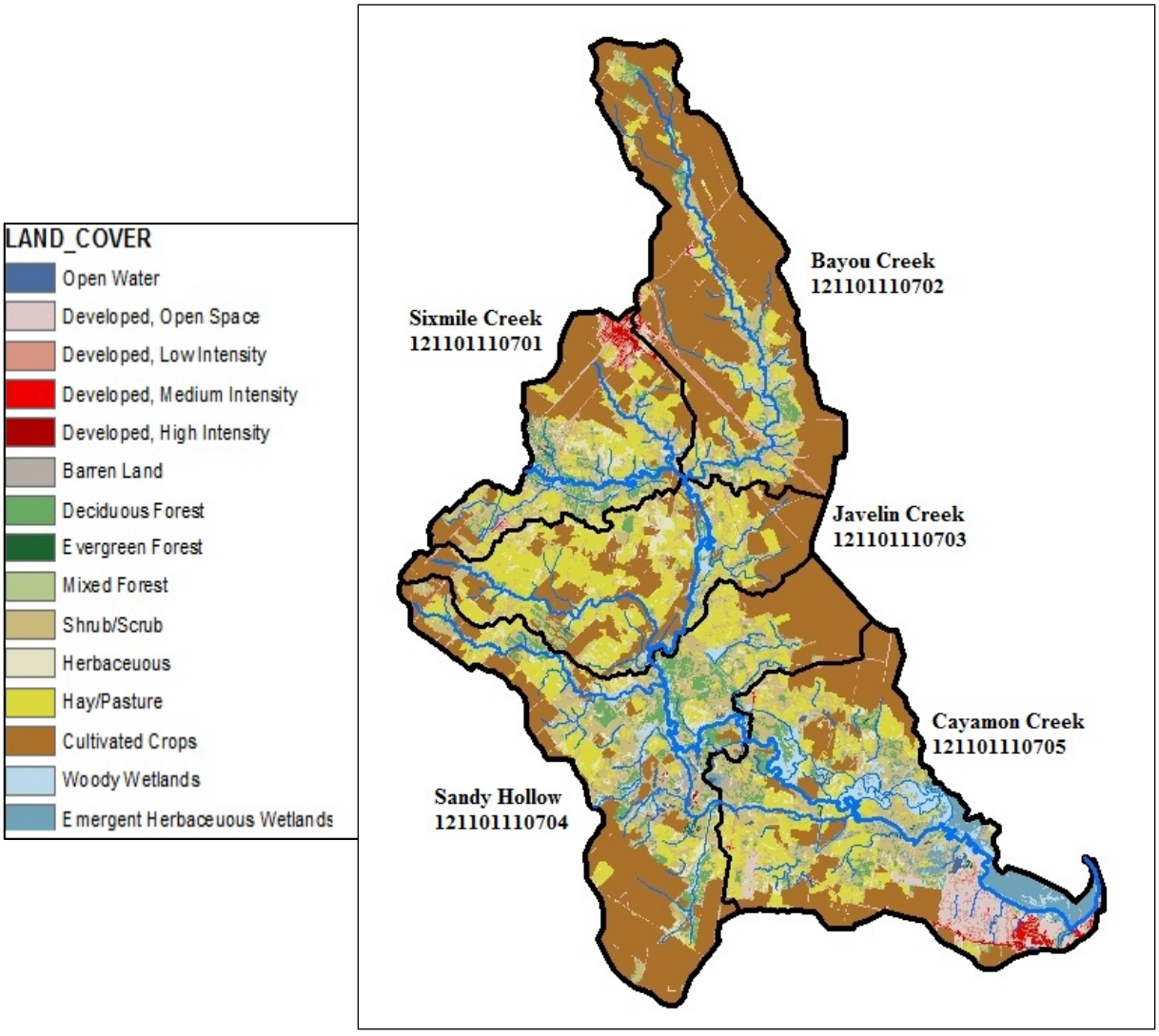


Figure 4.1: Land Use / Land Cover Map of the Lower Nueces River Watershed

Cultivated crops, shrub/scrub, and hay/pasture cover a little over 75% of the watershed. Cities and communities that lie wholly within the watershed include County Road (CR) 73, San Patricio, Sandia, and Sandy Hollow. One percent of Corpus Christi and 83% of Mathis lie within the watershed. Table 4.1 includes the LULC breakdown for the watershed (see Appendix D for descriptions).

Table 4.1. Land use classifications in the Lower Nueces River Watershed.

Classification	Total Acres	Proportion of Watershed (%)
Cultivated Crop	44,794	38
Shrub / Scrub	22,391	19
Hay / Pasture	21,363	18
Deciduous Forest	6,614	6
Developed Open Space	5,843	5
Woody Wetlands	4,943	4
Herbaceous	3,939	3
Emergent Herbaceous Wetlands	2,805	2
Developed Low Intensity	2,162	2
Developed Medium Intensity	760	1
Open Water	619	<1
Barren Land	432	<1
Evergreen Forest	105	<1
Developed High Intensity	82	<1
Mixed Forest	12	<1
Total	**116,863**	**100%**

DETERMINING SOURCES OF POLLUTION

Load Duration Curve

A widely accepted approach for predicting whether pollutants are coming from point and/or nonpoint sources is the use of a Load Duration Curve (LDC). An LDC is developed by first constructing a flow duration curve (FDC) using historical streamflow data (Figure 4.2). Historical streamflow data are used to determine how frequently stream conditions exceed different flows. Flow data are then multiplied by a threshold concentration (such as a desired target or an official water quality criteria) of a pollutant, including *E. coli* bacteria or a specific nutrient. The threshold used for each parameter evaluated was its water quality or screening criteria.

When flow and the critical concentration are multiplied together, they produce the estimated pollutant load (Figure 4.3). The resulting LDC can then be used to show the maximum load a stream can carry without exceeding regulatory criterion or screening criteria across the range of flow conditions (low flow to high flow). In addition, stream monitoring data for a pollutant can be plotted on the curve to show when and by how much criteria are exceeded. For example, in Figure 4.3, the solid line indicates the maximum allowable stream load for *E.coli* bacteria and the red boxes represent monitored loads from water quality sample data. Where the red boxes are above the solid line, the actual stream load has exceeded the regulatory limit, and a violation of the standard has occurred.

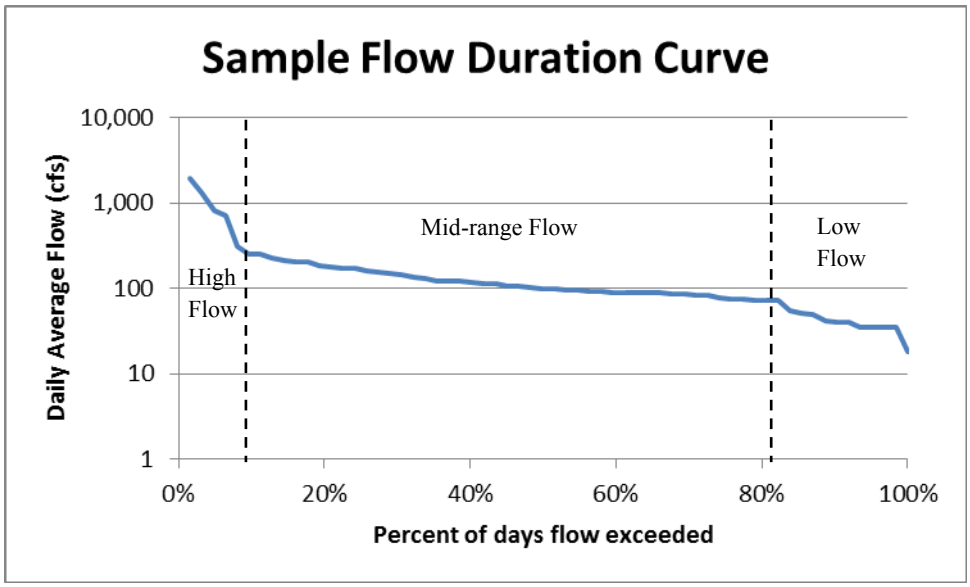


Figure 4.2 Sample Flow Duration Curve

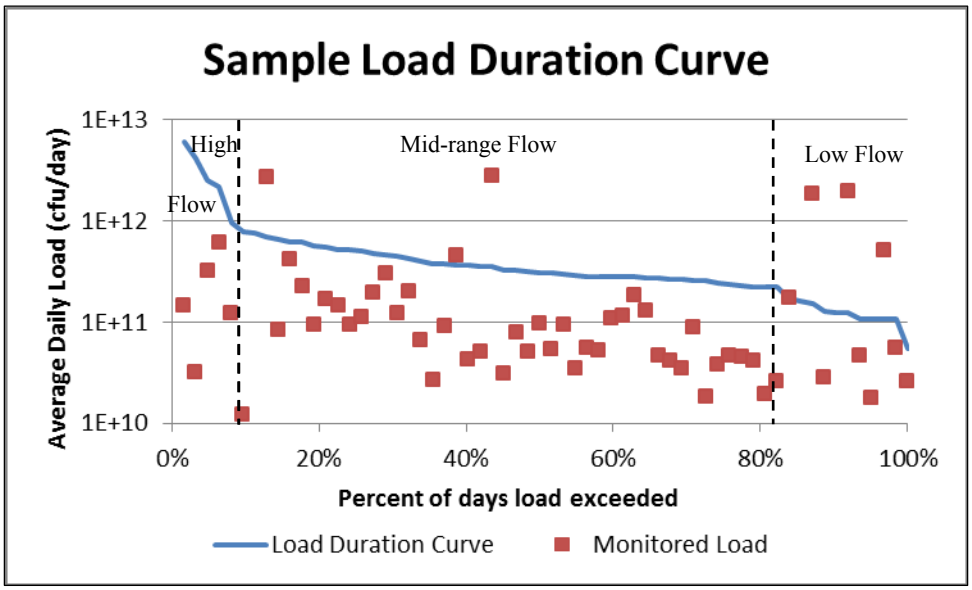


Figure 4.3. Sample Load Duration Curve

By considering the processes at work during high, mid-range, and low flows, it is possible to link pollutant concentrations with potential point or nonpoint sources of pollution. Next, by using a regression analysis of monitored data, estimates of the percent reduction needed to achieve acceptable pollutant loads can be determined.

Spatially Explicit Load Enrichment Calculation Tool (SELECT)

To estimate the distribution of potential pollutant sources and their contributions within a watershed, the SELECT approach was developed by the Spatial Sciences Laboratory and the Biological and Agricultural Engineering Department at Texas A&M University. Using the best available data, a potential pollutant load is estimated for each source based on known pollutant production rates. SELECT utilizes numbers and estimated distributions of developed urban land coverage, pets, septic systems, permitted wastewater facilities, livestock, and wildlife. These sources can then be compared across different subwatersheds and to each other. As a result, areas with the greatest potential for impacting water quality can be identified, and major contributors in those areas can be selected for the implementation process. The results of the SELECT analysis are discussed in detail in Chapter 5, Pollutant Sources in the Lower Nueces River Watershed.

DATA LIMITATIONS

When determining the relationships between in-stream conditions and driving factors in the surrounding landscape, it is important to consider all potential sources of pollution and rely on the most dependable data available. In addition to receiving input from local stakeholders, information used in the analysis of the Lower Nueces River Watershed was gathered from a number of sources, including local and regional groups, river authorities, and state and federal agencies.

It is important to remember that information collected in the Lower Nueces River Watershed represents a snapshot in time of the processes at work. Whether associated with human activities (Figure 4.4), weather patterns, animal distributions, or other factors, the Lower Nueces River and other watersheds are very dynamic in nature, and conditions can change dramatically between years and even within a given season. Because of this, the actual input of pollutants from different sources may vary considerably over time.

Figure 4.4: Channel cut to the Nueces River on private property

Load Duration Curve ANALYSES

For the Lower Nueces River Watershed, TDS and chlorophyll-*a* are the only parameters that exceed their respective criteria. TDS is the measurement of the combined content of all inorganic and organic substances found in a liquid that are small enough to pass through a filter with two-micrometer pores. Therefore, there is no one single parameter that is contributing to the elevated TDS concentrations, but more likely a combination of nutrients, bacteria sources, and sediments. Chlorophyll-*a* in itself is not a pollutant, but can be an indication of excessive nutrients. *E. coli* is also discussed in detail as it appears to be increasing in the lower reach of the river. Graphs of the other parameters that were evaluated are shown in Appendix E.

LDC analyses for the Lower Nueces River were performed for the two monitoring stations where water quality monitoring data are currently collected, have sufficient data for the analyses, and have daily stream flow data via USGS gauges. Water quality data collected from January 1998 through December 2013 and the recorded flow data from January 1992 through December 2013 were used for the analysis. A third monitoring station was established beginning November 2011 resulting in only nine data points at the time of the analysis. Flow data at this site are estimated values recorded during the sampling events. An LDC for this site was created to get an approximate relationship between measured values and the water quality criterion. Additional data are needed to generate a more statistically meaningful curve.

Station 12965 is the most upstream station and is located at the La Fruta Bridge on SH 359 southwest of Mathis, TX. Station 12964 is located mid-way in the segment at FM 666 in San Patricio, TX. Station 20936 is the most downstream station and is located at the boat ramp in Hazel Bazemore Park. See Figure 4.5 for a map of the station locations.

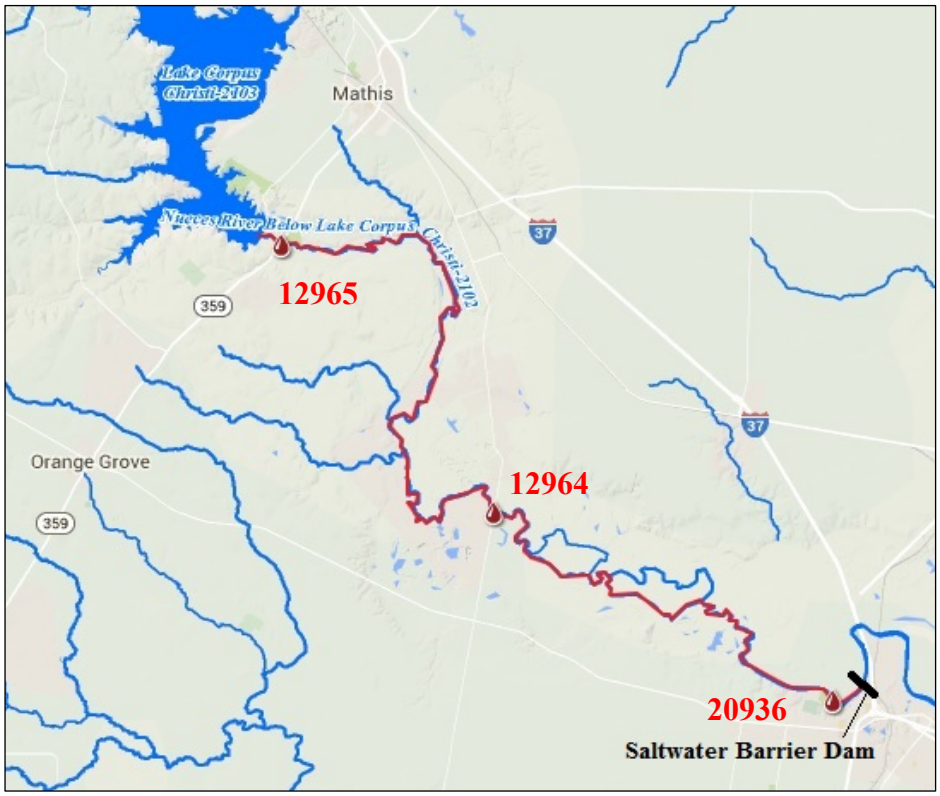


Figure 4.5: Monitoring Stations Location Map

FLOW DURATION CURVES

At Stations 12965 and 12964, high flows occur <= 9% of the time, mid-range flows between 1% and 91% of the time, and low flows occur <= 1% of the time. All recorded flows at 20936 are within the mid-range of the other stations. Since releases are constantly made from Lake Corpus Christi to WTP intakes located below the most downstream sampling site, the FDCs (Figure 4.6) are very similar. The flow data for Station 12965 is a continuous record from January 1992 through December 2013. The flow data for Station 12964 begins in April 1992, but has numerous gaps, especially during the very high flows in 2002 and 2007 (> 7,100 cfs) recorded at Station 12965. Therefore, the flow volume axis on the FDC for Station 12965 is an order of magnitude higher than the one for Station 12964.

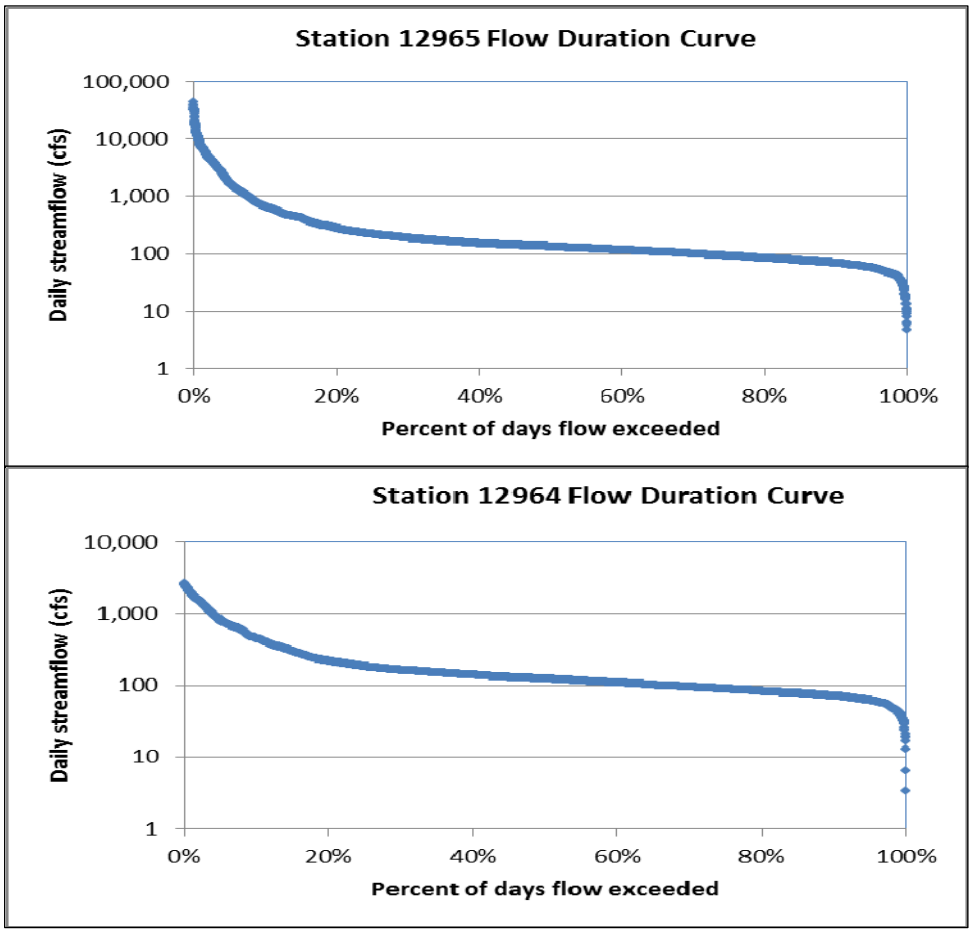


Figure 4.6: FDCs for Stations 12965 and 12964

TOTAL DISSOLVED SOLIDS

An increasing trend in TDS levels was first noted in NRA's 2008 Basin Summary Report for TCEQ's CRP, and the average has exceeded the water quality criteria of 500 mg/l as of the 2012 Texas Integrated Report. The computed averages in 2012 and draft 2014 Integrated Reports are 546 mg/l and 621 mg/l, respectively. The LDCs (Figure 4.7) support this assessment.

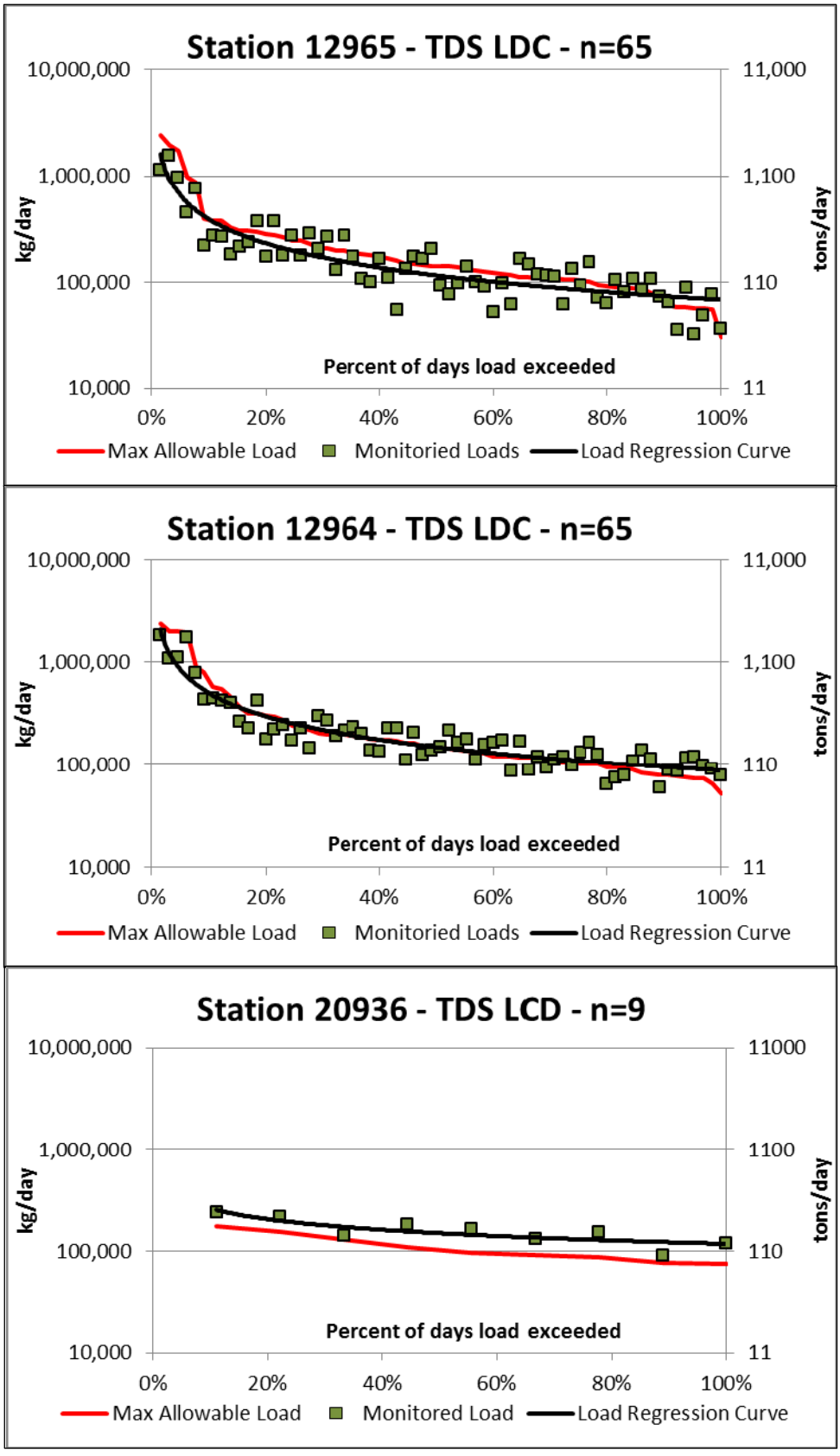


Figure 4.7: LDCs for TDS


Station 12965

Based on the analyses, the water quality criteria for TDS are being met during high flows. However, load reductions are needed at mid-range and low flows. The proposed load reduction of 32.2% will address the highest percent reduction[19] needed to fully meet standards. Since there are no permitted discharge locations in the segment, groundwater seepage during dry/low rainfall periods may be contributing to the load. Studies have been conducted to assess chloride levels in the river with respect to the manufacturing water conservation water management strategy for the Coastal Bend Regional Water Planning Area[20]. These studies indicate that the increase in chloride from upstream to downstream is related to groundwater influx. TDS and chloride levels are generally related and time plots show similar trends (Figures 4.8 and 4.9). Flow data from Station 12965 is also plotted on the graphs. The release from Lake Corpus Christi to meet downstream water rights is usually about 100 cfs. Lower TDS and chloride concentrations tend to be related to higher than average flow. Also, Figure 28 on Page 61 of the *Brackish Groundwater Manual for Texas Regional Water Planning Groups*[21] shows near-surface groundwater TDS levels in the range of 1,000 mg/l to 3,000 mg/l.

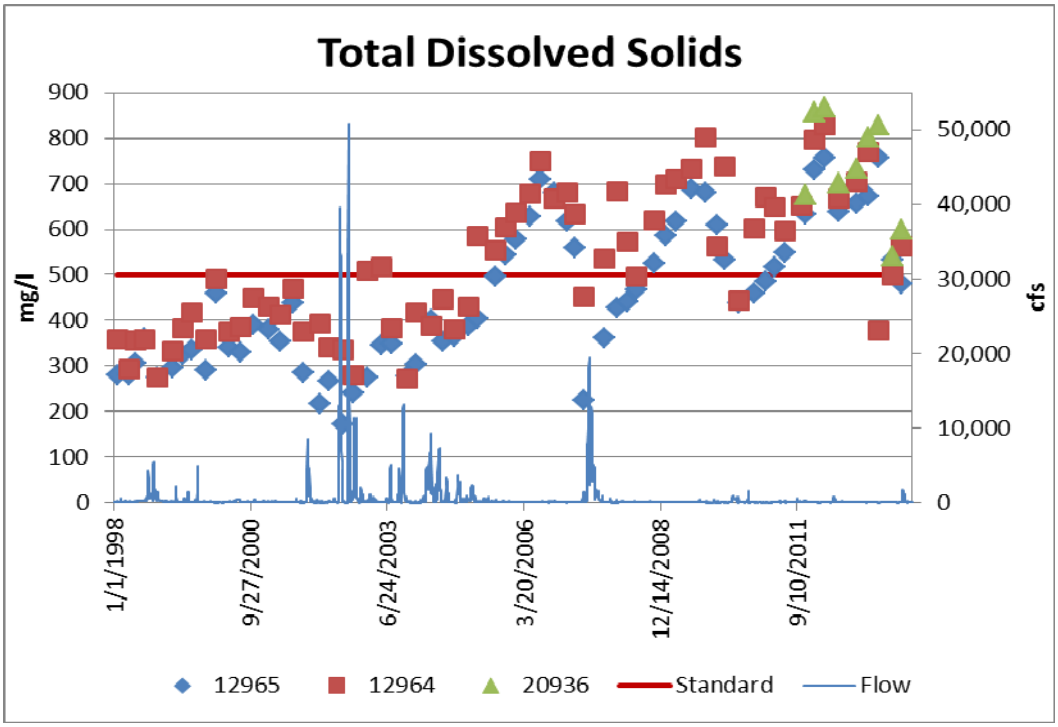


Figure 4.8: TDS vs Time

[19] Average of the percent reductions at Station 12965 during low flow (>95% exceedance)
[20] http://www.twdb.texas.gov/waterplanning/rwp/plans/2011/N/Region_N_2011_RWPV2.pdf, Section 4C.3
[21] https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/2001483395.pdf

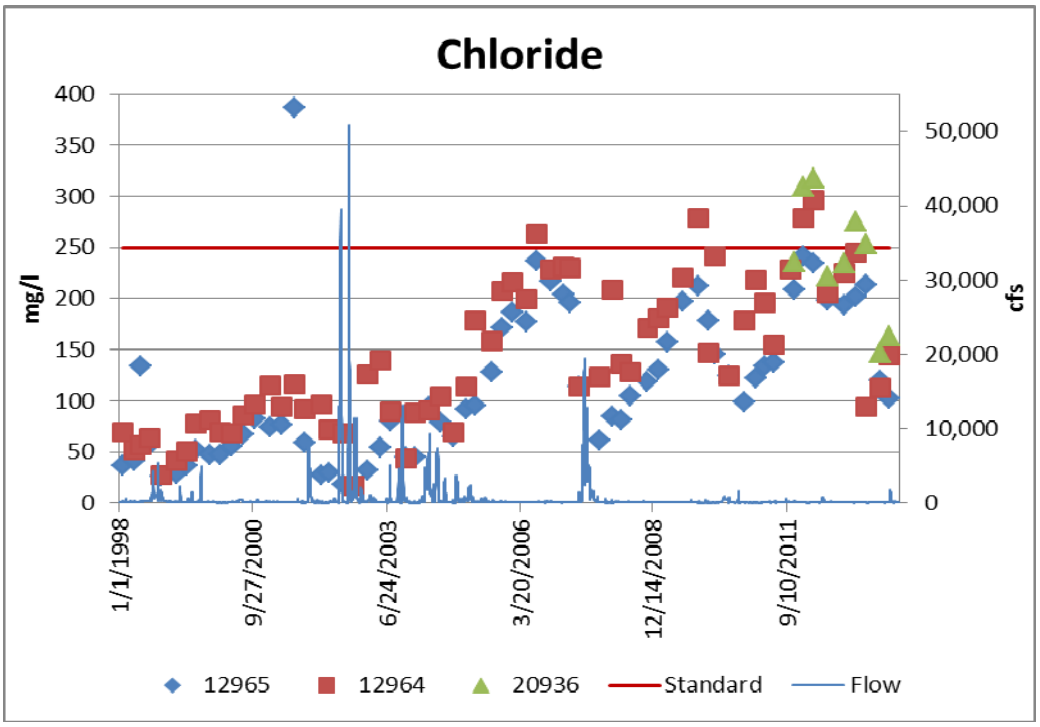


Figure 4.9: Chloride vs Time

CHLOROPHYLL-*a*

Increasing trends in chlorophyll-*a* levels were first noted in NRA's 2008 Basin Summary Report at stations 12965 and 12964. There has been a concern for this parameter at station 12964 since the 2008 Texas Water Quality Inventory and at station 12965 since the 2012 Texas Integrated Report. All measured values to-date have met the water quality criteria at station 20936. As of the draft 2014 Texas Integrated Report, 14 out 28 samples exceeded the 14.1µg/l criteria at station 12965 and 11 out of 33 samples exceeded the criteria at station 12964. However, the LDCs (Figure 4.10) indicate that the only reduction needed (56.9%) is at station 12965 during low flows.

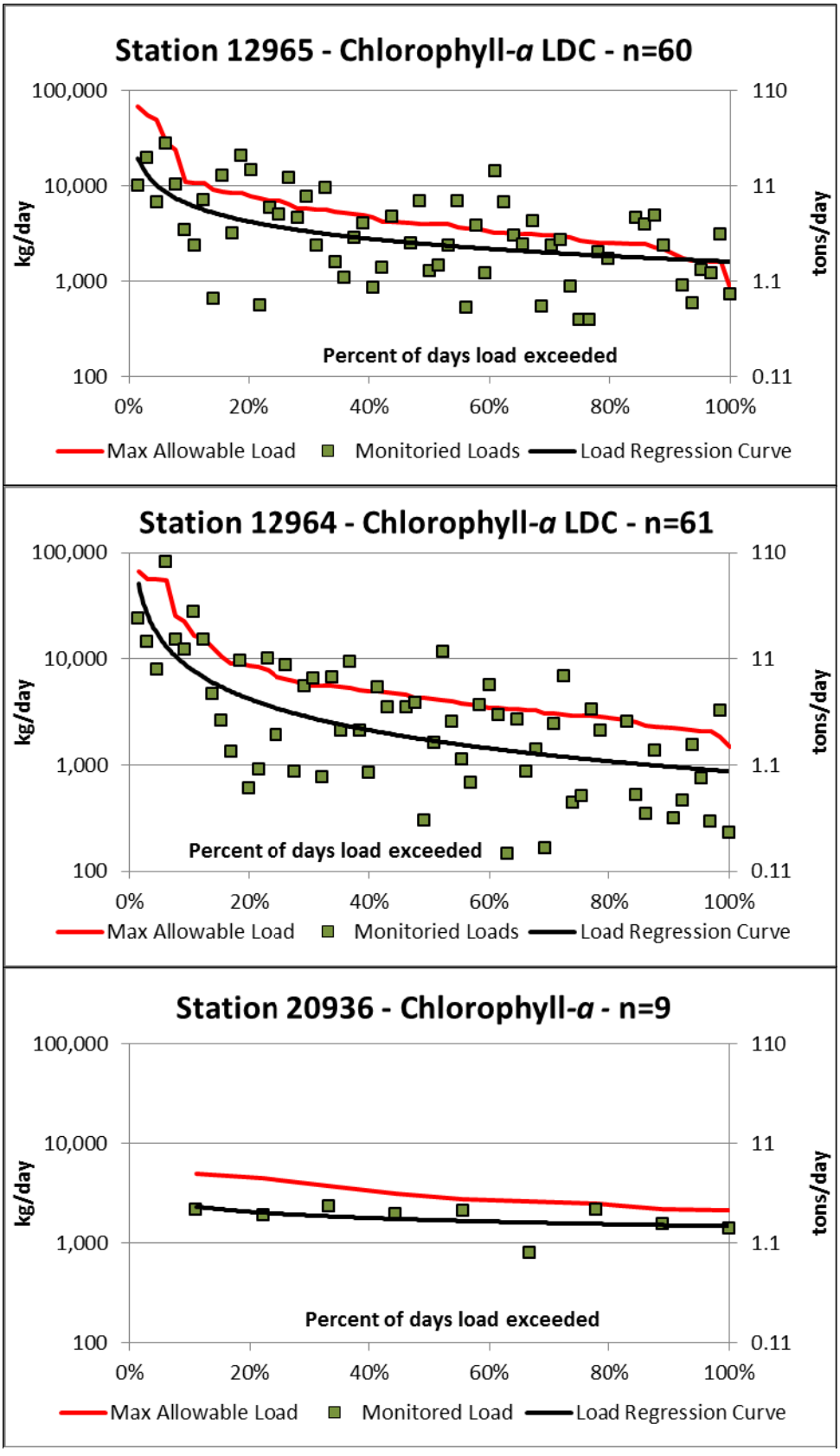


Figure 4.10: LDCs for Chlorophyll-*a*

As apparent in a time plot of the data (Figure 4.11), something changed beginning in about 2003. Removing the pre-2003 data shifts the LDC closer to the maximum allowable load, but still just meets the criteria for all but low flows at station 12965.

It is possible that the overall increase in TDS, chloride, and chlorophyll-*a* concentrations are related to the City of Corpus Christi's 2001 Agreed Order with TCEQ requiring freshwater to be released to the bays and estuaries. From 1995 to 2001, an Interim Order required the City to release a given amount of water from Lake Corpus Christi every month, regardless of the inflows into the Lake Corpus Christi / Choke Canyon Reservoir System. The Agreed Order now requires that the City "pass through" up to a target amount of water each month based on inflows into the reservoir system. Therefore, only during heavy rainfall and flood events upstream of the reservoirs does the flow on the river below Lake Corpus Christi receive high flows.

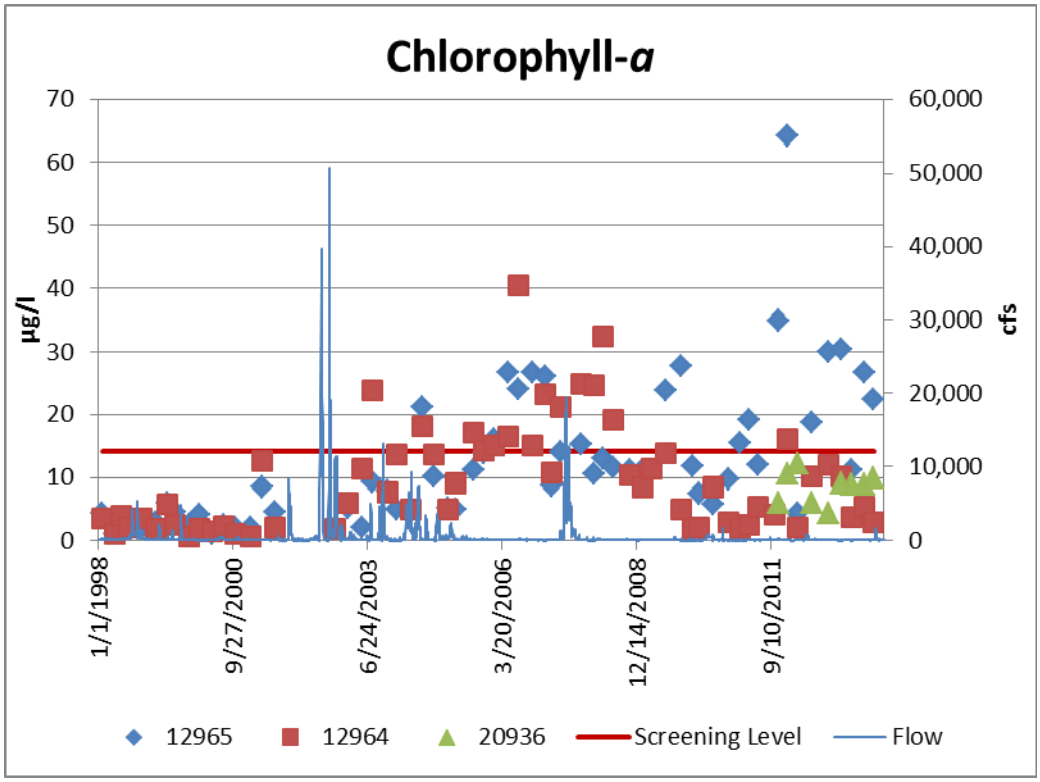


Figure 4.11: Chlorophyll-*a* vs Time

BACTERIA

E. coli levels are currently meeting the water quality criteria. However, an increasing trend in the bacteria levels was identified at station 12964 in NRA's 2013 Basin Summary Report. The LDC analysis (Figure 4.12) indicates that station 12964 is closest to exceeding the standard. This site is located immediately downstream of a housing subdivision, which is on septic systems. Based on the time plot of the data (Figure 4.13), the levels at station 20936 are similar to those at station 12964. Additional subdivisions are located between this site and 20936. There are no houses along the river between Lake Corpus Christi and station 12965. Swimming and boating are common occurrences on the river, and efforts need to be made to keep them below the standard and safe for recreation.

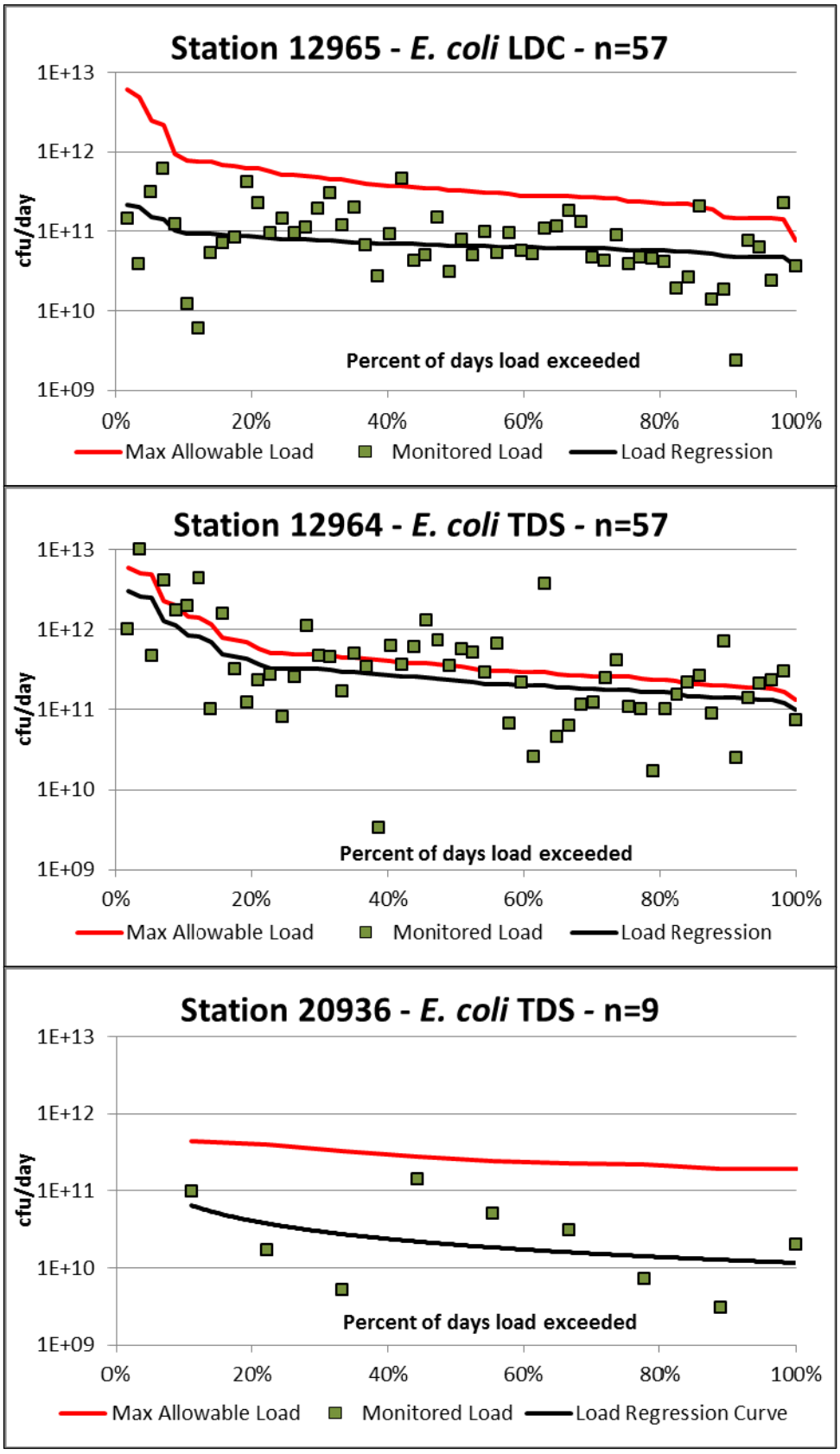


Figure 4.12: LDCs for *E. coli*

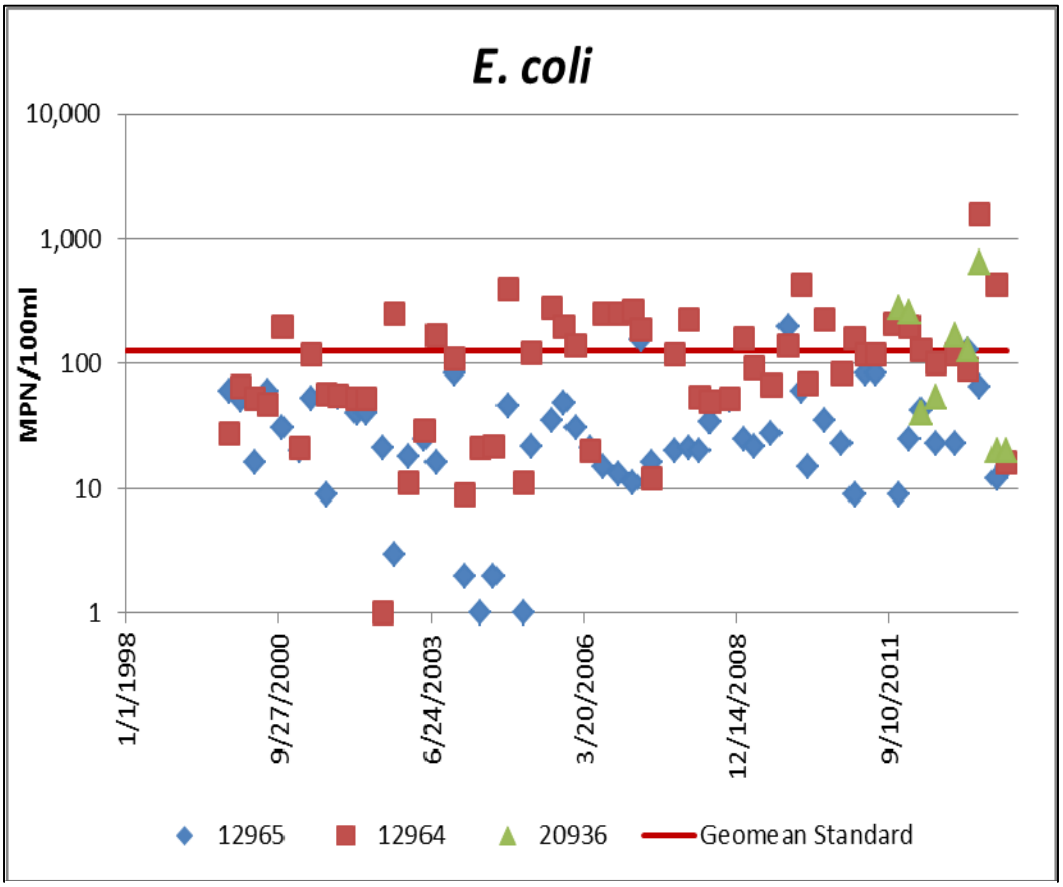


Figure 4.13: *E. coli* vs Time

SUPPLEMENTAL ANALYSIS

Additional analysis was done to determine if there were statistical correlations[22] between the nutrients (ammonia, nitrates, and total phosphorous) and TDS and /or between nutrients and chlorophyll-*a*. The correlations that were identified are:

- Total phosphorous and chlorophyll-*a* at Station 12964
- Total phosphorous and TDS at Station 12964
- Total phosphorous and TDS at Station 20936

However, as indicated in the LDC for total phosphorus, (Figure E.5), the loadings associated with this parameter are below the maximum allowable load. Therefore, neither SELECT analysis nor load reductions were conducted on total phosphorous specifically, but rather based on which subwatershed has the most potential for runoff from cultivated crop acreage (Figure 5.7).

Analysis also showed that there is a correlation between TDS and chlorophyll-*a* at Stations 12965 and 12964. Therefore, reductions in TDS loadings by implementation of the management measures, Chapter 6, are expected to also reduce chlorophyll-*a* levels.

[22] Excel's Regression Analysis was used for this analysis. A statistical correlation is identified when the t-stat $> |2|$ and the p-value < 0.1.

5. Pollutant Sources in the Lower Nueces River Watershed

As mentioned in Chapter 4, SELECT analysis was developed to estimate pollutant loading, primarily bacteria, based on LULC and animal populations. Bacteria sources are also often sources of nutrients. The analysis can be adapted to estimate loading from failing septic systems and relative potential loading of other constituents from agricultural lands and urban areas. The bacteria loads are estimated based on available animal population data. While absolute numbers may be higher or lower depending on changing stocking rates and wildlife populations, the relative loading from each subwatershed remains the same. A numeric load reduction is not currently required to meet water quality standards. But since *E. coli* concentrations appear to be increasing, this analysis can be used to identify the subwatersheds with the highest potential for *E. coli* contributions for proposed best management practices (BMP)s to prevent further degradation.

As the LDC analysis indicated, the TDS impairment and the chlorophyll-*a* concern are slightly above their standards and bacteria is approaching the standard. As indicated by Figure 4.9, TDS concentrations decrease for a time during and after high flow events. Chlorophyll-*a* concentrations do not show the same response to flow, Figure 4.12, but both concentration increases are likely related to the change in operating procedures for water releases from Lake Corpus Christi with the 2001 Agreed Order. These operation procedures are designed to maximize the yield of the system for water supply. Therefore, in order to bring TDS and chlorophyll-*a* into compliance and/or prevent any further water quality degradation, SELECT was utilized to identify the subwatersheds that have the greatest potential on contributing to these parameters and be targeted for BMP implementation.

AGRICULTURE

Agricultural contributions were evaluated for both livestock (Figure 5.1) and cultivated croplands (Figure 5.6). For cattle, sheep, goats, and horses, the 2012 Census of Agriculture – County Data provided by the USDA, National Agricultural Statistics Service was used to estimate the number of animals in each county. The Confined Animal Feeding Operation (CAFO) in Jim Wells County is estimated to have 1,500 cattle. Since their permit is a no-discharge permit, the Jim Wells County total was reduced by this amount.

The average daily *E. coli* productions for livestock that was used in the SELECT analysis were:

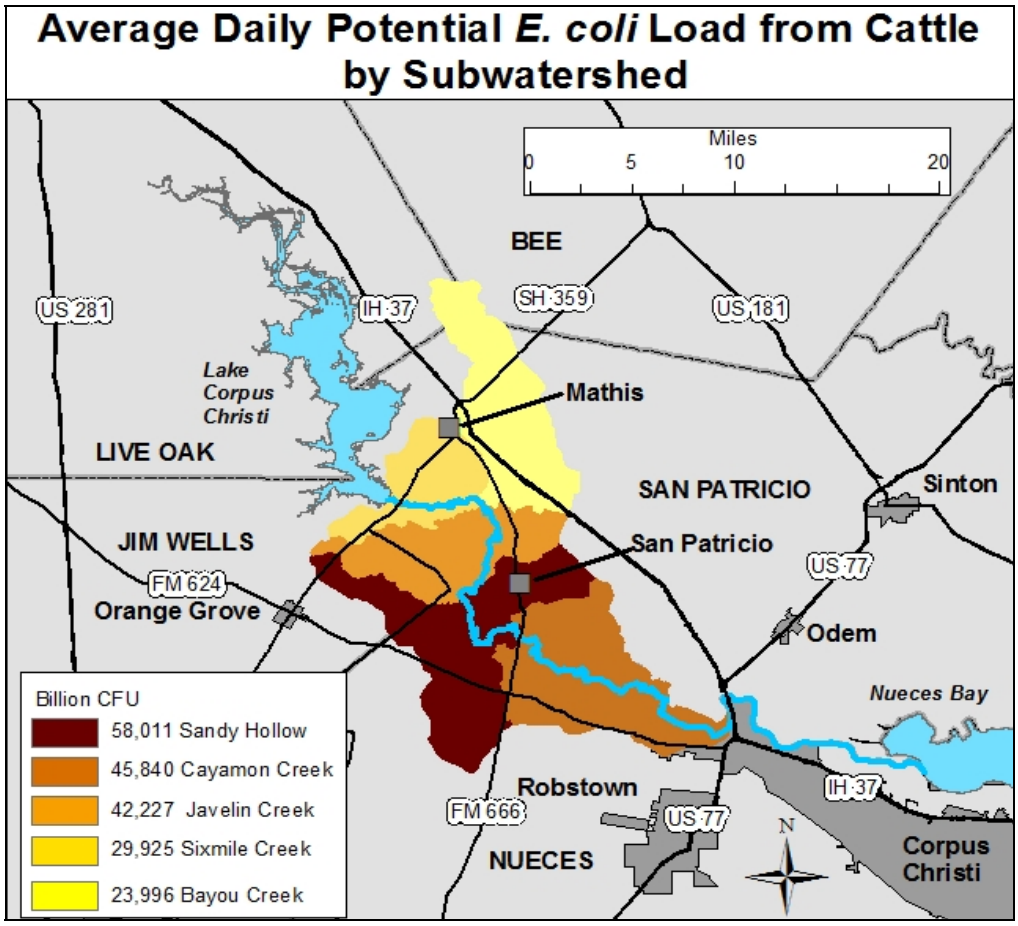
- Cattle: $10*10^{10}$ cfu/day *0.5 per cow (SELECT default value)
- Sheep: $1.2*10^{10}$ cfu/day *0.5 per sheep (SELECT default value)
- Goats: $1.2*10^{10}$ cfu/day *0.5 per goat (SELECT default value)
- Horses: $4.8*10^{8}$ cfu/day *0.5 per horse (SELECT default value)

The loading values used in the SELECT analysis are estimates of how much bacteria could be produced on a single day for each animal type based on estimated populations. The analysis does not suggest that all this bacteria makes its way into river and streams. *E. coli* bacteria begin to die off once they are outside of the host organism, and much of the feces are consumed by dung beetles and other insects. It is estimated that in parts of Texas, up to 80% of cattle dung is processed by dung beetles.[23]

[23]http://voices.nationalgeographic.com/2012/04/17/weird-wild-dung-beetles-favorite-poop-revealed/

The SELECT results, population estimates, LULC classifications, and maps of the suitable habitat for cattle (Figure 5.2), sheep (Figure 5.3), goats (Figure 5.4), and horses (Figure 5.5), are displayed on the next four pages.

Figure 5.1: Livestock



Population Estimates

County	# in County	% of County in Watershed	# in Watershed
Bee	30,130	0.2 %	57
Jim Wells	39,866	3.8 %	1,470
Live Oak	34,736	0.3 %	95
Nueces	12,306	5.0 %	611
San Patricio	13,883	12.7 %	1,767
Total			4,000

Land Use Land Cover

Classification	% of Watershed Area
Deciduous Forest	5.30 %
Evergreen Forest	0.10 %
Mixed Forest	0.02 %
Shrub/Scrub	17.43 %
Herbaceous	3.81 %
Hay/Pasture	18.07 %
Suitable Habitat	44.73 %

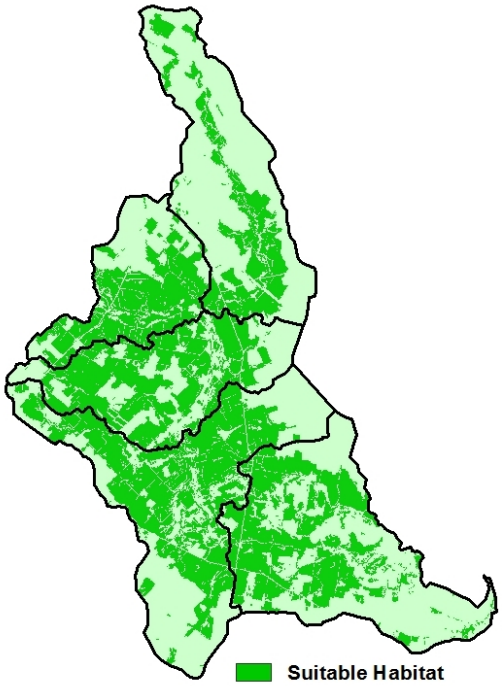
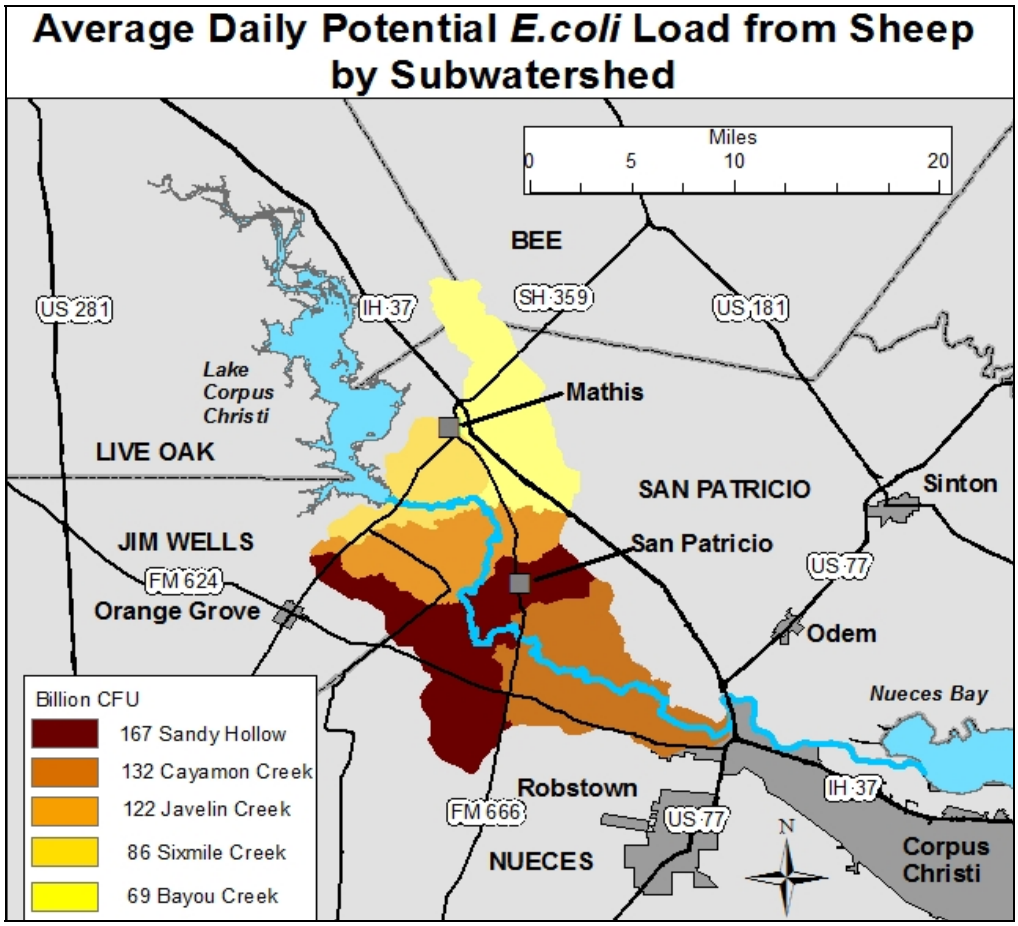


Figure 5.2: SELECT Analysis for Cattle



Population Estimates

County	# in County	% of County in Watershed	# in Watershed
Bee	193	0.2 %	0
Jim Wells	930	3.8 %	36
Live Oak	135	0.3 %	0
Nueces	420	5.0 %	21
San Patricio	306	12.7 %	39
Total			96

Land Use Land Cover

Classification	% of Watershed Area
Deciduous Forest	5.30 %
Evergreen Forest	0.10 %
Mixed Forest	0.02 %
Shrub/Scrub	17.43 %
Herbaceous	3.81 %
Hay/Pasture	18.07 %
Suitable Habitat	44.73 %

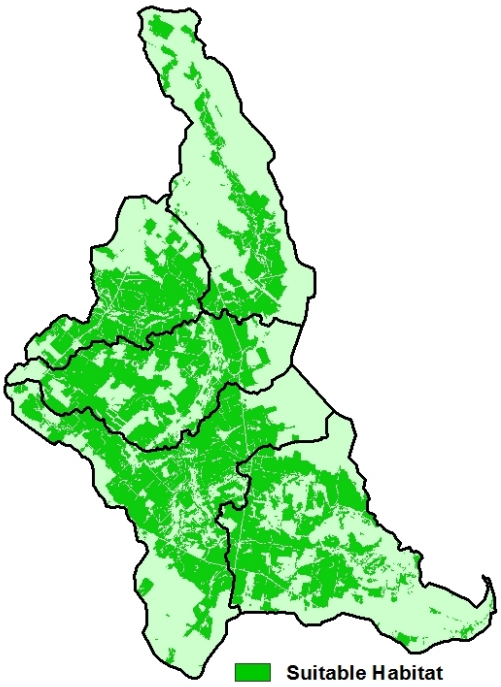
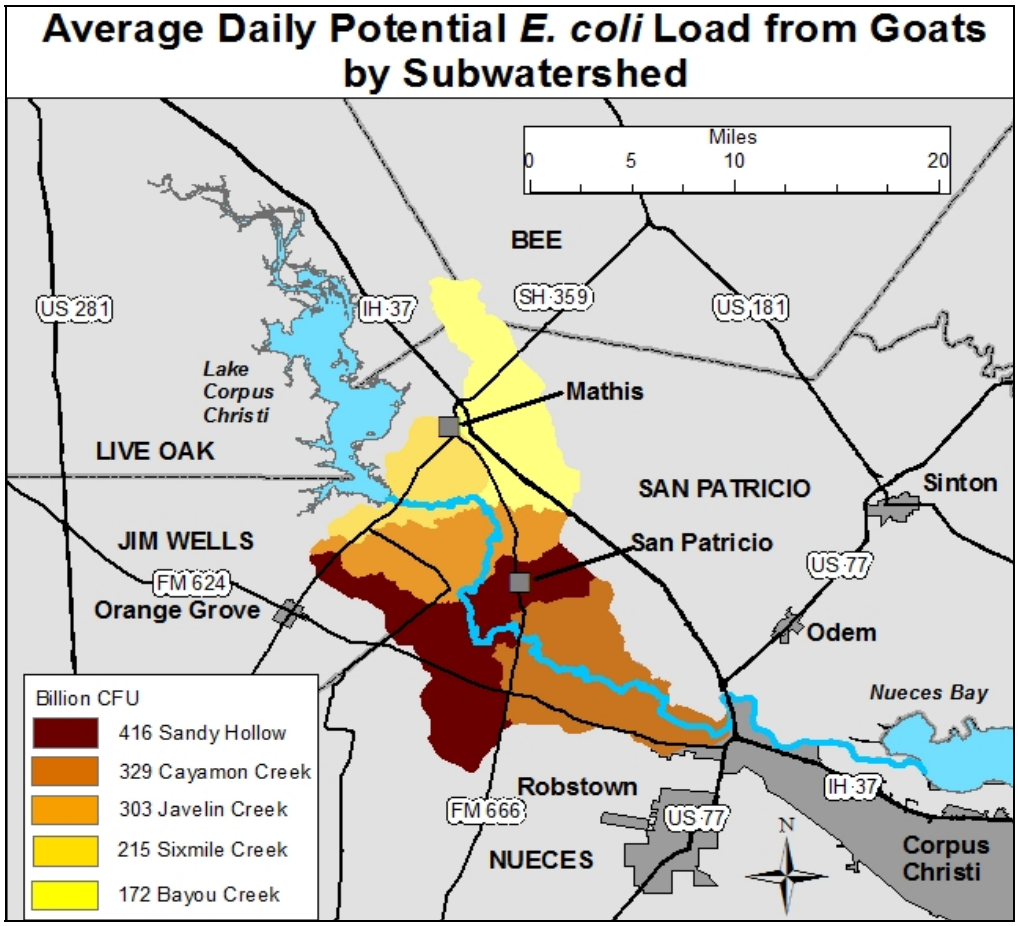


Figure 5.3: SELECT Analysis for Sheep



Population Estimates

County	# in County	% of County in Watershed	# in Watershed
Bee	1,974	0.2 %	4
Jim Wells	1,860	3.8 %	71
Live Oak	1,430	0.3 %	4
Nueces	788	5.0 %	39
San Patricio	952	12.7 %	121
Total			239

Land Use Land Cover

Classification	% of Watershed Area
Deciduous Forest	5.30 %
Evergreen Forest	0.10 %
Mixed Forest	0.02 %
Shrub/Scrub	17.43 %
Herbaceous	3.81 %
Hay/Pasture	18.07 %
Suitable Habitat	44.73 %

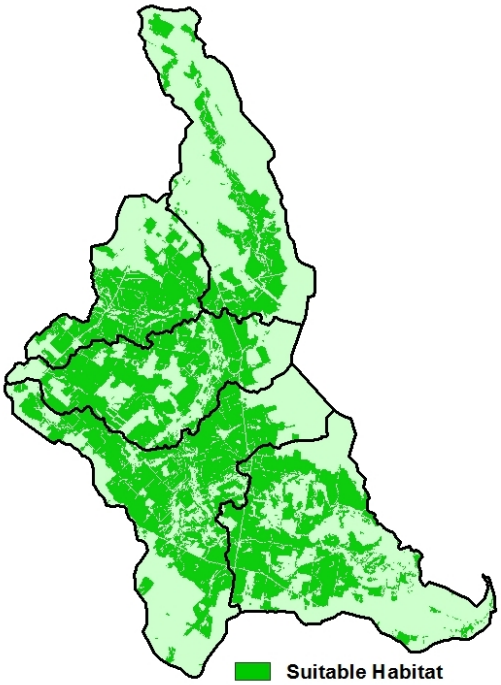
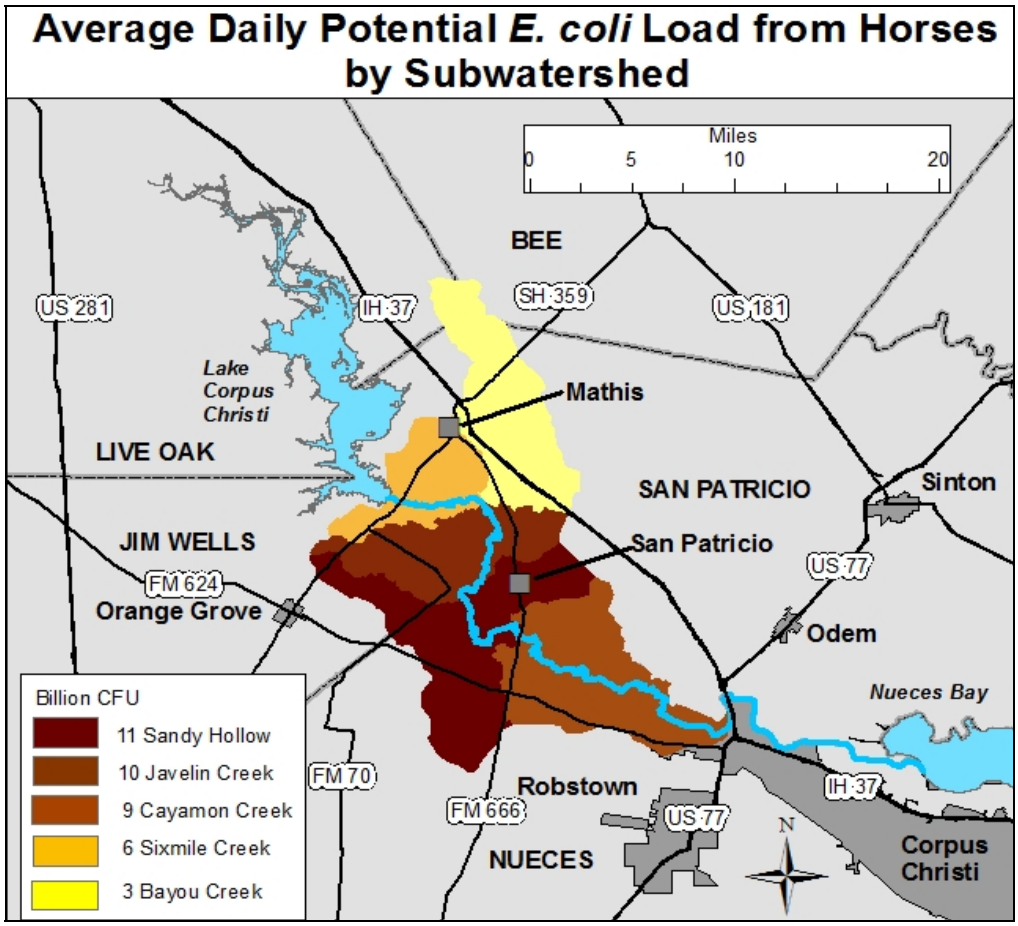


Figure 5.4: SELECT Analysis for Goats



Population Estimates

County	# in County	% of County in Watershed	# in Watershed
Bee	1,447	0.2 %	3
Jim Wells	1,108	3.8 %	42
Live Oak	1,063	0.3 %	3
Nueces	848	5.0 %	42
San Patricio	624	12.7 %	79
Total			169

Land Use Land Cover

Classification	% of Watershed Area
Herbaceous	3.81 %
Suitable Habitat	3.81 %

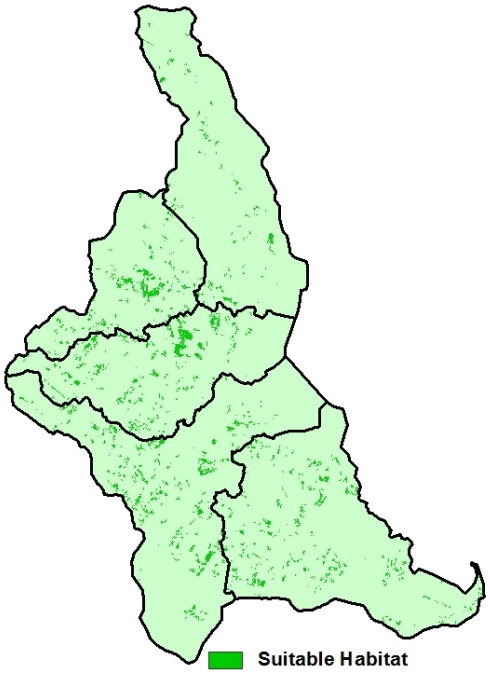


Figure 5.5: SELECT Analysis for Horses

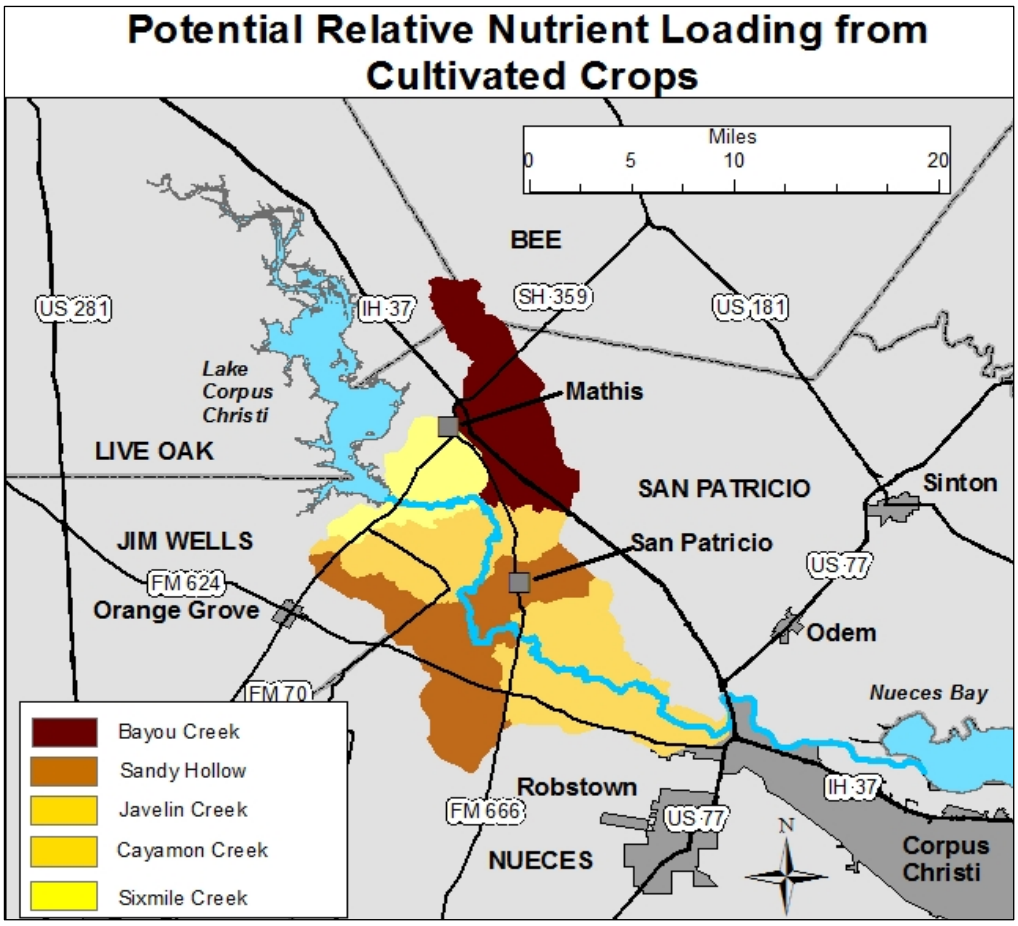
CROPS and SEDIMENT

Runoff from cultivated cropland (Figure 5.6) can also contribute to nutrient loading. The monitored values for nitrogen and phosphates are generally low, but SELECT analysis was run in order to see the relative potential nutrient loading between the subwatersheds based on the number of crop acres. (Figure 5.7)

Sediment runoff during rainfall events occurs from all LULC types. When high rainfall events occur while the ground is exposed after crops have been harvested, additional sediment runoff can lead to turbidity issues in the river. Such an occurrence happened in November 2009 and was documented by the USGS for the City of Corpus Christi. The study determined the average kilogram / acre (kg/ac) from each subwatershed that contributed to the loading. Higher loads were associated with areas of higher rainfall. The rainfall amounts ranged from 2.4" around the Sandy Hollow Creek subwatershed to 6.8" in the Bayou Creek subwatershed. The USGS concluded that the turbidity issues were primarily related to the runoff from the Bayou Creek and Sixmile Creek areas. The average sediment runoff for the entire watershed was 11.4 kg/ac during this event. The estimated sediment runoff potential during the November 2009 event for each subwatershed was:

- Bayou Creek: 20.1 kg/ac
- Sixmile Creek: 15.9 kg/ac
- Javelin Creek: 9.3 kg/ac
- Sandy Hollow: 7.4 kg/ac
- Cayamon Creek: 4.5 kg/ac

Figure 5.6: Row Crop



Subwatershed	Crop Acres	% of Subwatershed
Bayou Creek	15,744	65.6%
Sandy Hollow	11,920	38.8%
Javelin Creek	6,602	34.4%
Cayamon Creek	6,356	21.9%
Sixmile Creek	3,872	27.8%

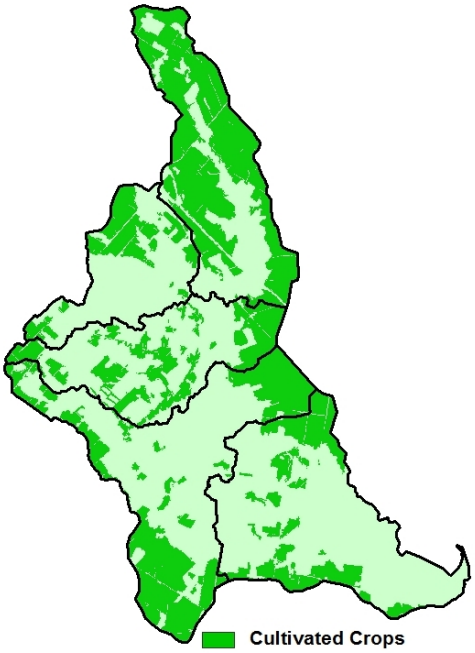


Figure 5.7: SELECT Analysis for Cultivated Crops

WILDLIFE

Wildlife contributions were evaluated for deer (Figure 5.8). The deer population was estimated at 27 deer per 1000 acres of suitable habitat (SELECT default value). San Patricio County has seen an increase in the deer population due to less hunting occurring in this area.

The average daily E. coli productions for deer that was used in the SELECT analysis was $3.8*10^8$ cfu/day *0.5 per deer (SELECT default value).

The SELECT results, population estimates, LULC classifications, and maps of the suitable habitat for deer (Figure 5.10) are displayed on the following page.

There are numerous other animal species that contribute to bacteria loading, but it is difficult to estimate their populations. If BMPs are developed to address wildlife in general, it could possibly be assumed that they occupy the same habitat as deer, and therefore the relative loading from the subwatersheds would remain the same.

Figure 5.8: Deer

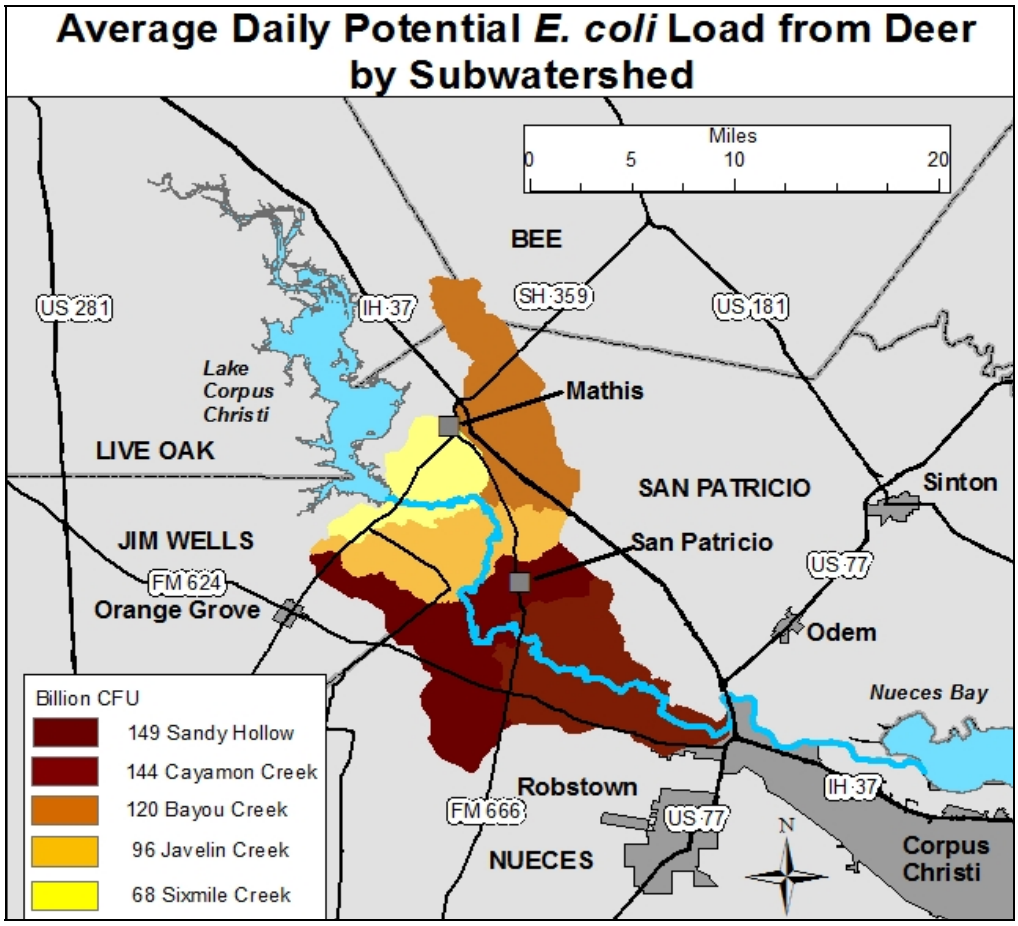
FERAL HOGS

Contributions were also evaluated for feral hogs (Figure 5.9). The literature estimates of 1.3 to 2.5 feral hogs per square mile were considered too low by the Lower Nueces River Watershed stakeholders so an estimated 12 feral hogs per square mile used for the analysis. The 12 per square mile may also be low, so the actual loading values may be under estimated, but the relative contributions remain the same. Suitable habitat for the hogs was based on suitable habitat within an average of 100 meters (m) of any water body.

The average daily E. coli productions for feral hogs that was used in the SELECT analysis was $1.1*10^{10}$ cfu/day *0.5 per hog (SELECT default value).

The SELECT results, population estimates, LULC classifications, and maps of the suitable habitat for feral hogs (Figure 5.11) is displayed on Page 39.

Figure 5.9: Feral Hogs



Population Estimates
27 / 1,000 acres.

Land Use Land Cover

Classification	% of Watershed Area
Deciduous Forest	5.30 %
Evergreen Forest	0.10 %
Mixed Forest	0.02 %
Suitable Habitat	5.42 %

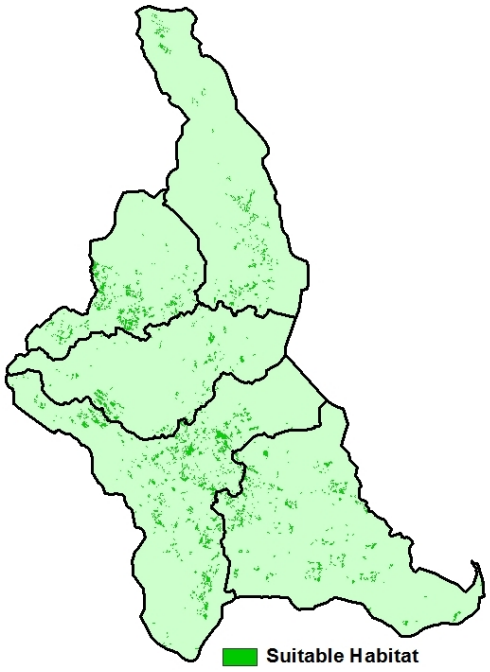
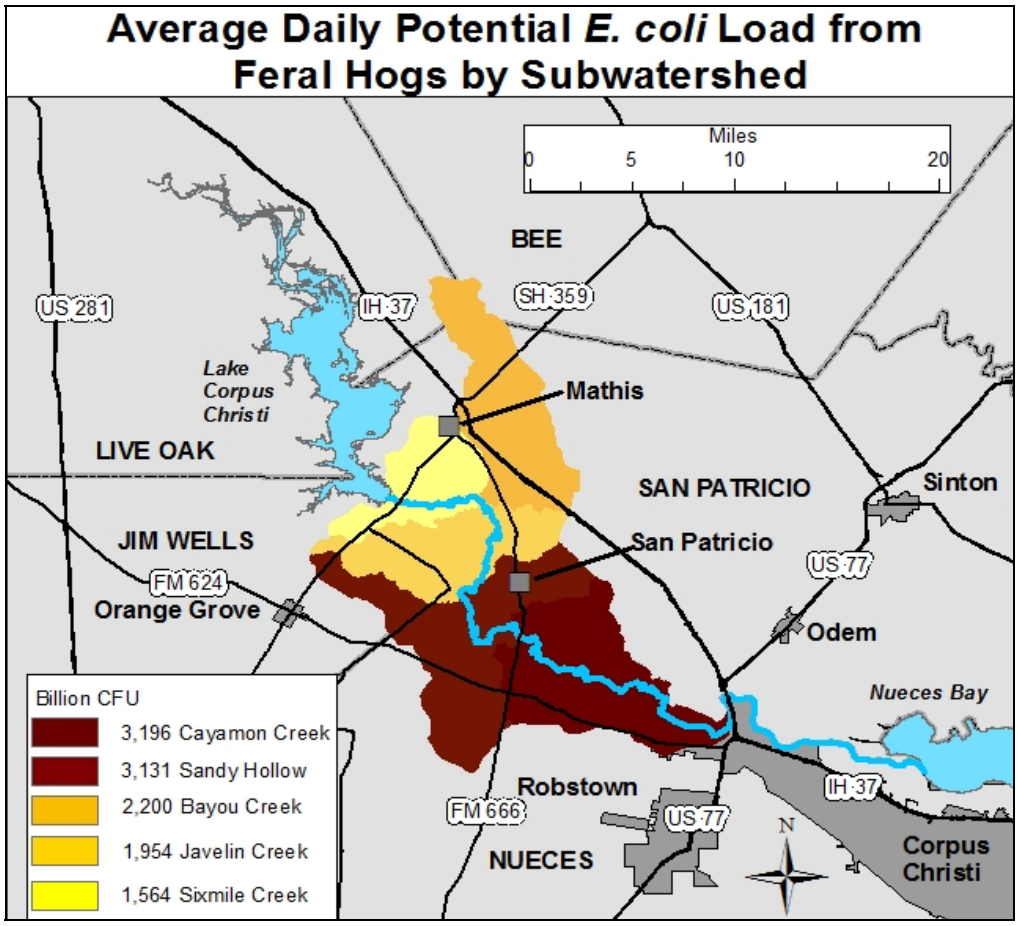


Figure 5.10: SELECT Analysis for Deer



Population Estimates

12 / square mile within 100 meter stream buffer.

Land Use Land Cover

Classification	% of Watershed Area	% Within 100m of Water Body
Developed, Open Space	4.80 %	0.68 %
Developed, Low Intensity	1.90 %	0.22 %
Barren Land	0.43 %	0.07 %
Deciduous Forest	5.30 %	1.32 %
Evergreen Forest	0.10 %	0.03 %
Mixed Forest	0.02 %	0.01 %
Shrub/Scrub	17.43 %	4.05 %
Herbaceous	3.81 %	0.48 %
Hay/Pasture	18.07 %	1.99 %
Cultivated Crops	38.16 %	2.05 %
Woody Wetlands	5.98 %	3.57 %
Suitable Habitat	98.45 %	14.47 %

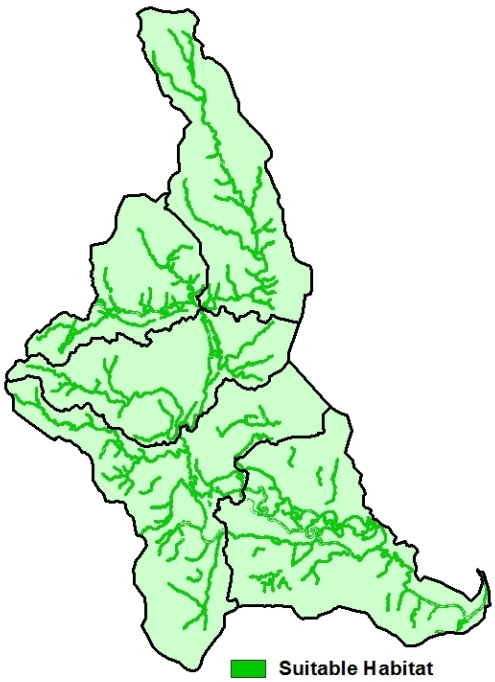


Figure 5.11: SELECT Analysis for Feral Hogs

PETS

The estimate of the dog population (Figure 5.12) was based on the American Veterinary Medical Association's estimate of 0.8 dogs per average household. The United States Census Bureau, State & County QuickFacts website, http://quickfacts.census.gov/qfd/states/48000.html, was used to estimate the number of households in the watershed. The following general equation was used for each county:

(((A - B) * C) + (D * E)) * 0.8 where

A = # housing units in the county
B = # housing units in cities in the county
C = % of the county within the watershed
D = # housing units in cities within the watershed
E = % areas of the cities within the watershed

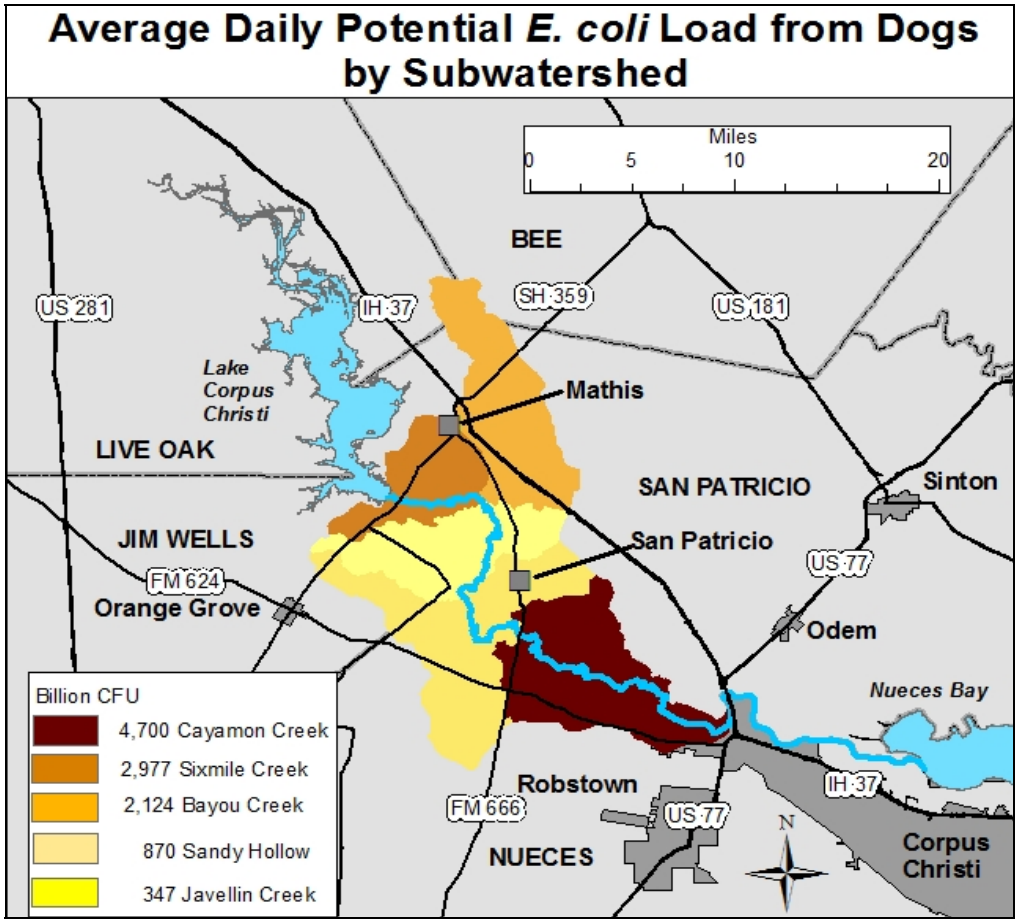
County	Bee	Jim Wells	Live Oak	Nueces	San Patricio
A	10,608	16,118	6,047	143,411	26,744
B	5,383 (Beeville)	7,313 (Alice)	0	125,469 (Corpus Christi) 4,067 (Robstown)	3,714 (Ingleside) 1,838 (Mathis) 5,907 (Portland) 2,125 (Sinton)
C	0.2	3.8	0.3	5.0	12.7
D * E	0	0	0	1,255 (1% of Corpus Christi)	1,525 (83% of Mathis)
# dogs	8	268	15	1,559	2,557

The average daily *E. coli* productions for dogs that was used in the SELECT analysis was $5*10^9$ cfu/day *0.5 (stakeholder accepted value).

While there are many dog owners who pick up after their dogs, there are many who do not. The waste and bacteria it contains are transported to streams not only during rainfall events, but also as a result of over-watering yards. Since the majority of other pet waste, such as from cats, hamsters, rabbits, and birds, are collected and disposed of in the trash, dogs were the only pets evaluated for this WPP. Raising chickens has become more popular recently and their contributions to bacteria loading may need to be investigated.

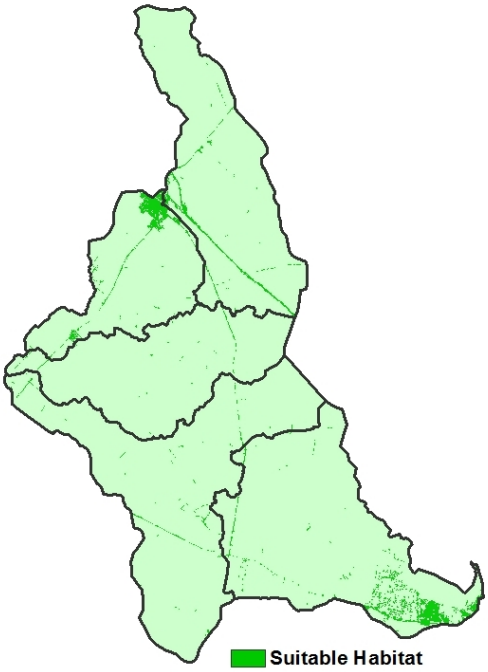
The SELECT results, population estimates, LULC classifications, and maps of the suitable habitat for dogs (Figure 5.13) are displayed on the next page.

Figure 5.12: Dog



Population Estimates (0.8 dogs per housing unit)

County	Housing Units in County	Estimated Housing Units in Watershed	Dogs in Watershed
Bee	10,608	10	8
Jim Wells	16,118	335	268
Live Oak	6,047	18	15
Nueces	143,411	1,948	1,559
San Patricio	26,744	3,197	2,557
Total			4,407



Land Use Land Cover

Classification	% of Watershed Area
Developed, Low Intensity	1.90 %
Developed, Medium Intensity	0.74 %
Developed, High Intensity	0.10 %
Suitable Habitat	2.74 %

Figure 5.13: SELECT Analysis for Dogs

SEPTIC SYSTEMS

The on-site sewage facility (OSSF) inventory that was compiled for this WPP identified 508 permitted OSSFs within the watershed at the time of the data collection. Records from the Jim Wells, Nueces, and San Patricio County health departments were reviewed for this inventory.

It is recognized that this is not a full inventory of all the OSSFs and that some of the systems have approximate latitude/longitude coordinates. Older OSSFs were in place before permits were required, the counties regularly receive requests for new permits, and some OSSFs have been removed since the data collection. An effort was made to assign coordinates to the OSSFs that did not have this information included in the permit. Coordinates using Google Earth® for an address were used, if found. Some addresses only returned a general location based on the city or road name. Therefore, there are multiple OSSFs with identical coordinates. The inventory, included with Figure 5.14, does show the areas where the systems are concentrated.

To estimate failing OSSFs within the watershed, it is assumed that the OSSFs installed since the inventory are working properly. While it is not probable that all 508 inventoried OSSFs are failing, the full inventory was used to account for undocumented OSSFs.

Table 5.1 shows the loading from possibly failing OSSFs based on distances from the river and its tributaries. For example, there are 8 OSSFs located within 100m of a stream in the Cayamon Creek subwatershed. The totals are cumulative, i.e., the 60 OSSFs located within 500m include the 8 within 100m. The approximate average daily *E. coli* bacteria production per failing OSSF used in the analysis was of $2.6*10^{11}$ cfu/day (stakeholder accepted value). This assumes 2 people per household, each using 70 gallons per day. Figure 5.14 shows the potential for *E.coli* loading from septic systems for those that are within 500m of the river and its tributaries.

Table 5.1. Estimate of bacteria loading from OSSFs (Load = 10^{13} cfu/day)

Distance within	Cayamon Creek		Sandy Hollow		Javelin Creek		Sixmile Creek		Bayou Creek		Total	
	#	Load	#	Load	#	Load	#	Load	#	Load	#	Load
100m	8	0.2	9	0.2	4	0.1	5	0.1	3	<0.1	**29**	**0.8**
500m	60	1.6	95	2.5	25	0.6	32	0.8	37	1.0	**249**	**6.6**
1,000m	83	2.2	114	3.0	49	1.3	66	1.7	128	3.4	**440**	**11.6**
1,500m	87	2.3	132	3.5	72	1.9	77	2.0	131	3.4	**499**	**13.1**
Total	**90**	**2.4**	**132**	**3.5**	**74**	**1.9**	**81**	**2.1**	**131**	**3.4**	**508**	**13.4**

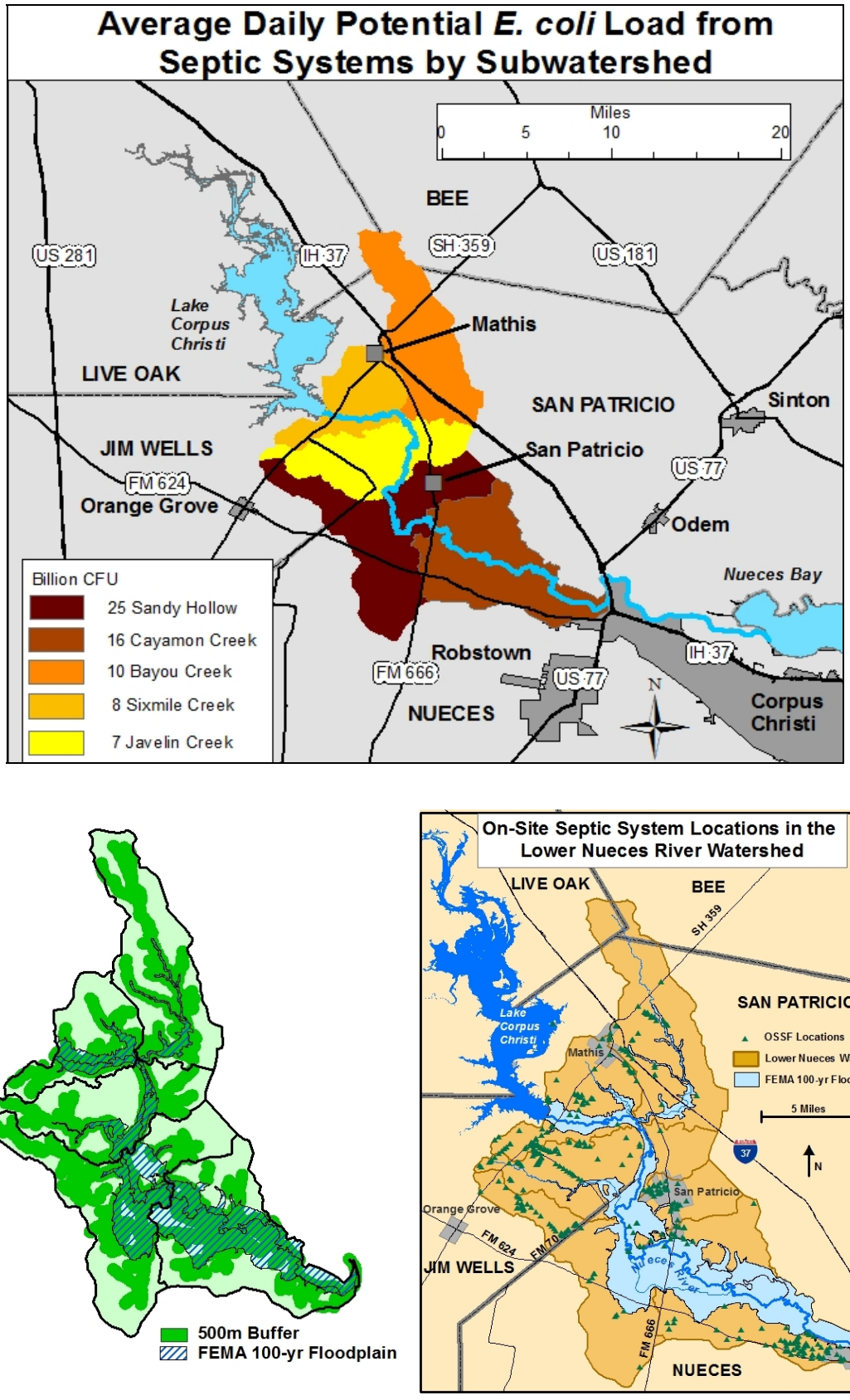


Figure 5.14: SELECT Analysis for Septic Systems

OIL AND GAS PRODUCTION

The RRC's Pubic Geographic Information System (GIS) Viewer http://wwwgisp.rrc.state.tx.us/GISViewer2/ shows numerous oil and gas well locations within the Lower Nueces River Watershed, many of which are active. When operated properly, oil and gas operations should not pose a threat to the enviroment. However, there is always the possiblity of hydrocarbon and saltwater releases from these operations. Improperly plugged and abandoned (P&A) wells are also possible sources of contamination. There are currenlty no known issues related to the oil and gas industry in this watershed. Accessibility in some areas is limited – Figure 5.15 is of an old cable bridge across the river that was used by gaugers to access wells on the north side (bottom of photo) of the river in the East Riverside Well Field.

Figure 5.15: Cable Bridge in East Riverside Well Field

ILLEGAL DUMPING

Unfortunately, illegal dumping is a problem nearly everywhere. While many purposely dump directly into a stream so that their trash is carried away, items dumped near the river ofter wind up in the river during floods. Not only does trash and debris from illegal dumping contribute to the problem, but landowners along the river can contribute to the issue. Some properties go underwater when Lake Corpus Christi fills and spills during flood events, the most recent being in May and June 2015.

Larger items that have been found in the river, such as refrigerators, car parts, old boats, etc, can be moved during high flow events and, depending on the water depth, wind up becoming boating hazards. Fluids may also leak from motors.

There have been a number of cleanup events in neighborhoods along the river before the trash and debris can end up in the river. The last event, in April 2013, removed over 130 tons / 1,000 cubic yards of trash and over 3,000 tires. A tractor-trailer, Figue 5.16, was completely filled with the tires. The Nueces River Preservation Association (NRPA) conducts annual on-the-river cleanups and the City of Corpus Christi will periodically conduct cleanup runs.

Figure 5.16: Tractor-trailer filled with tires during a cleanup.

6. Management Measures

Based on a thorough evaluation of water quality data and supporting information characterizing the watershed, the stakeholders identified management measures that will be necessary to reduce pollutants from entering the Lower Nueces River. LDC analysis of historical data provided the basis for determining needed load reductions, and SELECT analysis enabled identification of target locations within the watershed to most efficiently achieve reduction goals. Management measures are proposed primarily to address TDS concerns in the watershed, indirectly through implementation of agricultural BMPs, which will also result in reductions in bacteria and nutrient loading.

The management measures discussed in this chapter represents the stakeholders' recommendations and plans to reduce the major potential sources of loading within the watershed. Management measures were established under six general categories: agricultural nonpoint source, riparian habitat conservation, wastewater and urban, wildlife, feral hog, and cleanup.

AGRICULTURAL NONPOINT SOURCE MANAGEMENT MEASURES

Both the NRCS and TSSWCB offer agricultural producers technical assistance as well as financial assistance for "on-the-ground" implementation. To receive financial assistance from TSSWCB, the landowner must develop a Water Quality Management Plan (WQMP) with the local SWCD that is customized to fit the needs of their operation. The NRCS offers options for development and implementation of both individual practices and whole farm conservation plans.

According to TSSWCB records, there are 47 certified WQMPs in Nueces and San Patricio counties within the Lower Nueces River Watershed covering 14,581 acres of cropland, pastureland, and rangeland. Since 2012, there have been numerous other Conservation Plans, implemented through the NRCS, covering an additional 16,419 acres throughout the watershed. These existing plans include essential practices of specific applicability to the water quality goals of this WPP.

Areas of land immediately adjacent to the river that are not currently under any management plan includes the City of Corpus Christi and the smaller communities along the river in Nueces and San Patricio counties.

The Agricultural Work Group recommended that status reviews of the existing management plans be conducted as a management measure for agricultural nonpoint sources. The TSSWCB will conduct status reviews on approximately 5 plans per year.

Although the LDCs do not indicate a necessary reduction in bacteria or nutrient loading to achieve state standards, the SELECT analysis has identified the relative loading for these parameters from each subwatershed. The status reviews will ensure that potential contributions are being addressed by the WQMPs and other management plans.

Livestock and Cropland Operations

The average farm size is estimated to be 588 acres in Bee County[24], 546 acres in Jim Wells County[25], 622 acres in Live Oak County[26], 807 acres in Nueces County[27], and 601 acres in San Patricio County[28]. Animal population estimates for cattle, sheep, goats, and horses were derived from the 2012 Census of Agriculture – County Data. Animal units were then estimated using accepted animal unit conversions: 1.0 for cattle, 0.2 for sheep, 0.17 for goats, and 1.25 for horses. The estimated number of farms per county was estimated by dividing total crop and hay/pasture acreage by the average farm size. Based on the number of implemented WQMPs, past and present, additional WQMPs may be recommended. Table 6.1 provides a summary of the distribution by county by subwatershed of animal units and cropland acreage. The estimated number of farms, TSSWCB WQMPs, and additional recommended number of WQMPs, by county, are also included in the table. Figure 6.1 shows the overlay of the counties with respect to the subwatersheds.

Table 6.1. Summary of the distribution by county by subwatershed of animal units, cropland acreage, estimated number of farms, past and present WQMPs, and additional recommended number of WQMPs

County	Subwatershed	Animal Units	Cultivated Crop Acres	Est. Number of Farms	Current # of WQMPs	Recommended # of WQMPs
Bee	Bayou Creek	23	949	2	0	
Jim Wells	Sandy Hollow	180	1,657	24	0	1
	Javelin Creek	591	3,717			
	Six Mile Creek	200	585			
Live Oak	Bayou Creek	39	1,379	2	0	
Nueces	Cayamon Creek	600	3,338	47	26	1
	Sandy Hollow	655	6,840			
	Javelin Creek	61	579			
San Patricio	Cayamon Creek	380	3,018	56	21	1
	Sandy Hollow	401	3,423			
	Javelin Creek	259	2,306			
	Sixmile Creek	441	3,287			
	Bayou Creek	442	13,416			
Total		4,272	44,494	121	47	

[24] http://www.city-com/county/Bee_County-TX.html
[25] http://www.city-com/county/Jim_Wells_County-TX.html
[26] http://www.city-com/county/Live_Oak_County-TX.html
[27] http://www.city-com/county/Nueces_County-TX.html
[28] http://www.city-com/county/San_Patricio_County-TX.html

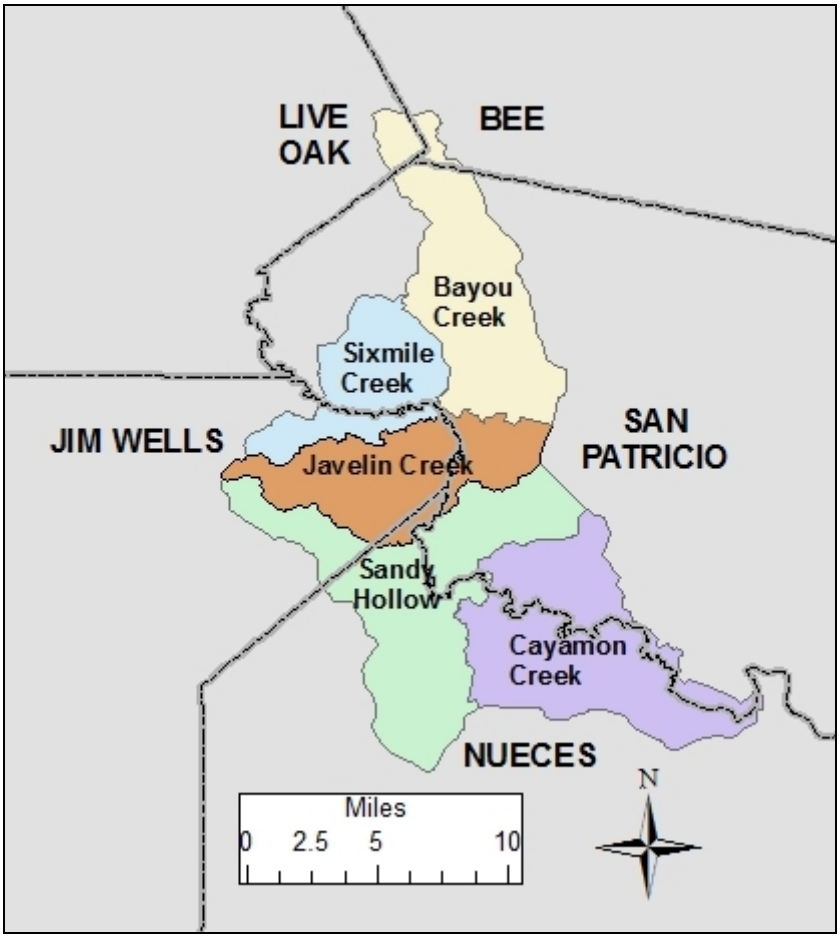


Figure 6.1: Location of Subwatersheds with respect to Counties

Financial incentives and technical assistance programs will be directed to the counties and subwatersheds with the greatest relative loading potential, the number of operations and those located closest to streams and drainage areas. However, recognizing that livestock numbers within individual subwatersheds vary due to weather conditions and market economics, programs provided in the watershed will require flexibility.

To optimize the water quality benefits of plan development and implementation, management practices which most effectively control bacteria and nutrient losses will be promoted and given top priority. Based on site-specific characteristics, plans should include one or more of the following management practices to reduce pollutant loads from agricultural lands:

- ***Residue Management***: Management of the residual material left on the soil surface of cropland, for the purpose of reducing nutrient and sediment loss through wind and water erosion.
- ***Critical Area Planting***: Establishes permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices.
- ***Filter Strips***: Establishes a strip or area of herbaceous vegetation between agricultural lands and environmentally sensitive areas to reduce pollutant loading in runoff.

- ***Nutrient Management***: Manages the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize agricultural nonpoint source pollution of surface and groundwater resources.
- ***Riparian Forest Buffers***: Establishes an area dominated by trees and shrubs located adjacent to and up-gradient from watercourses to reduce excess amounts of sediment, organic material, nutrients, and pesticides in surface runoff and excess nutrients and other chemicals in shallow groundwater flow.
- ***Terraces***: Used to reduce sheet and rill erosion, prevent gully development, reduce sediment pollution/loss, and retain runoff for moisture conservation.
- ***Grassed Waterways***: Natural or constructed channel-shaped or graded and established with suitable vegetation to protect and improve water quality.
- ***Prescribed Grazing***: Manages the controlled harvest of vegetation with grazing animals to improve or maintain the desired species composition and vigor of plant communities
- ***Riparian Herbaceous Buffers***: Establishes an area of grasses, grass-like plants, and forbs along watercourses to improve and protect water quality by reducing sediment and other pollutants in runoff, as well as nutrients and chemicals in shallow groundwater.
- ***Watering Facilities***: Places a device (tank, trough, or other water-tight container) that provides animal access to water and protects streams, ponds, and water supplies from contamination through alternative access to water.
- ***Field Borders***: Establishes a strip of permanent vegetation at the edge or around the perimeter of a field.
- ***Conservation Cover***: Establishes permanent vegetative cover to protect soil and water.
- ***Stream Crossings***: Creates a stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles, improving water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream.
- ***Alternative Shade***: Although not currently an approved financial incentive practice, creation of shade reduces time spent loafing in streams and riparian areas, thus reducing pollutant loading. Efforts will be made to include this practice as a component of livestock management plans.

RIPARIAN HABITAT CONSERVATION MANAGEMENT MEASURES

Healthy, well-functioning riparian zones play key roles in maintaining water quality and streamflow. Acquiring conservation easements through the purchase or donation of development rights along the Nueces River and tributary streams is one avenue for protecting riparian zones from development. Easements allow land owners to retain ownership of their land while agreeing to leave it in its natural state for perpetuity. *Conservation easements do not imply nor provide for public access to these lands.* Riparian lands can also be purchased fee-simple and managed for their protection by a conservation organization or public entity. Agencies and organizations that assist with acquiring conservation easements include the TPWD via the Texas Farm and Ranch Lands Conservation Program, the NRCS via the Farm and Ranch Lands Protection Program, the Texas Agricultural Land Trust (TALT), and the Texas Land Conservancy.

WASTEWATER AND URBAN MANAGEMENT MEASURES

These projects and BMPs address possible infrastructure related solutions to preventing contaminants from flowing into the river.

Municipal and Public Utility Districts / Wastewater Treatment Facilities

Municipal utility districts (MUD) are a special-purpose districts that provided public utilities (such as electricity, natural gas, water, wastewater) to district residents. Local residents may vote to establish a MUD, which is represented by a board of directors elected by constituents. As governmental bodies, they are usually nonprofit. Public utility districts (PUD) have similar functions, but are created by a local government body such as a city or county, and have no authority to levy taxes.

State regulations do not allow for multiple properties to share OSSFs. As a result, small lots could have inadequate room for a proper OSSF system, if there is one at all. Most, if not all, homes on property adjacent to the river rely on OSSFs. This includes properties within the city limits of Corpus Christi. Failure of these systems is inevitable when areas are inundated during floods. The creation of a localized wastewater treatment facility through a MUD or PUD would greatly reduce the amount of human bacteria that reaches the river.

Connections to the City of Corpus Christi Wastewater System

The homes on the river and businesses on FM 624 in the Calallen area of Corpus Christi are on septic systems. Existing wastewater lines run within a couple of blocks from some of these homes and businesses. The stakeholders are interested in proposing to the City of Corpus Christi that they consider connecting these areas to the existing infrastructure.

OSSF Repair and Replacement Program

An inventory of permitted OSSFs was created during the development of this WPP. This inventory represents a snapshot in time of the systems that are within the watershed. Chapter 5 includes a discussion on the details of the inventory and how it was used to estimate bacteria loading from failing systems.

The OSSF inventory was also used to develop a management plan for a voluntary inspection plan (Appendix F). Based on available funding sources, areas will be targeted to offer these inspections and provide financial assistance to eligible participants for repair or replacement of the OSSF if needed. Areas that will be targeted will be based on distance from the river or one of its tributaries, within the Federal Emergency Management Agency (FEMA) 100-yr floodplain, neighborhoods with small lots, age of the systems, and areas where no permits were recorded in known subdivisions.

Solid Waste Transfer Station

As discussed in Chapter 5, illegal dumping into rivers and streams and in floodplains is a source of unsightly trash and, depending on what has been dumped, a source of various contaminants. One reason that illegal dumping occurs is the lack of convenient locations for people to take their trash. Another reason is the time and expense of hauling trash and debris to a landfill and having to pay disposal fees. Having solid waste transfer stations in key locations would eliminate some of the illegal dumping. This strategy has been well received by the stakeholders when it has been discussed at the stakeholder meetings.

There is currently one such station within a reasonable distance of the Lower Nueces River Watershed. It is located in Jim Wells County just west of Orange Grove on FM 624. The Partnership will investigate the possibility of working with the City of Corpus Christi to provide a similar service in the area of the city within the watershed. Similar investigations will be directed toward county governments.

Municipal Separate Storm Sewer System Permit Program

Stormwater from urban areas is managed by the TCEQ Municipal Separate Storm Sewer System (MS4) Permit program. In areas with populations of greater than 100,000, a Phase I MS4 permit is required. The City of Corpus Christi falls under this category and does have its permit.

For smaller urbanized areas that do not meet those requirements, but have a residential population density of at least 1,000 per square mile and are immediately adjacent to an impaired waterbody, a Phase II MS4 permit is required. There are currently no cities within the watershed that meet this requirement. Cities operating under a Phase II permit are required to develop a stormwater management plan (SWMP) that includes at least the following six control measures:

- Public education and outreach;
- Public involvement;
- Detection and elimination of illicit discharges;
- Controls for stormwater runoff from construction sites;
- Post-construction stormwater management in areas of new development and redevelopment; and
- Pollution prevention and "good housekeeping" measures for municipal operations.

Although implementation of Phase II MS4 permits are not eligible for funding under the Federal Clean Water Act Section 319(h) NPS Grant Program, all the required measures will complement the efforts of the Lower Nueces River WPP and benefit water quality.

Storm Water Retention Ponds

Retention ponds can be an effective way to filter out contaminants from storm water and reduce erosion. This BMP has become an accepted component to many of the more recent developments, whether it's a commercial business with a large impervious parking lot or new subdivisions for aesthetics and flood control. There is also the potential for beneficial uses of these waters. Retention ponds could be implemented even if a MS4 permit is not required, and should be encouraged for all future developments.

WILDLIFE MANAGEMENT MEASURES

The Partnership recognized that all wildlife are potential contributors of bacteria to the watershed. Other non-domestic animals such as feral dogs and cats are contributors but their populations and locations can not be predicted or estimated because of insufficent data. Small native wildlife, such as racoons and birds are also contributors but again, their populations can not be predicted. The contribution from these sources is likely to be small and is considered background nonpoint source pollution. Stakeholders have also raised concerns about the whitetail deer population impacts on water quality. Several of these concerns have been addressed to varying degrees within the WPP. However, TPWD is responsible for hunting regulations and offers management advice through technical guidance programs so that landowners may make educated decisions on how to manage wildlife so that both habitat and wildlife species are held in a healthy state

The bacteria loading from deer in the watershed is relatively low compared to cattle, goats, and feral hogs (Figure 6.2). However the stakeholders have seen an increase in the deer population, primarily due to a decrease in hunting. Therefore, the number of deer per 1,000 acres used in the SELECT analysis may have been underestimated and the actual loading higher.

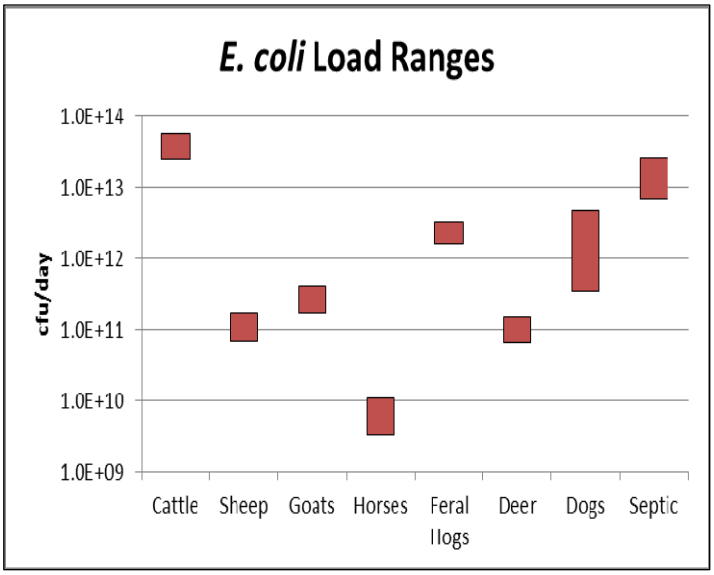


Figure 6.2: Relative ranges in loading by potential source

While historically, whitetail deer have not been managed for water quality concerns, there are a few management measures that could be implemented. Efforts will be made to raise landowner awareness about the Wildlife Management Plan (WMP) program and Managed Land Deer permits that are available through TPWD. Once a WMP is in place, the landowner has more flexible seasons and increased harvest opportunities.

FERAL HOG MANAGEMENT MEASURES

The Texas A&M AgriLife Extension's Coping with Feral Hogs website, http://feralhogs.tamu.edu/, is an excellent source of information on feral hogs. The site is designed to provide information to landowners and the general public on feral hog control, damage, diseases, and hunting.

Damage caused by feral hogs is a growing problem due to their destructive feeding habits, potential to spread disease, and their increasingly growing population. A common saying is that there are two kinds of properties in Texas – those that have a feral hog problem and those that will have a problem. Legal control methods include shooting, snaring, trapping, and capture via the use of dogs that are specially trained for that purpose. These methods have shown to be useful in significantly reducing the feral hog population. However, none of these techniques will guarantee total or permanent eradication of a hog population. Since feral hogs are not protected in Texas, they may be taken at any time on private

property. The only license requirement is a hunting license. It is also legal to hunt hogs from helicopters. There are a number of helicopter operators that offer their services to conduct these hunts.

Hunters have a positive impact on the local economy. Efforts will be made to develop a more efficient way of pairing hunters in need of a hunting lease with landowners that may want to better manage their deer populations but have no interest in personally hunting.

CLEANUP MANAGEMENT MEASURES

These projects and BMPs address the hyacinth management, large man-made debris removal, and general cleanups. Although these measures may not directly address the TDS impairment, they will contribute to the overall health of the river, improve aesthetics, and promote stewardship of the river.

Hyacinth Control

The need for the development of a hyacinth control management plan, (Appendix G), was based on documented hyacinth colonies completely covering parts of the river. The picture in Figure 6.3 was taken by a canoeist in March 2011. A similar blockage was encountered by some of the Nueces River Watershed Partnership members on a kayak tour of the river in May 2011.

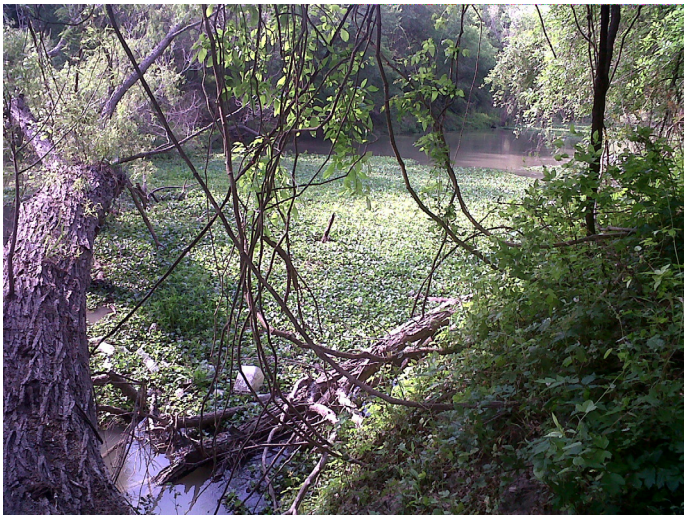


Figure 6.3: Hyacinth Colony March 2011

An aerial survey via helicopter was conducted in February 2015. The entire 39 miles were flown and GoPro® photographs taken every two seconds. During the February survey, there were no large colonies observed. It was estimated that only about 1% of the river surface had hyacinth on it, primarily along the banks and at woody debris impediments. A second survey was conducted in August 2015 after the flood waters receded. Smaller and fewer colonies where spotted on the second trip, most likely cleared out by the flood. An additional survey above Lake Corpus Christi to try and locate the source /upper extent of the hyacinth is planned for the summer of 2016.

Large Debris Removal

A large debris survey was conducted on April 16-17, 2014 by the Blackland Research Center (BRC) at Texas A&M University using a side-scan sonar. The roughly 12 miles that were covered resulted in 2,942 images of the river bottom. The images are available for viewing at https://www.nueces-ra.org/sonar/index.php. Instructions are included on the page. Due to the size of the images, twelve sets of files were created for viewing. The final report from BRC is available at https://nueces-ra.org/NRWP/pubs.php.

From those images, 375 objects were noted, 323 of which included woody debris, tires, and piers that are not considered harmful. 16 objects were considered high priority and noted for removal. The remaining

36 objects were considered medium priority objects that needed to be identified and possibly removed. NRPA volunteers have begun the investigation and marking of these objects. Appendix H contains the Large Debris Removal Plan based on the survey and follow-up investigation.

The CBBEP will provide funding to assist with the removal of items through a contract with the NRA. The removal of these items was originally planned to be completed by August 31, 2015, but flooding and reconstruction of the boat ramp at Hazel Bazemore has delayed it until later in the year.

Volunteer Cleanups

Previous cleanups along CR 73 and on-the-river cleanups are discussed in Chapter 5. These events have removed tons of trash and debris from adjacent lands and the river. Unfortunately, there is a continuing need for more cleanups. The NRPA plans to continue their annual volunteer on-the-river cleanup (from the saltwater barrier dam to just upstream of CR 73). Nueces County has been very supportive of these efforts and provides for the disposal of the trash and debris. Stakeholders that live on the upstream portion of the river are asking for assistance to coordinate cleanups of the river and adjacent lands from upstream near SH 359 to FM 666.

Plug and Abandon Oil and Gas Wells and Pipeline Inspections

The RRC has jurisdiction and oversight over oil and gas operations in the State of Texas. As mentioned in Chapter 5, there are a number of oil and gas wells and pipelines within the watershed. The Partnership will seek funding to contract with RRC to investigate the extent of improperly P&A'd wells, inspect oil and gas pipelines, and develop a plan to address any issues that are found. The RRC GIS database contains all wells and pipelines. When the original operators can be identified, the RRC pursues having them be responsible for any work that would need to be done. If the operators cannot be identified, the RRC does the work as funding becomes available. Similar to OSSFs, the project should target wells within 500m of the Lower Nueces River and its tributaries and / or within the FEMA 100-yr floodplain.

7. Education and Outreach

Education and outreach is a very important management measure. Each of the measures discussed in Chapter 9 will contain education and outreach components. An aggressive outreach and education program will be vital to successful engagement of watershed stakeholders and will require input and cooperation from all entities identified in Table 9.1.

Website, Newsletters, Fact Sheets

NRA will continue to host http://www.nuecesriverpartnership.org/, the Nueces River Watershed Partnership website, posting relative information as it becomes available. Bi-annual newsletters will be created and distributed to keep the stakeholders informed on the WPP implementation progress. Fact sheets will be created and distributed at local events and workshops as warranted.

Classroom Presentations

NRA provides education presentations for numerous schools of the Nueces River Basin and surrounding areas. Grants from groundwater conservation districts in 13 counties are used to see every 5th grader in those counties. In some cases the presentations are targeted to specific grade levels to reinforce the Texas Essential Knowledge and Skills curriculum. NRA uses the following tool in their presentations.

Nueces Basin Model – This model is used to demonstrate NPS pollution. The scaled model has the major roads, rivers, and water bodies labeled on it. During a presentation, the students locate the towns and other landmarks near them. The students then simulate pollutants such as too much fertilizer, leaking oil from cars, illegal dump sites, etc. using drops of food coloring. They then spray the model with water using spray bottles. This process enables them to visualize how pollution washes off the land in one area and transported via the rivers and stream downstream to Choke Canyon Reservoir, Lake Corpus Christi, and the Gulf of Mexico.

Rainfall Runoff Model – This model is used to demonstrate how ground cover affects water quality. There a are bins that represent impervious covers, such as parking lots, bare ground, soils with a poor plant growth/root system, and soils with a healthy plant growth/root system, Each bin has holes in the bottom for water to drain out. The presenter then pours water into a perforated trough above the bins to simulate rain. The participants are able to see the difference in the clarity of the water as it drains from each bin.

Aquifer Model – This model is used to demonstrate surface and groundwater interactions. The model consists of a "cross section" of land within a clear plexiglass frame. The cross section includes a river channel and water wells. The participants are able to see how groundwater travels and how it is affected to surface and water wells.

Rainwater Harvesting – This model is used to demonstrate how rain water can be captured from runoff from roofs. Different filtering/cleansing is needed depending on the intended use of this water, from watering gardens to being the water supply for a home.

Local Events

NRA demonstrates the education models at a variety of outreach events on a regular basis. Some of the local outreach events for which NRA intends to continue participating in are discussed below.

Earth Day Bay Day – CBBF sponsors this event every year around Earth Day. The goals of Earth Day Bay Day are:

- ***Education*** – Educate the public about our bays, estuaries, other native habitats, and the importance of clean air, clean water and a clean environment.
- ***Conservation***– Teach citizens to become environmentally proactive in their day-to-day lives. Demonstrate how easy and important it is to reduce, reuse, and recycle, as well as to compost and conserve energy, water and other resources.
- ***Habitat Protection*** – Encourage protection of native habitats, such as seagrasses, by promoting low-to no-impact outdoor activities such as kayaking, windsurfing, birding, fly-fishing, gardening and hiking.
- ***Participation***– Facilitate the active engagement of our visitors with local groups, such as the CBBF, the Audubon Outdoor Club, the Coastal Bend Audubon Society, the Master Naturalists and Master Gardeners, the local Farmer's Market, CBBEP, Sierra Club and Surfrider Foundation.

World of Water Day – The City of Corpus Christi Utilities Department sponsors this event every year in observance of Water Utilities Week. This free event features water-related science displays and experiments. Children and their families enjoy hands-on activities, win prizes, and see environmental displays and activities. Each year, the celebration helps raise awareness and appreciation for the dedicated City professionals who work in Water Supply and Distribution, Wastewater, and Storm Water.

Ag Fairs

NRA demonstrates the education models at a number of county ag fairs each year and intends to continue providing this outreach for the foreseeable future.

Workshops, Programs, and Campaigns

Numerous agencies provide educational workshops covering a variety of topics. Several of the workshops discussed below have been conducted during development of the WPP. NRA will work with the lead agency for each of these workshops to offer them to the stakeholders during implementation of the WPP.

Texas Watershed Steward – This program is implemented through a partnership between Texas A&M AgriLife Extension and the TSSWCB. The program provides science-based, watershed education to help citizens identify and take action to address local water quality impairments. Texas Watershed Stewards learn about the nature and function of watersheds, potential impairments, and strategies for watershed protection.

Remarkable Riparian – This program was initiated by NRA to provide information to Nueces River Basin landowners on the importance of riparian areas to the health and function of rivers. The goal of the program is to provide this information to landowners and other decision makers through mailings, workshops, and on-the-ground visits.

Riparian and Stream Ecosystem Education Program
The Riparian and Stream Ecosystem Education program is an educational training offered by Texas Water Resources Institute in cooperation with the TSSWCB and other partner agencies and organizations. The training focuses on water quality issues including the key role riparian areas play in helping improve and protect water quality in the area. Topics covered include: the definition of a watershed and riparian area, riparian vegetation ratings, how to photo monitor, and local resources for landowners.

Texas Well Owner Network (TWON) and OSSF Maintenance – The TWON program is an educational training offered by Texas A&M AgriLife Extension in cooperation with the TSSWCB and other partner agencies and organizations. The TWON program is for Texas residents who depend on household wells for their drinking water needs and want to become familiar with Texas' groundwater sources, water quality, water treatment, and well maintenance issues. OSSF maintenance is a one-hour component of the workshop, or can be offered separately as a two-hour workshop.

Lone Star Healthy Streams – This program is implemented through a partnership between Texas A&M AgriLife Extension and the TSSWCB. Its goal is the protection of Texas waterways from bacterial contamination originating from livestock operations and feral hogs that may pose a serious health risk to Texas citizens. To achieve this important goal, the program's objective is the education of Texas farmers, ranchers, and landowners about proper grazing, feral hog management, and riparian area protection to reduce the levels of bacterial contamination in streams and rivers.

Wildlife Management –Texas A&M AgriLife Extension provides a wealth of information on wildlife management at http://wildlife.tamu.edu/wildlifemanagement/. Stakeholders will be directed to the website for guidance on wildlife management. NRA will work with Texas A&M AgriLife Extension to develop a presentation for the Nueces River Watershed Partnership, focusing on the Lower Nueces River.

Feral Hog Management – Texas A&M AgriLife Extension has created the http://feralhogs.tamu.edu/ website to provide information to landowners and the general public on feral hog control, damage, diseases, and hunting tips. They also developed a Feral Hog Manual for the Lone Star Healthy Streams program which can be provided to stakeholders. NRA will work with Texas A&M AgriLife Extension to develop a presentation for the Nueces River Watershed Partnership, focusing on the Lower Nueces River.

Household Hazardous Waste Collection Days – City of Corpus Christi
The City of Corpus Christi offers free disposal of household hazardous waste to Corpus Christi residents at the J.C. Elliott Collection Center, Monday through Saturday, from 8:00 a.m. to 5:00 p.m.

Household Hazardous Waste Collection Days – TCEQ
The TCEQ offers assistance to provide for a one-time or recurring collection of household hazardous waste at a designated site with waste stored for less than 48 hours. These are typically mobile events since they involve transporting aggregated household hazardous waste directly to a permanent collection center, another collection event, or a hazardous waste facility. The Nueces River Watershed Partnership will work with the TCEQ to provide periodic household hazardous waste collection days in the unincorporated areas of the watershed.

Soil and Water Testing Campaign – Texas A&M AgriLife Extension

Texas A&M AgriLife Extension, through their County Extension Agents, offers soil and water testing to encourage proper nutrient management in both agricultural and urban areas. The Nueces River Watershed Partnership will work with the extension agent to provide periodic free and/or reduced-rate testing opportunities.

Anti-Littering Campaign

NRA has developed the very successful Up2U anti-littering campaign. With guidance from local partners, NRA designed and launched the initial components of the Up2U Clean Rivers and Beaches campaign to swimmers, kayakers, and tubers on the rivers of the Upper Nueces Basin in 2004. The campaign was re-designed for delivery in the coastal market in 2009. The campaign, which advocates personal responsibility for environmental protection, especially litter prevention, has reached over 120,000 people since its inception. The cornerstone of the campaign is a logo emblazoned mesh litter bag which is both a litter prevention tool and an advertising tool. With sponsorship from more than ten organizations, these bags are now being distributed to beach goers, boaters, students and litter prevention advocates from the Nueces headwaters to the coast.

Volunteer Monitoring – The Center for Coastal Studies at TAMUCC, NRA, and CBBF partnered with the Texas Stream Team at The Meadows Center for Water and the Environment to develop a Regional Texas Stream Team volunteer monitoring group for the Coastal Bend Area. Portions of the Lower Nueces River that could benefit from volunteer monitoring will be evaluated and a volunteer monitoring program implemented if feasible.

Signage and Displays

An efficient way to reach as many people as possible is to place signs and displays in areas that are likely to be seen. This includes signs along roads displays in parks and public buildings.

Roadway Signage

Warning signs (Figure 7.1) have been effective deterrents to illegal dumping at the sites where they have been deployed, especially if there is a chance that the perpetrators could be identified on camera. Signs can also provide useful information to the public regarding to whom illegal dumping should be reported. The Nueces River Watershed Partnership will work to identify locations, acquire permissions, and determine the appropriate signage for each location. The possibilities range from the "Don't Mess With Texas Waters" campaign signs to providing "No Dumping" signs to private landowners.

Figure 7.1: Warning Signs

Interpretive Centers / Kiosks

In January 2012, two interactive kiosks (Figure 7.2) were placed in the Nueces County Courthouse and the Corpus Christi Museum of Science and History. The display includes maps, videos, and a Google Earth® flyover of the Lower Nueces River. The goal for displaying these kiosks is to bring awareness of where we get our drinking water and how everyone plays a role in protecting that water.

The educational kiosks were developed by the Guadalupe-Blanco River Authority for NRA and the Lower Nueces River Watershed Partnership through a TSSWCB grant. The kiosks are updated with current information when applicable.

Figure 7.2: Kiosk

8. Measures of Success

ADAPTIVE MANAGEMENT

Due to the dynamic nature of watersheds and the countless variables governing landscape processes across scales of time and space, some uncertainty is to be expected when a WPP is developed and implemented. As the recommended management measures of the Lower Nueces River WPP are put into action, it will be necessary to track the water quality response over time and make any needed adjustments to the implementation strategy.

Adaptive management is the ongoing process of accumulating knowledge of the cause of an impairment as implementation efforts progress, which may result in the need to reassess modeled loads. As implementation activities are instituted, water quality is tracked to assess impacts and guide adjustments, if necessary, to future implementation activities. This on-going, cyclic implementation and evaluation process serves to focus project efforts and optimize impacts. Watersheds in which the impairment is dominated by nonpoint source pollutants, such as the Lower Nueces River, are good candidates for adaptive management.

Adaptive management relies on constant input of watershed information and the establishment of intermediate and final water quality targets. Pollutant concentration targets for the Lower Nueces River were developed for each assessment period, based on a consistent reduction, until the assessed values reach these targets (Table 8.1). In the table, the values listed for the '2014 Assessment' row are as reported in the 2014 Draft Integrated Report. The data for the 2016 Assessment, collected between December 1, 2007 and November 30, 2014, were used for the '2016 Estimate' values.

Table 8.1: Target Reductions

Year	TDS Average mg/l (Std = 500mg/l)	Chlorophyll-*a* % of values exceeding the 14.1 µg/l criteria (AU_01 and AU_02)	E. coli Geomean (AU_01) (Std = 126 cfu/100ml)
2014 Assessment Results	621	41	116
2016 Estimate	589	28	114
2018 Goal	584	34	120
2020 Goal	564	34	116
2022 Goal	504	34	112
2024 Goal	494	27	108
2026 Goal	453	25	104

While some of the less complex management measures recommended here will be relatively simple to implement early in the process, implementation of other measures will require more time, energy, and funding. For this reason, reductions in pollutant loads and associated concentrations initially may be gradual. However, it can be assumed that reductions in the loadings will be tied to the implementation of management measures throughout the watershed. Thus, these projected pollutant targets will serve as

benchmarks of progress, indicating the need to maintain or adjust planned activities. While water quality conditions likely will change and may not precisely follow the projections indicated here, these estimates serve as a tool to facilitate stakeholder evaluation and decision-making based on adaptive management.

MONITORING AND WATER QUALITY CRITERIA

The ultimate measure of success will be to lower TDS, chlorophyll-a, and bacteria numbers with each subsequent Texas Integrated Report.

NRA conducts quarterly water quality monitoring at three sites along the river: at SH 359, FM 666, and Hazel Bazemore Park. The water samples are analyzed for a number of parameters, including TDS, chlorophyll-*a*, and *E. coli*. The USGS flow station at FM 666 also records specific conductance (SC) which can be used to estimate TDS (SC * 0.65 = TDS). In addition, the Conrad Blucher Institute for Surveying and Science (CBI) at TAMUCC maintains three real-time monitoring stations for the City of Corpus Christi. Two are in the river: located at San Patricio Estates, approximately 3 miles upstream of FM 666, and at the O. N. Stevens WTP intake; and one is in Lake Corpus Christi at Wesley Seale Dam. They record a number of parameters, including SC and turbidity. The CBI stations were established in November 2012. Figure 8.1 shows the location of the monitoring sites.

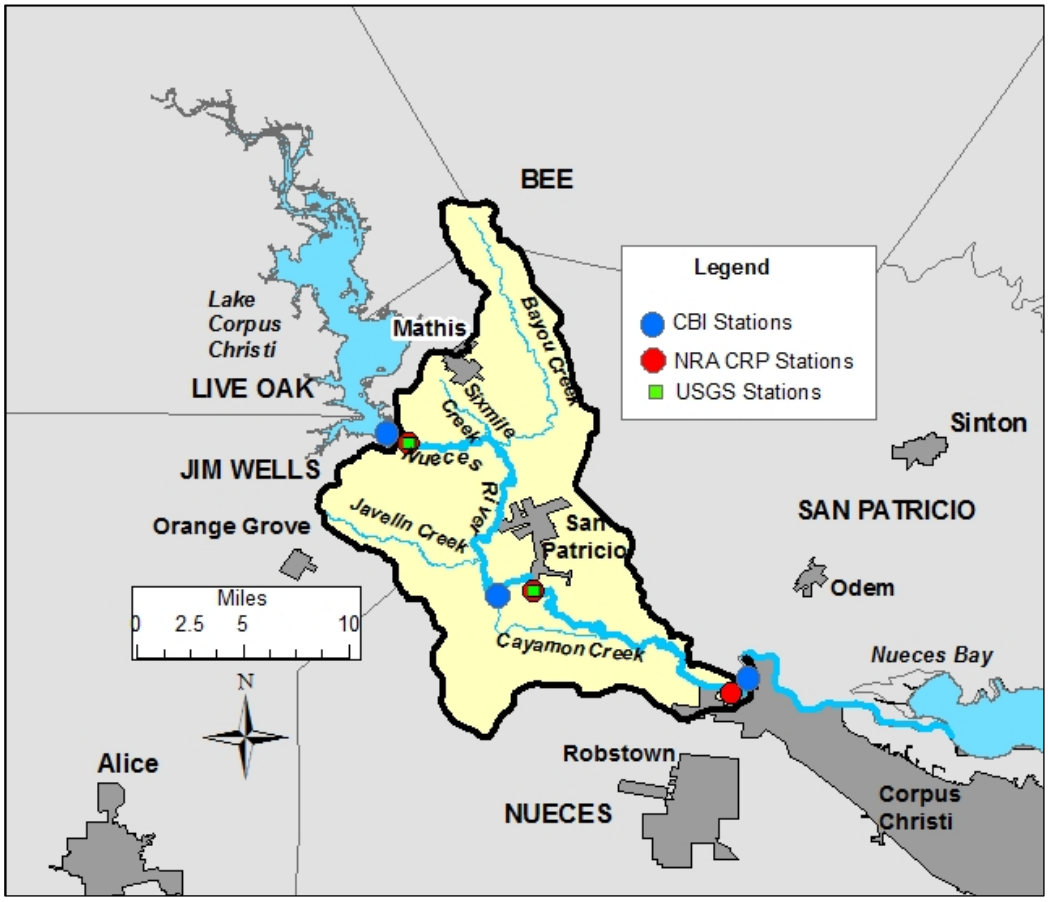


Figure 8.1: Monitoring Locations

The data will be routinely analyzed to track TDS, chlorophyll-*a*, and *E. coli* levels. Graphs of the sampling data and flow, TDS averages, and *E. coli* geomeans will be plotted. In addition, the plots will show when specific management measures were implemented and when significant events happen, such as the July 2002 and May - June 2015 floods. This area is prone to severe flooding when Lake Corpus Christi is full and is unable to hold additional flood waters. Figures 8.2. 8.3, and 8.4 show the extreme flooding that can happen in this area. When this happens, most of the communities along the river that rely on OSSFs are completely inundated. These flood events compound any water quality issues that exist.

Figure 8.2: October 15, 2013, at 7.16' and 64 cfs

Figure 8.3: May 21, 2015, at 28.71' and 6,900 cfs

Figure 8.4: CR 73 under water during July 2002 flood.

IMPLEMENTATION DOCUMENTATION

The documentation of the implementation and success of the management measures described in Chapter 6 and discussed below will be reported on the project website.

Agricultural Nonpoint Source Management Measures

- The number of additional WQMPs and their associated acreage will be documented.
- The number of status reviews per year.

Reduction in TDS, chlorophyll-a, and bacteria numbers will indicate success of these measures.

Riparian Habitat Conservation Management Measures

- The number of acres converted to conservation easements will be documented.
- The number of properties purchased by the City of Corpus Christi and San Patricio County will reported along with a summary of the number of building and septic systems removed.

Prevention of additional TDS, chlorophyll-a, and bacteria loadings will indicate success of these measures.

Wastewater And Urban Management Measures

- The feasibility of the creation of a MUD or PUD will be investigated and documented. If so, the number of OSSFs that are removed will be documented.
- The feasibility of the City of Corpus Christi providing connections to existing wastewater lines will be investigated and documented. If so, the number of OSSFs that are removed will be documented.
- The volunteer inspection offers, distribution list, and the number of participants, along with the number of OSSFs that are repaired and replaced will be documented.
- The feasibility of the creation of solid waste transfer stations will be investigated and documented. If so, the amount of trash and debris received at the location(s), as provided by the managing entity, will be documented.
- If and when the City of Mathis is required to have a Phase MS4 permit will be documented.
- The creation of any storm water retention ponds will be documented.

Reduction in TDS and bacteria numbers will indicate success of these measures.

Wildlife Management Measures

- Outreach and education workshops about wildlife management will be documented.
- Property owner's adoption of practices to manage wildlife populations, if provided, will be documented.

Reduction in bacteria numbers will indicate success of these measures.

Feral Hog Management Measures

- Outreach and education workshops about feral hog management will be documented.
- Property owner's adoption of practices to manage feral hog populations, if provided, will be documented.

Reduction in bacteria numbers will indicate success of these measures.

Cleanup Management Measures

- Implementation of the hyacinth management plan will be documented.
- The items removed as a result to the large debris survey will be documented.
- Volunteer cleanups, including the number of volunteers and amount of debris removed will be documented.
- The feasibility of contracting with the RRC to investigate the need to P&A any of the oil and gas wells and inspect oil and gas pipelines in the watershed will be investigated and documented. If so, the number and location of wells that are P&A'd and the number of pipelines inspected will be documented.

Reduction in TDS and chlorophyll-*a* numbers will indicate success of these measures.

Education and Outreach

Although education and outreach is not technically a management measure, providing these events to promote ownership and change habits can help water quality in the watershed. In that respect, the education and outreach opportunities described in Chapter 7 will be widely promoted and event-specific documentation will be recorded.

9. Implementation

This chapter outlines needed technical assistance, a schedule for implementation of the recommended management measures, an estimate of the associated costs, potential sources of funding, and an estimate of load reductions expected as a result of program implementation. Some management measures identified are part of ongoing budgeted operations of counties and municipalities. All management measures identified in the Lower Nueces River WPP are voluntary. The schedule for implementation is based on a combination of factors, such as available resources, financial ability, and political will.

TECHNICAL ASSISTANCE

Successful implementation of the Lower Nueces River WPP relies on active engagement of local stakeholders, but also will require support and assistance from a variety of other sources. The technical expertise, equipment, and manpower required for many management measures are beyond the capacity of the local stakeholders alone. As a result, direct support from one or a combination of several entities will be essential to achieve water quality goals in the watershed. Focused and continued implementation of key restoration measures will require the creation of at least one full-time equivalent position in the watershed to coordinate and provide technical assistance to stakeholders.

AGRICULTURAL NONPOINT SOURCE MANAGEMENT MEASURES

Technical support from the Jim Wells, Nueces, and San Patricio SWCDs and USDA-NRCS personnel is critical to promoting management measures on individual agricultural properties. As discussed in Chapter 6, due to the extent of existing WQMPs, the main focus of agricultural measures will be status reviews of existing plans. These reviews may result in plan modification that would further reduce contributions to loadings. The one plan per implementation period noted in Table 9.1 includes these possible modifications.

South Texas Land and Water Initiative (STLWI)

NRA submitted the STLWI to the NRCS for, and received a State Resource Concern designation for portions of the Nueces River and Nueces – Rio Grande Coastal basins – the gray areas in Figure 9.1. The Lower Nueces River Watershed is included within the area. A Partnership Agreement between NRCS and NRA has been developed for complementary and compatible activities related to providing financial and technical assistance to farmers and ranchers through provisions of the Environmental Quality Incentives Program (EQIP). Activities will include efforts to encourage conservation of natural resources through technical and financial assistance which may be provided by both NRCS and NRA. The project proposal was developed with input from SWCDs, TALT, Texas A&M Institute for Renewable Natural Resources, and CBBEP. The Partnership Agreement will remain in effect through March 2019. The project includes education and outreach activities and may include water quality monitoring components. The monitoring would complement and be conducted under the current CRP monitoring program.

Figure 9.1: South Texas Land and Water Initiative Location Map

RIPARIAN HABITAT CONSERVATION MANAGEMENT MEASURES

The acquisition of conservation easements and/or purchase of development rights could play a critical role in preserving the existing riparian areas. For all but a few areas along the river, the riparian corridor is in good shape, and maintaining it now through easement incentives and education would be much more efficient than trying to reestablish it in the future.

San Patricio County has been acquiring properties that are prone to flooding and currently own approximately 2,300 acres (9 miles of riverfront). These properties will never be developed as they are held in perpetuity by a land trust. The City of Corpus Christi, in partnership with Nueces County and CBBEP, are acquiring abandoned properties along the river that have gone to auction for back taxes. In both cases, structures are removed and the properties will be left in a natural state. In addition, the Ed Rachal Foundation has acquired approximately 6 miles of riverfront property in San Patricio County. The

City of Corpus Christi, working with NRA and TALT, is considering conservation easements as an option for protecting its water source.

WASTEWATER AND URBAN MANAGEMENT MEASURES

Managing OSSFs is the dominant wastewater management measure for the Lower Nueces River watershed. The implementation of a volunteer inspection and repair/replacement program will require assistance from licensed installers and/or county inspectors. The initial focus will be in areas within the FEMA 100-yr floodplain and/or within 500 m of the river or its tributaries.

Although OSSFs are the only viable wastewater alternative for the majority of the watershed, the feasibility of creating MUDs for small subdivisions adjacent to the river, such as along CR 73 in Nueces County, Sandy Hollow in Jim Wells County, and San Patricio in San Patricio County, needs to be evaluated. This evaluation would include the legalities involved for each county to implement this measure. Additionally, the feasibility of connecting homes in the Calallen area of Corpus Christi to the City's existing wastewater infrastructure will be investigated. The TWDB's State Revolving Fund (SRF) or Texas Capital Fund Community Development Block Grants could provide for financial assistance for these types of projects, but cost share expenses for the affected homeowners are probable.

Illegal dumping is a problem everywhere, and items often end up in the river. One of the main reasons for this is the lack of convenient locations for people to take their trash and debris. Contributing factors include the expense of driving long distances, disposal fees, and hours of operations. Local solid waste transfer stations could reduce a large amount of illegal dumping. The cooperation of the City of Mathis, City of Corpus Christi, and the counties will be crucial for implementation and management of such stations.

Pet waste collection stations could be implemented in public access locations with the watershed and/or adjacent to the river. These locations include Hazel Bazemore Park, San Patricio County La Fruta Park, Lake Corpus Christi State Park (a portion of which is within the watershed), and the Wilderness Lakes RV Resort just upstream of SH 359.

WILDLIFE MANAGEMENT MEASURES

Education programs for wildlife management are coordinated through Texas A&M AgriLife Extension. Wildlife assessments may be utilized to better define the extent and distribution of the problem and to direct control efforts.

FERAL HOG MANAGEMENT MEASURES

Education programs for feral hog control are coordinated through Texas A&M AgriLife Extension. Feral hog surveys may be utilized to better define the extent and distribution of the problem and to direct control efforts.

CLEANUP MANAGEMENT MEASURES

If the hyacinth control is determined to be beneficial to the health of the river and/or affects the City of Corpus Christi's water supply operations on the river, a physical removal and/or herbicide application program will be developed. Long term control will require identifying and targeting the upstream source.

Cooperation with the City of Corpus Christi and the TCEQ will be necessary to ensure proper and safe administration of herbicides.

Removal of the large debris targeted by the side-scan sonar survey and identified by the NRPA as items that need to be removed will be funded by the CBBEP. The volunteer cleanups will continue with the local support of the local governments and the Nueces River Watershed Partnership.

The RRC will be consulted on a potential survey of oil and gas wells and pipelines and whether or not a P&A strategy needs to be developed for the Lower Nueces River Watershed.

SCHEDULE, MILESTONES, AND ESTIMATED COSTS

The implementation schedule, milestones, and estimated costs of implementation are presented in Table 9.1. A 10-year project timeline has been constructed for implementation of the Lower Nueces River WPP. Increments of years 1-3, 4-6, and 7-10 post-approval and implementation of the plan have been defined. In addition, estimated quantitative targets have been established for most management measures. This allows key milestones to be tracked over time so that stakeholders can effectively gauge implementation progress and success. In the event that insufficient progress is being made toward achievement of a particular milestone, efforts will be intensified or adjusted as necessary. In addition, changes in water quality often are delayed following initial implementation of management measures, and substantive changes generally require several years to be discernible.

Table 9.1: Management measures jurisdiction, implementation milestones, and estimated financial cost

Management Measure	Jurisdiction	Unit Cost	Number Implemented			Total Cost
			Year			
			1-3	4-6	7-10	
Agricultural Nonpoint Source Management Measures						
WQMPs	SWCD/ TSSWCB	$15,000/plan	1	1	1	$45,000
WQMP Status Review	SWCD/ TSSWCB	$350/review	15	15	20	$17,500
Riparian Habitat Conservation Management Measures						
Purchase of Properties	City of Corpus Christi and Counties	$1,000/ property	5	5	5	$15,000
Acquisition of Conservation Easements	City of Corpus Christi/NRA/ TALT	$1,000/acre	970 acres*			$970,000
Wastewater And Urban Management Measures						
Municipal Utility Districts / Wastewater Treatment Facilities	Local Residents	TBD**			1	TBD
Public Utility Districts / Wastewater Treatment Facilities	Cities of Corpus Christi, Mathis, and San Patricio and Counties					
Connections to the City of Corpus Christi Wastewater System	Local Residents/ Businesses and the City of Corpus Christi	$72,935/ Connection		20		$1,458,700
OSSF Repair	TCEQ and Homeowners	$5,000/system	10	10	10	$150,000
OSSF Replacement	TCEQ and Homeowners	$10,000/system	10	10	10	$300,000
Solid Waste Transfer Stations	Cities of Corpus Christi, Mathis, and San Patricio and Counties	$50,000/year/ station		2		$700,000

* Assumes 200 foot easements along 20 miles, approximately half, of the Lower Nueces River segment.
** To Be Determined

Table 9.1: Management measures jurisdiction, implementation milestones, and estimated financial cost (continued)

Management Measure	Jurisdiction	Unit Cost	Number Implemented			Total Cost
			Year			
			1-3	4-6	7-10	
Wastewater And Urban Management Measures (continued)						
Storm Water Retention Ponds	Developers	TBD				TBD
Pet Waste Collection Stations	TPWD, TCEQ, and Counties	$620/station + $85 annual/station	5			$7,350
Wildlife Management Measures						
Workshops	Texas A&M AgriLife Extension	$1,000/ workshop	3	3	4	$10,000
Feral Hog Management Measures						
Workshops	Texas A&M AgriLife Extension	$1,000/ workshop	3	3	4	$10,000
Cleanup Management Measures						
Hyacinth Control	City of Corpus Christi	TBD				TBD
Large Debris Removal	NRA, CBBEP, and NRPA	$30,000	1			$30,000
Volunteer Cleanups	NRPA	$3,000/cleanup	3	3	4	$30,000
Oil and Gas Well P&A	RRC and TCEQ	TBD				TBD

Education and outreach will be an integral part to the implementation of any management measure. These strategies, discussed in detail in Chapter 7, will be implemented as opportunities arise and funding is available. Therefore, specific unit costs and implementation numbers are difficult to estimate, but can be documented when they occur. NRA intends to play a key role in this implementation. Most of their environmental related contracts contain education and outreach components which are paid for by the contract. NRA also has contracts with a number of groundwater conservation districts to provide non-point source pollution education to schools in their districts. Grant funds are applied for to provide delivery of targeted outreach, such as the Remarkable Riparian. In addition, most of the agencies identified in the Sources of Funding section, below, have their own goals and objectives for implementing their programs.

PROGRAM COORDINATION

In addition to technical and financial assistance required for implementation of management measures and outreach programs, it is recommended that funding is continued for the NRA to facilitate continued progress. The NRA will oversee project activities, seek additional funding, organize and coordinate regular updates for the Partnership, maintain the website, and coordinate outreach and education efforts in the watershed. An estimated $100,000 per year, for all expense categories, will be required for program coordination.

SOURCES OF FUNDING

Successful acquisition of funding to support implementation of management measures will be critical for the success of the Lower Nueces River WPP. Most of the management measures identified in the WPP will require significant funding for both initial and sustained implementation. Discussions with the Steering Committee and Work Groups, city officials, agency representatives, and other professionals will continue to refine estimated financial needs. Traditional funding sources will be utilized where available, and creative new approaches to funding will be sought. Some of the key potential funding sources that will be explored are discussed below.

TEXAS COMMISSION ON ENVIRONMENT QUALITY PROGRAMS

Section 319(h) Federal Clean Water Act

The USEPA provides funding to states to support projects and activities that meet federal requirements of reducing and eliminating nonpoint source pollution. In Texas, both the TSSWCB and the TCEQ receive section 319(h) funds to support nonpoint source projects, with TSSWCB funds going to agricultural and silvicultural issues and TCEQ funds going to urban and other non-agricultural issues.

Texas Clean Rivers Program (CRP)

The CRP is a statewide water quality monitoring, assessment, and public outreach program funded by state fees. The TCEQ partners with 15 regional river authorities to work toward achieving the goal of improving water quality in river basins across the state. CRP funds are used to promote watershed planning and provide quality-assured water quality data. The Partnership will continue to engage this source to support and enhance surface water quality monitoring in the watershed. NRA conducts water quality sampling for the Lower Nueces River watershed.

TEXAS DEPARTMENT OF AGRICULTURE PROGRAMS

Feral Hog Abatement Grant Program

TDA provides funding for practical, effective projects aimed at controlling the feral hog population across the state. The Feral Hog Abatement Grant Program is a one-year grant program focused on implementing a long-term statewide feral hog abatement strategy. Currently Texas A&M AgriLife Extension Service - Wildlife Services and the Texas Parks and Wildlife Department receive funding under this grant program.

Texas Capital Fund

As part of the Community Development Block Grant, this program provides more than $10 million in competitive awards each year to small Texas cities and counties. The Texas Capital Fund provides funding for infrastructure projects that include water and sewer lines, and drainage improvements.

TEXAS PARKS AND WILDLIFE DEPARTMENT PROGRAMS

Boating Access Grant Program

The Boatting Access Grant Program provide 75% matching fund grant assistance to construct new, or renovate existing, public boat ramps that provide public access to public water for recreational boating. The program includes dredging, stump removal, and aquatic weed control when activity can be shown to clear lanes to make a water body more accessible for recreational motorboats.

Landowner Incentive Program

The TPWD Landowner Incentive Program (LIP) is designed to meet the needs of private landowners wishing to enact good conservation practices on their land. As a program, LIP efforts are focused on projects aimed at creating, restoring, protecting, and enhancing habitat for rare or at-risk-species throughout the State. The proposed conservation practices must contribute to the enhancement of at least one rare or at-risk species or its habitat as identified by the Texas State Wildlife Action Plan or the LIP Priority Plant Species List.

Outdoor Recreation Grants

This program provides 50% matching grant funds to municipalities, counties, municipal utility districts (MUD) and other local units of government with a population less than 500,000 to acquire and develop parkland or to renovate existing public recreation areas. There will be two funding cycles per year with a maximum award of $500,000. Eligible sponsors include cities, counties, MUDs, river authorities, and other special districts.

Texas Farm & Ranch Lands Conservation Program

Established by Senate Bill 1273 in 2005. Provides grants to landowners for the sale of conservation easements that create a voluntary free-market alternative to selling land for development, which stems the fragmentation or loss of agricultural lands.

TEXAS STATE SOIL AND WATER CONSERVATION BOARD PROGRAMS

Section 319(h) Federal Clean Water Act

The USEPA provides funding to states to support projects and activities that meet federal requirements of reducing and eliminating nonpoint source pollution. In Texas, both the TSSWCB and the TCEQ receive section 319(h) funds to support nonpoint source projects, with TSSWCB funds going to agricultural and silvicultural issues and TCEQ funds going to urban and other non-agricultural issues.

Water Quality Management Plan Program (WQMP)

The WQMP is administered by the TSSWCB as a voluntary mechanism by which site-specific plans are developed and implemented on agricultural and silvicultural lands to prevent or reduce nonpoint source pollution. Plans include appropriate treatment practices, production practices, management measures, technologies, or combinations thereof. Plans are developed in cooperation with local SWCDs, cover an entire operating unit, and allow financial incentives to augment participation. Funding from the WQMP program will be sought to support implementation of agricultural management measures in the watershed.

TEXAS WATER DEVELOPMENT BOARD PROGRAMS

Agricultural Water Conservation Loan Program

Provides grants and low-interest loans to political subdivision and private individuals for agricultural water conservation and/or improvement projects. The program also provides a linked deposit loan program for individuals to access TWDB funds through participating local and state depository banks and farm credit institutions.

Clean Water Act State Revolving Fund (SRF)

The State Revolving Fund (SRF) administered by the TWDB provides loans at interest rates below the market to entities with the authority to own and operate wastewater treatment facilities. Funds are used in the planning, design, and construction of facilities, collection systems, storm water pollution control projects, and nonpoint source pollution control projects.

Economically Distressed Area Program (EDAP)

EDAP is administered by the TWDB and provides grants, loans, or a combination of financial assistance for wastewater projects in economically distressed areas where present facilities are inadequate to meet residents' minimal needs. While the majority of the watershed does not meet these requirements, small pockets within the area may qualify based on economic requirements of the program. Groups representing these areas may pursue funds to improve wastewater infrastructure.

Regional Water Supply and Wastewater Facility Planning Program

The TWDB offers grants for assessments to determine the most feasible alternatives to meet regional water supply and wastewater facility needs, estimate costs associated with implementing feasible wastewater facility alternatives, and identify institutional arrangements to provide wastewater services for areas across the state.

US DEPARTMENT OF AGRICULTURE –NATURAL RESOURCES CONSERVATION SERVICE PROGRAMS

Agricultural Management Assistance (AMA)

The AMA provides financial and technical assistance to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation into their farming operations.

Conservation of Private Grazing Land (CPGL)

The CPGL initiative will ensure that technical, educational, and related assistance is provided to those who own private grazing lands. It is not a cost share program. This technical assistance will offer opportunities for: better grazing land management; protecting soil from erosive wind and water; using more energy-efficient ways to produce food and fiber; conserving water; providing habitat for wildlife; sustaining forage and grazing plants; using plants to sequester greenhouse gases and increase soil organic matter; and using grazing lands as a source of biomass energy and raw materials for industrial products.

Conservation Stewardship Program (CSP)
The CSP helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance - the higher the performance, the higher the payment.

Conservation Technical Assistance Program (CTA)
The CTA Program provides land users with proven conservation technology and the delivery system needed to achieve the benefits of a healthy and productive landscape. The primary purposes of the CTA Program are to: reduce soil loss from erosion; solve soil, water quality, water conservation, air quality, and agricultural waste management problems; reduce potential damage caused by excess water and sedimentation or drought; enhance the quality of fish and wildlife habitat, improve the long term sustainability of all lands, including cropland, forestland, grazing lands, coastal lands, and developed and/or developing lands, and assist others in facilitating changes in land use as needed for natural resource protection and sustainability.

Regional Conservation Partnership Program (RCPP)
The RCPP Program is a new, comprehensive and flexible program that uses partnerships to stretch and multiply conservation investments and reach conservation goals on a regional or watershed scale. Partners participating in RCPP can use their local knowledge and networks to undertake conservation projects by joining with agricultural producers to restore or sustain natural resources such as: clean and abundant water; healthy, productive soils; and enhanced wildlife and pollinator habitat.

Environmental Quality Incentives Program (EQIP)
The Environmental Quality Incentives Program is administered by the USDA-NRCS. This voluntary conservation program promotes agricultural production and environmental quality as compatible national goals. Through financial incentives, EQIP offers financial and technical assistance to eligible participants for the installation or implementation of structural controls and management practices on eligible agricultural land. This program will be engaged to assist in the implementation of agricultural management measures in the watershed.

Farm Service Agency – Conservation Reserve Program
The Conservation Reserve Program is a voluntary program for agricultural landowners. Through this program one can receive annual rental payments and cost-share assistance to establish long term, resource conserving covers on eligible farmland. The program provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. By reducing water runoff and sedimentation, Conservation Reserve Program protects groundwater and helps improve the condition of lakes, rivers, ponds, and streams.

Rapid Watershed Assessments
Rapid watershed assessments provide initial estimates of where conservation investments would best address the concerns of landowners, conservation districts, and other community organizations and stakeholders. These assessments help land-owners and local leaders set priorities and determine the best actions to achieve their goals.

Rural Development Program
The USDA Rural Development Program offers grants and supports low-interest loans to rural communities for water and wastewater development projects.

US ENVIRONMENTAL PROTECTION AGENCY PROGRAMS
Environmental Education Grants
The Grants Program sponsored by USEPA's Environmental Education Division, Office of Children's Health Protection and Environmental Education, supports environmental education projects that enhance the public's awareness, knowledge, and skills to help people make informed decisions that affect environmental quality. USEPA awards grants each year based on funding appropriated by Congress. Annual funding for the program ranges between $2 and $3 million. Most grants will be in the $15,000 to $25,000 range.

Section 106 State Water Pollution Control Grants
Through the Clean Water Act, federal funds are allocated to be used in conjunction with matching state funds to support state water quality programs, including water quality assessment and monitoring, water quality planning and standard setting, total maximum daily load development, point source permitting, training, and public information. The goal of these programs is the prevention, reduction, and elimination of water pollution.

Section 319(h) Federal Clean Water Act
The USEPA provides funding to states to support projects and activities that meet federal requirements of reducing and eliminating nonpoint source pollution. In Texas, both the TSSWCB and the TCEQ receive section 319(h) funds to support nonpoint source projects, with TSSWCB funds going to agricultural and silvicultural issues and TCEQ funds going to urban and other non-agricultural issues. Section 319(h) grant funds from the TSSWCB supported the development of the Lower Nueces River WPP. Additional 319(h) funding will be sought through both the TSSWCB and TCEQ to support implementation efforts related to their respective areas of responsibility.

ESTIMATED LOAD REDUCTIONS
TDS has not been directly measured in many agricultural BMP studies. Therefore, estimates of attainable TDS load reductions from WQMPs are difficult to determine. Previous studies, primarily associated with filter strips, have demonstrated reductions in components of TDS, such as nitrates and dissolved metals. One study[29] published in 1989 indicated a 62-75% reduction in TDS attributed to filter strips. LDC analysis indicated that a 32.2% reduction is needed for TDS to meet the water quality standard. Load reductions from P&As will be dependent on the number of wells P&A'd and the proximity to the river.

Estimated load reduction for TDS cannot be reasonably estimated, and based on the NRCS's knowledge of current agricultural practices and management plans in place, only a few additional WQMPs may be added over the years, thus the 1 per implementation period in Table 9.1. Therefore the estimated load reductions for TDS in Table 9.2 are based on that possibility.

[29] Schwer, C.B., Clausen, J.C., Vegetative Filter Treatment of Dairy Milkouse Wastewater, https://dl.sciencesocieties.org/publications/jeq/abstracts/18/4/JEQ018004044

Although the Lower Nueces River is not impaired for bacteria, the levels have been increasing. A reduction in bacteria concentrations will be realized as the wastewater and urban management measures are implemented. Table 9.2 contains the estimated load reductions for these management measures.

Table 9.2: Estimated load reductions expected upon implementation of Lower Nueces River WPP

Management Measure	**Expected TDS Load Reduction**
WQMP Implementation	3.4×10^{10} - 4.1×10^{10} mg/day[30] (34,000 – 41,000 kg/day)
Management Measure	**Expected *E. coli* Load Reduction[31]**
Municipal Utility Districts / Wastewater Treatment Facilities	4.68×10^{13} cfu/day[32]
Public Utility Districts / Wastewater Treatment Facilities	
Connections to the City of Corpus Christi Wastewater System	
OSSF Repair	
OSSF Replacement	
Pet Waste Collection Stations	3.43×10^{11} cfu/day[33]

[30] Assumes 62% - 75% reduction of the average low flow loading of $5.4*10^{10}$ mg/day.

[31] The measured loads shown in Figure 4.12 are less than the expected reduction because not all produced bacteria makes its way into the river.

[32] Assumes 100 OSSFs are removed via connections to a MUD or PUD; 60 OSSFs are repaired or replaced; and 20 OSSFs are removed via connections to existing infrastructure.

[33] Assumes $6.38 * 10^9$ per year per station

Appendix A: List of Acronyms

AU	Assessment Unit
AMA	Agricultural Management Assistance
BMP	Best Management Practice
BRC	Blackland Research Center
CAFO	Confined Animal Feeding Operation
CBBEP	Coastal Bend Bays and Estuaries Program
CBBF	Coastal Bend Bays Foundation
CBCOG	Coastal Bend Council of Governments
CBI	Conrad Blucher Institute for Surveying and Science
cfs	cubic feet per second
cfu	colony forming units
CPGL	Conservation of Private Grazing Land
CR	County Road
CRP	Clean Rivers Program
CSP	Conservation Stewardship Program
CTA	Conservation Technical Assistance Program
CTC	Central Texas Coast
EDAP	Economically Distressed Area Program
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FDC	Flow Duration Curve
FM	Farm to Market Road
FY	Fiscal Year
GIS	Geographic Information System
HUC12	Hydrologic Unit Code-12
kg/ac	kilogram per acre
LDC	Load Duration Curve
LIP	Landowner Incentive Program
LULC	Land use / Land cover
m	meters
NLCD	National Land Cover Data
NPS	Nonpoint Source
NRA	Nueces River Authority
NRCS	Natural Resources Conservation Service
NRPA	Nueces River Preservation Association
OSSF	On-Site Sewage Facility
mg/l	milligrams per liter
MS4	Municipal Separate Storm Sewer System
MUD	Municipal Utility District
P&A	Plugged and Abandoned
PUD	Public Utility District
RRC	Railroad Commission of Texas

List of Acronyms

SC	Specific Conductance
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SH	State Highway
SPMWD	San Patricio Municipal Water District
SRF	State Revolving Fund
STLWI	South Texas Land and Water Initiative
SWCD	Soil and Water Conservation District
SWMP	Stormwater Management Plan
SWPP	Source Water Protection Plan
TAG	Technical Advisory Group
TALT	Texas Agricultural Land Trust
TAMUCC	Texas A&M University – Corpus Christi
TBD	To Be Determined
TDA	Texas Department of Agriculture
TDS	Total Dissolved Solids
TCEQ	Texas Commission on Environmental Quality
TFB	Texas Farm Bureau
TGLO	Texas General Land Office
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWON	Texas Well Owner Network
TxDOT	Texas Department of Transportation
µg/l	micrograms per liter
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCID	Water Conservation and Improvement District
WMP	Wildlife Management Plan
WPP	Watershed Protection Plan
WWTF	Wastewater Treatment Facility
WQMP	Water Quality Management Plan
WTP	Water Treatment Plant

Appendix B: Nine Elements of Successful Watershed Plans

A. IDENTIFICATION OF CAUSES AND SOURCES OF IMPAIRMENT
An identification of the causes of water quality impairment or concern and pollutant sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan (and to achieve any other watershed goals identified in the watershed protection plan). Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed.

Element A is covered in Chapter 5, pages 29 – 45.

B. EXPECTED LOAD REDUCTIONS
An estimate of the load reductions expected for the management measures proposed as part of the watershed plan. Percent reductions can be used in conjunction with a current or known load.

Element B is covered in Chapter 9, Table 9.2, page 76.

C. PROPOSED MANAGEMENT MEASURES
A description of the management measures that will need to be implemented to achieve the estimated load reductions and an identification of the critical areas in which those measures will be needed to implement the plan. These are defined as including BMPs and measures needed to institutionalize changes. A critical area should be determined for each combination of source and BMP.

Element C is covered in Chapter 6, pages 46 – 54 and Chapter 9, Table 9.1, pages 69 – 70.

D. TECHNICAL AND FINANCIAL ASSISTANCE NEEDS
An estimate of the amounts of technical and financial assistance needed, associated costs, and the sources and authorities that will be relied upon to implement this plan. Authorities include the specific state or local legislation which allows, prohibits, or requires an activity.

Element D is covered in Chapter 9, Table 9.1, pages 69 – 70.

E. INFORMATION, EDUCATION, AND PUBLIC PARTICIPATION COMPONENT
An information/education component that will be used to enhance public understanding of the plan and encourage their early and continued participation in selecting, designing, and implementing the appropriate NPS management measures.

Element E is covered in Chapter 3 (Public Participation), pages 13 – 15 and Chapter 7 (Information and Education), pages 55 – 59.

F. SCHEDULE
A schedule for implementing the NPS management measures identified in the plan that is reasonably expeditious. Specific dates are generally not required.

Element F is covered in Chapter 9, Table 9.1, pages 69 – 70.

G. MILESTONES
A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented. Milestones should be tied to progress of the plan to determine if it is moving in the right direction.

Element G is covered in Chapter 8, pages 60 – 64 and Chapter 9, Table 9.1, pages 69 – 70.

H. LOAD REDUCTION EVALUATION CRITERIA

A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality goals and, if not, the criteria for determining whether the watershed-based plan needs to be revised. The criteria for loading reductions do not have to be based on analytical water quality monitoring results. Rather, indicators of overall water quality from other programs can be used. The criteria for the plan needing revision should be based on the milestones and water quality changes.

Element H is covered in Chapter 8, Table 8.1, page 60.

I. MONITORING COMPONENT

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

Element I is covered in Chapter 8, pages 61-62.

From: USEPA*, Nonpoint Source Program and Grants Guidelines for States and Territories*

Appendix C: Steering Committee Ground Rules

GOALS

The goal of the Nueces River Watershed Partnership (Partnership) is to develop and implement a Watershed Protection Plan (WPP) to improve and protect the water quality of the Nueces River Below Lake Corpus Christi (Segment 2102). According to the *2012 Texas Water Quality Inventory and 303(d) List*, the Nueces River exhibits elevated nutrient levels, specifically chlorophyll-*a*, and is impaired by elevated total dissolved solids.

The Steering Committee will consider and attempt to incorporate the following into the

- development and implementation of the WPP:
- economic feasibility, affordability, and growth;
- unique environmental resources of the watershed;
- regional water planning efforts; and
- regional cooperation.

POWERS

The Steering Committee is the decision-making body for the Partnership. As such, the Steering Committee will formulate recommendations to be used in drafting the WPP and will guide the implementation of the WPP to success. Formal Steering Committee recommendations will be identified as such in the planning documents and meeting summaries.

Although formation of the Steering Committee was facilitated by the Nueces River Authority (NRA) and the Texas State Soil and Water Conservation Board (TSSWCB), the Steering Committee is an independent group of watershed stakeholders and individuals with an interest in restoring and protecting the designated uses and the overall health of the Lower Nueces River Watershed.

The Steering Committee provides the method for public participation in the planning process and will be instrumental in obtaining local support for actions aimed at restoring surface water quality in the Nueces River.

TIME FRAME

The Steering Committee will function under a September 2015 target date to complete the initial development of the WPP. Achieving water quality improvement in the Lower Nueces River may require significant time as implementation is an iterative process of executing programs and practices followed by achievement of interim milestones and reassessment of strategies and recommendations. The Steering Committee will function throughout the initial development period and may continue to function thereafter as a recommendation of the WPP.

Steering Committee Ground Rules

STEERING COMMITTEE MEMBERSHIP SELECTION

The Steering Committee is composed of stakeholders from the Lower Nueces River Watershed. Initial solicitation of members for equitable geographic and topical representation was conducted using three methods: 1) consultation with the County Extension Agents, NRA, Jim Wells, Nueces, and San Patricio County Soil and Water Conservation Districts, and local and regional governments, 2) meetings with the various stakeholder interest groups and individuals, and 3) self-nomination or requests by the various stakeholder groups or individuals.

Stakeholders are defined as either those who make and implement decisions, and / or those who are affected by the decisions made, and / or those who have the ability to assist with implementation of the decisions.

STEERING COMMITTEE

Members include both individuals and representatives of organizations and agencies. A variety of members serve on the Steering Committee to reflect the diversity of interests within the Lower Nueces River Watershed and to incorporate the viewpoints of those who will be affected by the WPP.

The size of the Steering Committee is not strictly limited by number but rather by practicality. To effectively function as a decision-making body, the membership shall achieve geographic and topical representation. If the Steering Committee becomes so large that it becomes impossible or impractical to function, the Steering Committee will institute a consensus-based system for limiting membership.

Steering Committee members are expected to participate fully in Steering Committee deliberations. Members will identify and present insights, suggestions, and concerns from a community, environmental, or public interest perspective. Steering Committee members are expected to work constructively and collaboratively with other members toward reaching consensus.

Steering Committee members will be expected to assist with the following:

- identify the desired water quality conditions and measurable goals;
- prioritization of programs and practices to achieve goals;
- help develop the WPP document;
- lead the effort to implement the WPP at the local level; and
- communicate implications of the WPP to other affected parties in the watershed.

Steering Committee members will be asked to sign the final WPP. The Steering Committee will not elect a chair, but rather remain a facilitated group. NRA and/or the TSSWCB will serve as the facilitator. In order to carry out its responsibilities, the Steering Committee has discretion to form standing and ad hoc work groups to carry out specific assignments from the Committee. Steering Committee members will serve on work groups and bring forth work group information and recommendations at Steering Committee and Partnership meetings.

WORK GROUPS

Topical work groups formed by the Steering Committee will carry out specific assignments from the Steering Committee. Initially formed standing work groups are:

- Agricultural Nonpoint Source Work Group
- Outreach and Education Work Group
- Utilities and Point Source Work Group
  (Industrial and Municipal Intakes, Storm Water, and Septic)
- Water Quality and Habitat Work Group
- Recreation Work Group

Each work group will be composed of a minimum of five members, with at least one of the members being on the Steering Committee, and any other members of the Partnership with a vested interest in that topic. There is no limit to the number of members on a work group. Each work group will elect a chair.

Tasks such as research or plan drafting will be better performed by these topical work groups. Work group members will discuss specific issues and assist in developing that portion of the WPP, including implementation recommendations. The NRA Coordinator will be available to assist each work group and help facilitate meetings. Work groups will present their results and recommendations to the Steering Committee during Partnership meetings.

Work groups and individual work group members are not authorized to make decisions or speak for the Steering Committee.

TECHNICAL ADVISORY GROUP

A Technical Advisory Group (TAG) consisting of state and federal agencies with water quality responsibilities will provide guidance to the Steering Committee and work groups. The TAG will assist the Steering Committee and work groups in WPP development by answering questions related to the jurisdiction of each TAG member. The TAG includes, but is not limited to, representatives from the following agencies:

- Texas Commission on Environmental Quality
- Texas A&M AgriLife Extension Service
- Texas Department of Agriculture
- Texas Parks and Wildlife Department
- Texas Railroad Commission
- Texas State Soil and Water Conservation Board
- Jim Wells, Nueces, and San Patricio County Soil and Water Conservation Districts
- Texas Farm Bureau
- Texas Water Development Board
- Texas A&M University – Corpus Christi
- U.S. Department of Agriculture – Natural Resources Conservation Service
- U.S. Environmental Protection Agency
- U.S. Geological Survey

REPLACEMENTS AND ADDITIONS

The Steering Committee may add new members if (1) a member is unable to continue serving and a vacancy is created or (2) important stakeholder interests are identified that are not represented by the existing membership. A new member must be approved by a majority of existing members. In either event, the Steering Committee will, when practical, accept additional members.

ALTERNATES

Members unable to attend a Steering Committee meeting (an absentee) may send an alternate. An absentee must provide advance notification, in writing, to the facilitator of the desire to send an alternate. An alternate attending with prior notification from an absentee will serve as a proxy for that absent Steering Committee member and will have voting privileges. The alternate must agree to vote as instructed by the absentee member. An alternate attending without advance notification will not be able to participate in Steering Committee votes. Absentees may also provide input via another Committee member or send input via the facilitator.

ABSENCES

All Steering Committee members agree to make a good faith effort to attend all Steering Committee meetings, however, the members recognize that situations may arise necessitating the absence of a member. Three absences in a row of which the facilitator was not informed of beforehand or without designation of an alternate constitutes a resignation from the Steering Committee.

DECISION-MAKING PROCESS

The Steering Committee will strive for consensus when making decisions and recommendations. Consensus is defined as everyone being able to live with the decisions made. Consensus inherently requires compromise and negotiation. If consensus cannot be achieved, the Steering Committee will make decisions by a simple majority vote provided a quorum is present. If members develop formal recommendations, they will do so by two-thirds majority vote provided a quorum is present. Steering Committee members may submit recommendations as individuals or on behalf of their affiliated organization.

QUORUM

In order to conduct business, the Steering Committee will have a quorum. Quorum is defined as at least one more than half (51%) of the Steering Committee (and/or alternates) present and a representative of either NRA or the TSSWCB present.

Steering Committee Ground Rules

FACILITATOR

The NRA Coordinator is an independent position, financed by the State of Texas through federal grant funds, with a specific role to perform in facilitating the Partnership and Steering Committee.

NRA Coordinator

The NRA Coordinator will serve as an educator and facilitator to help the Steering Committee organize its work, run meetings, coordinate educational trainings, draft notes and other materials if requested, and work with the TSSWCB to facilitate the development and implementation of the WPP. The NRA Coordinator will co-lead the meetings and work with all of the members to ensure that the process runs smoothly. The role of the NRA Coordinator includes working with the Steering Committee to prepare meeting summaries, assisting in the location and/or preparation of background materials, distributing documents the Steering Committee develops, conducting public outreach, moderating public workshops, providing assistance to Steering Committee members regarding Steering Committee business between meetings, and other functions as the Steering Committee requests.

MEETINGS

All meetings (Partnership, Steering Committee, and work group) are open and all interested stakeholders are encouraged and welcomed to participate.

Over the development period, regular meetings of either the Partnership, Steering Committee, or Work Groups will occur at least quarterly. The Steering Committee may determine the need for additional meetings. Steering Committee and work group meetings will be scheduled to accomplish specific milestones in the planning process.

Meetings will start and end on time. Meeting times will be set in an effort to accommodate the attendance of all Steering Committee members. The NRA Coordinator will notify members of the Partnership, Steering Committee, and work groups of respective meetings.

OPEN DISCUSSION

Participants may express their views candidly, but without personal attacks. Time is shared because all participants are of equal importance.

AGENDA

NRA and the TSSWCB, in consultation with Steering Committee members, are charged with developing the agenda. The anticipated topics are determined at the previous meeting and through correspondence. A draft agenda will be sent to the Steering Committee with the notice of the meeting. Agendas will be posted on the project website. Agenda items may be added by members at the time that the draft agenda is provided. The NRA Coordinator will review the agenda at the start of each meeting and the agenda will be amended if needed and the Steering

Committee agrees. The Steering Committee will then follow the approved agenda unless they agree to revise it. Items for discussion and possible vote that are brought up during a meeting but not on the agenda will be placed on the agenda for the next meeting.

MEETING SUMMARIES

NRA will take notes during the meetings and may provide audio recording. Meeting summaries will be based on notes and / or the recording. NRA and the TSSWCB will draft meeting notes and distribute them to the committee for their review and approval. All meeting summaries and presentations will be posted on the project website.

DISTRIBUTION OF MATERIALS

NRA and the TSSWCB will prepare and distribute the agenda and other needed items to members. Distribution will occur via email and websites, unless expressly asked to use U.S. Mail (i.e. member has no email access). To encourage equal sharing of information, materials will be made available to all. Those who wish to distribute materials to the Steering Committee or a work group may ask NRA or TSSWCB to do so on their behalf.

SPEAKING IN THE NAME OF THE COMMITTEE

Individuals do not speak for the Steering Committee as a whole unless authorized by the Steering Committee to do so. Members do not speak for the NRA or the TSSWCB and neither the NRA nor the TSSWCB speak for Steering Committee members. If Steering Committee spokespersons are needed, they will be selected by the Steering Committee.

DEVELOPMENT AND REVISION OF GROUND RULES

These ground rules were drafted by NRA and the TSSWCB and presented to the Steering Committee for their review, possible revision, and adoption. Once adopted, ground rules may be changed by two-thirds majority vote provided a quorum is present.

Appendix D: Land Use Land Cover Descriptions

Barren Land – (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover and includes transitional areas.

Cultivated Crops – Areas used for the production of annual crops, such as corn, soybeans, vegetables, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

Deciduous Forest – Areas dominated by trees where 75% or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest – Areas dominated by trees where 75% or more of the tree species maintain their leaves all year. Canopy is never without green foliage.

Mixed Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% but less than 50% of total vegetation cover.

Developed Open Space – Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Developed Low Intensity – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.

Developed Medium Intensity – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units.

Developed High Intensity – Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100% of the total cover.

Emergent Herbaceous Wetlands – Areas where perennial herbaceous vegetation accounts for 75-100% of the cover and the soil or substrate is periodically saturated with or covered with water.

Woody Wetlands – Areas where forest or shrubland vegetation accounts for 25-100% of the cover and the soil or substrate is periodically saturated with or covered with water.

Land Use Land Cover Descriptions

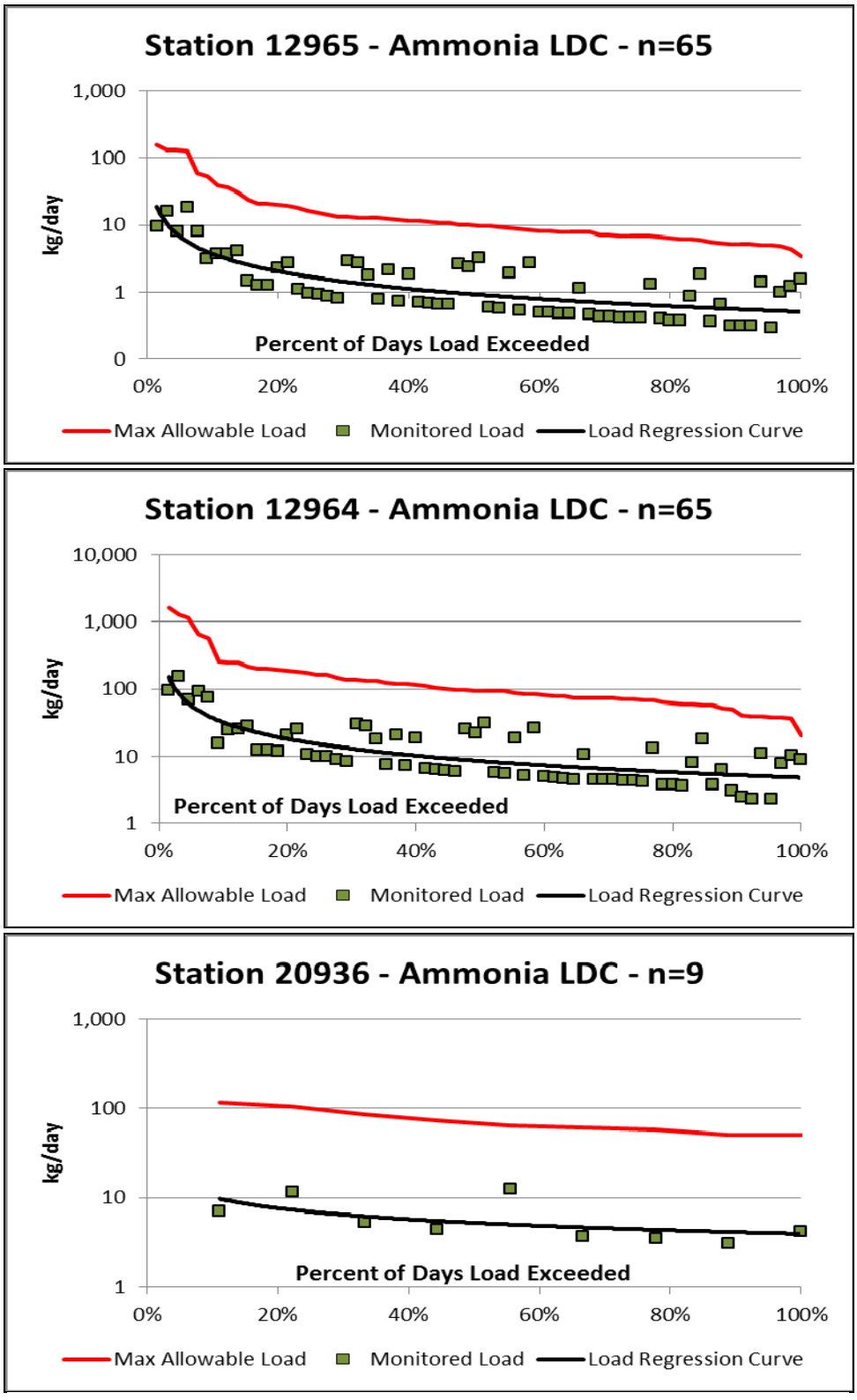
Herbaceous – Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25%, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Hay/Pasture – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

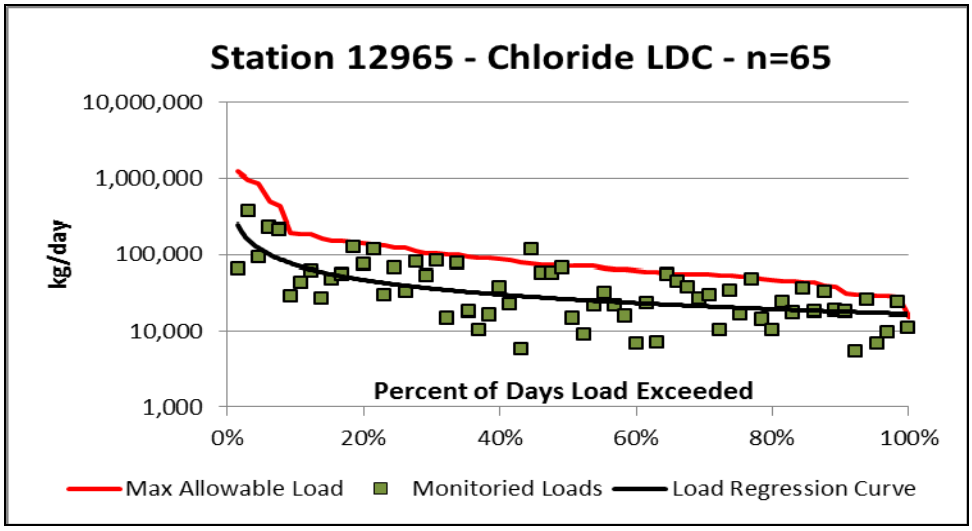
Open Water – All areas of open water, generally with less than 25% cover of vegetation or soil.

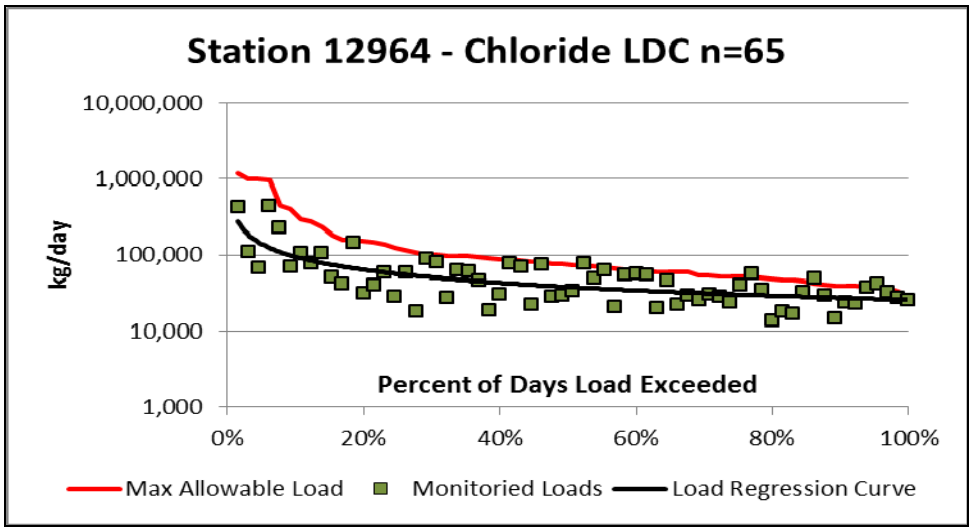
Shrub/Scrub – Areas dominated by shrubs; shrub canopy accounts for 25-100% of the cover. Shrub cover is generally greater than 25% when tree cover is less than 25%. Shrub cover may be less than 25% in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25% and shrubs cover exceeds the cover of the other life forms.

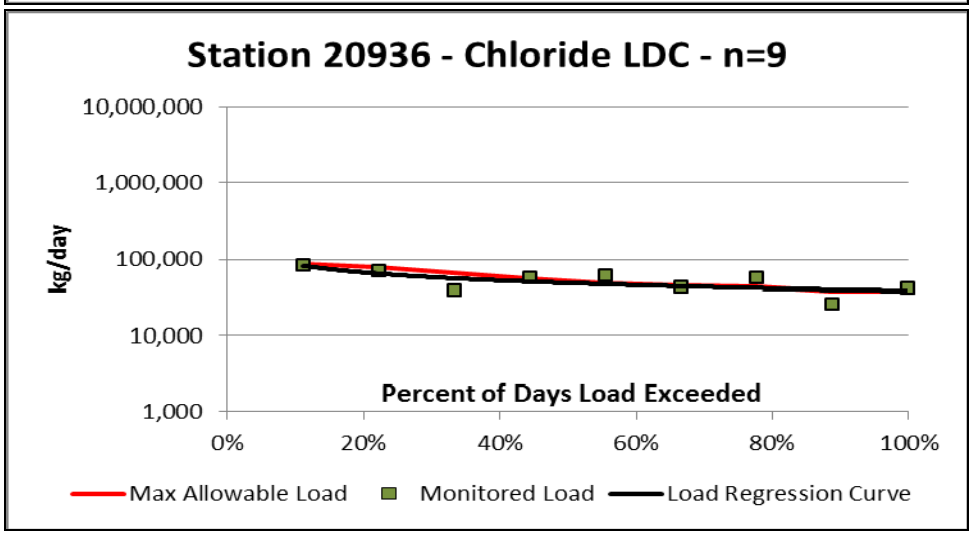
Appendix E: LDC Graphs of Additional Parameters



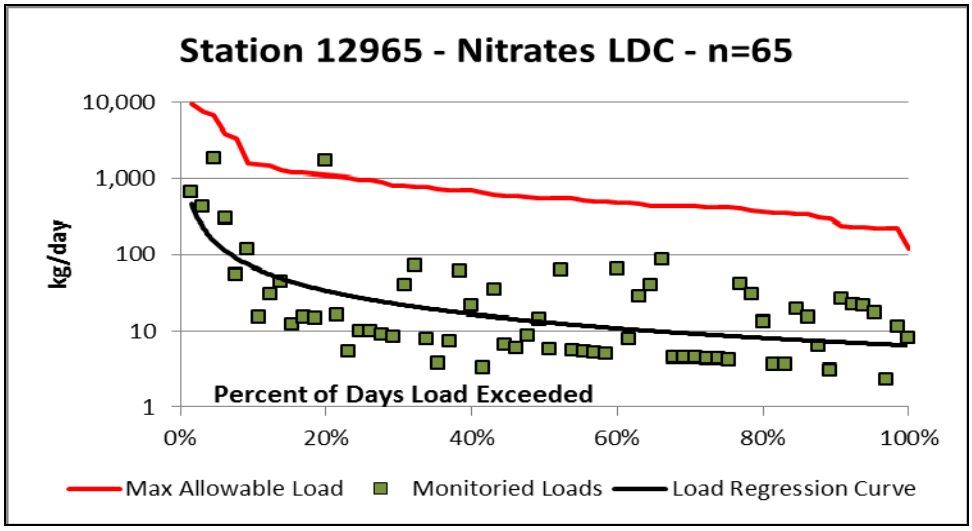
E.1: Ammonia LDCs

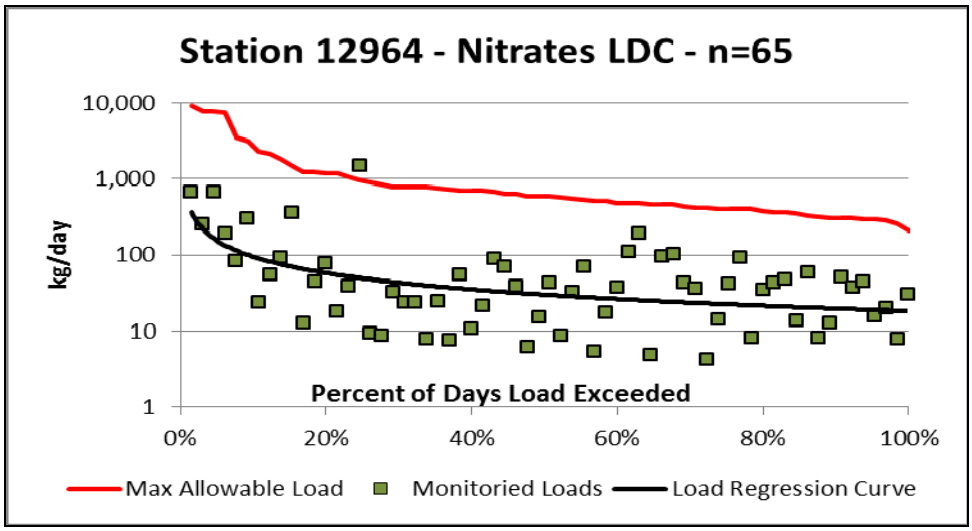


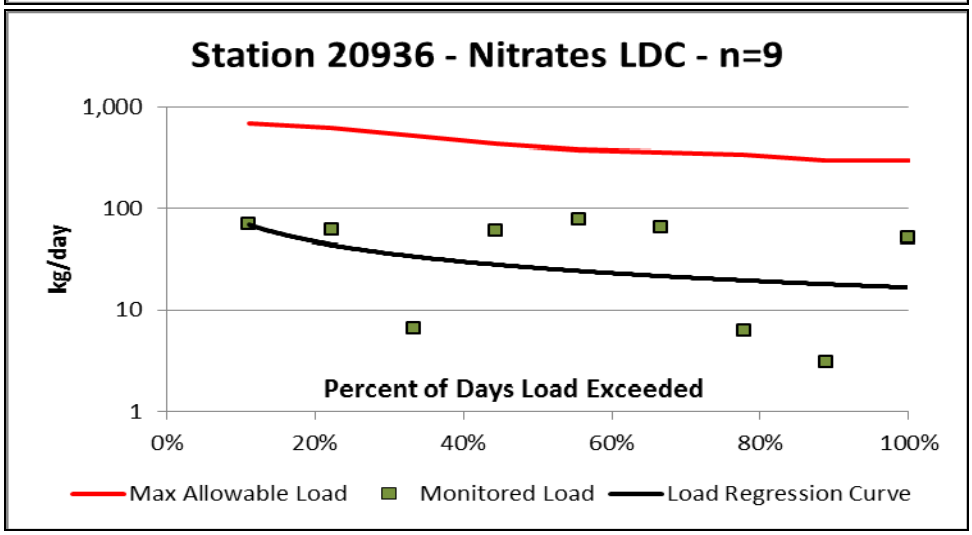




E.2: Chloride LDCs







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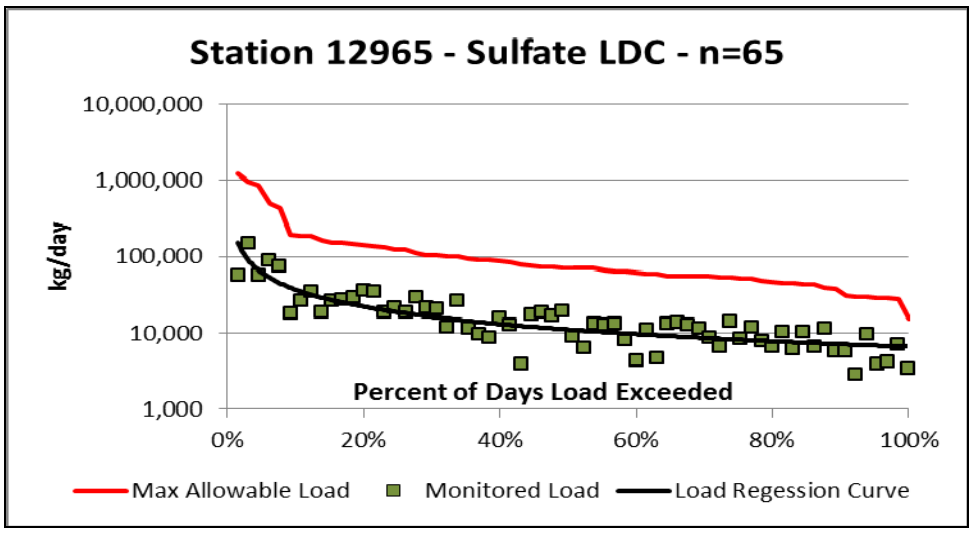
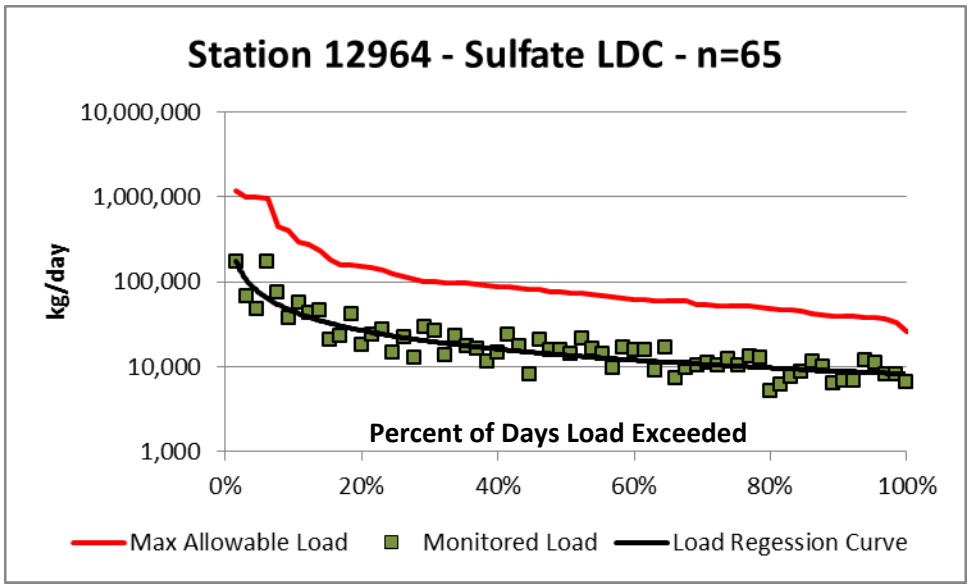
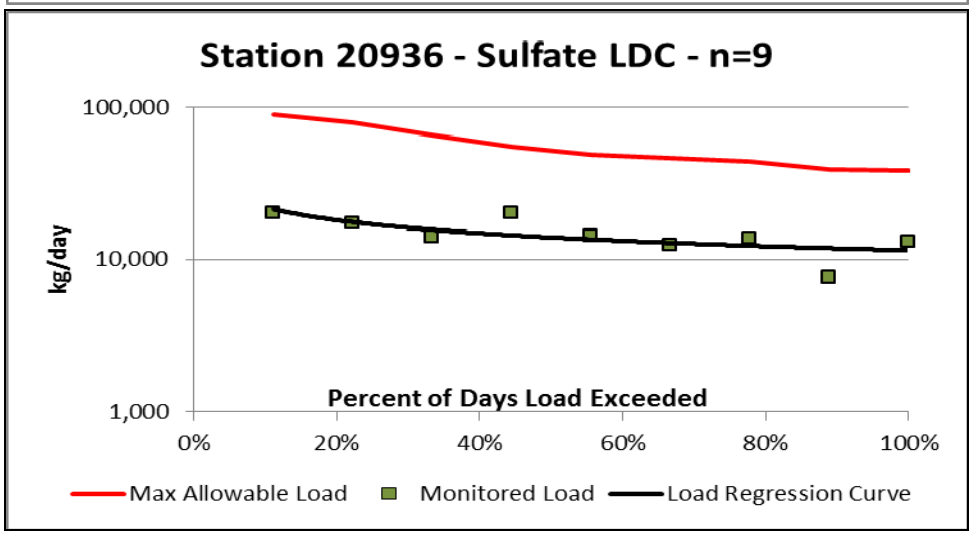
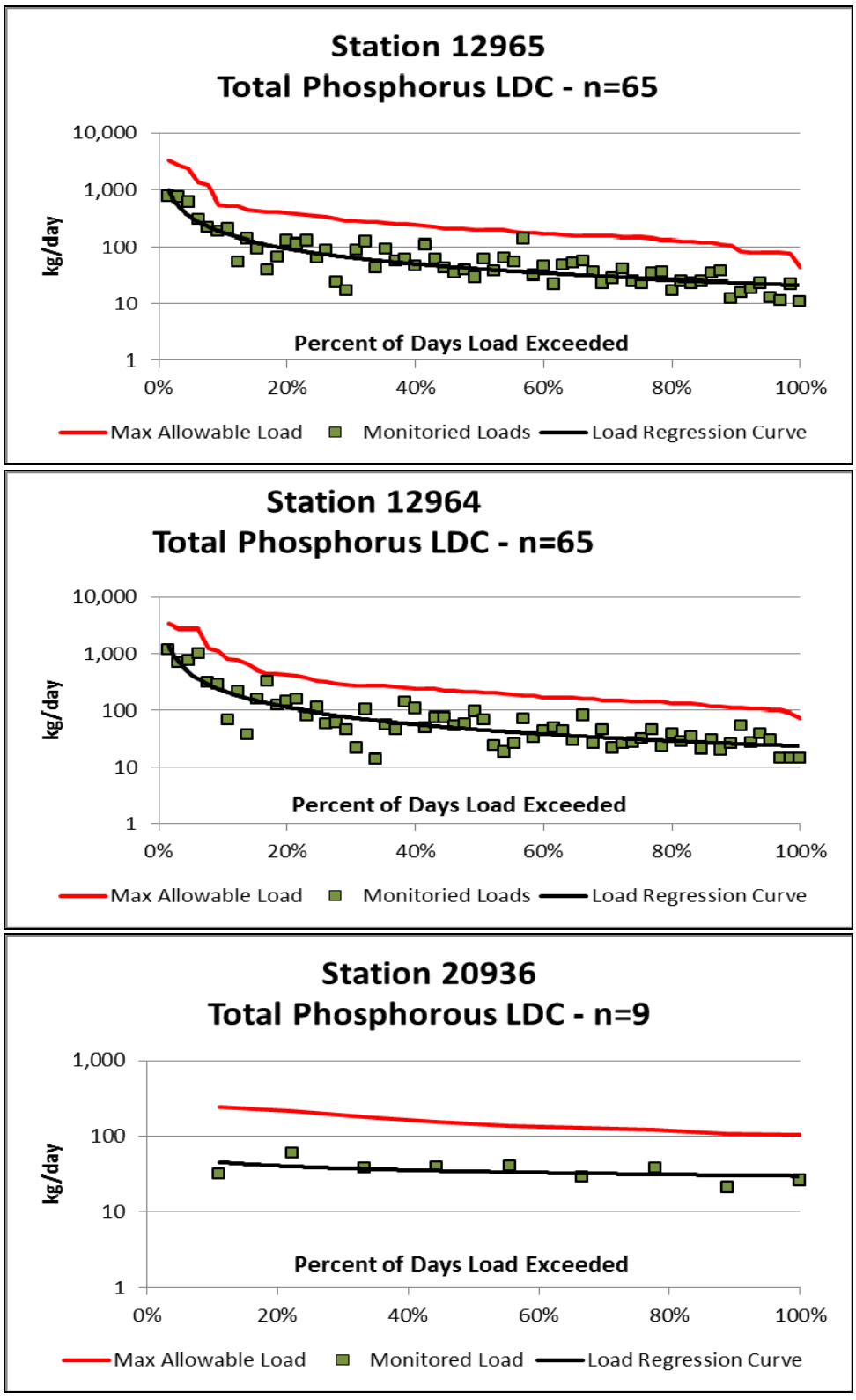






E.4: Sulfate LDCs



E.5: Total Phosphorus LDCs

Appendix F: OSSF Management Plan

As discussed in Chapter 6, Management Measures, an inventory of permitted OSSFs was created during the development of this WPP. This inventory represents a snapshot in time of the systems that are within the watershed (Figure 5.9).

Based on available funding sources, areas will be targeted to offer these inspections and provide financial assistance to eligible participants for repair or replacement of the OSSF if needed. Areas that will be targeted will be based on distance from the river or one of its tributaries, within the Federal Emergency Management Agency (FEMA) 100-yr floodplain, neighborhoods with small lots, age of the systems, and areas where no permits were recorded in known subdivisions (Figure F.1). Workshops will be held to provide information on the care of OSSFs and for homeowners to sign up for an inspection.

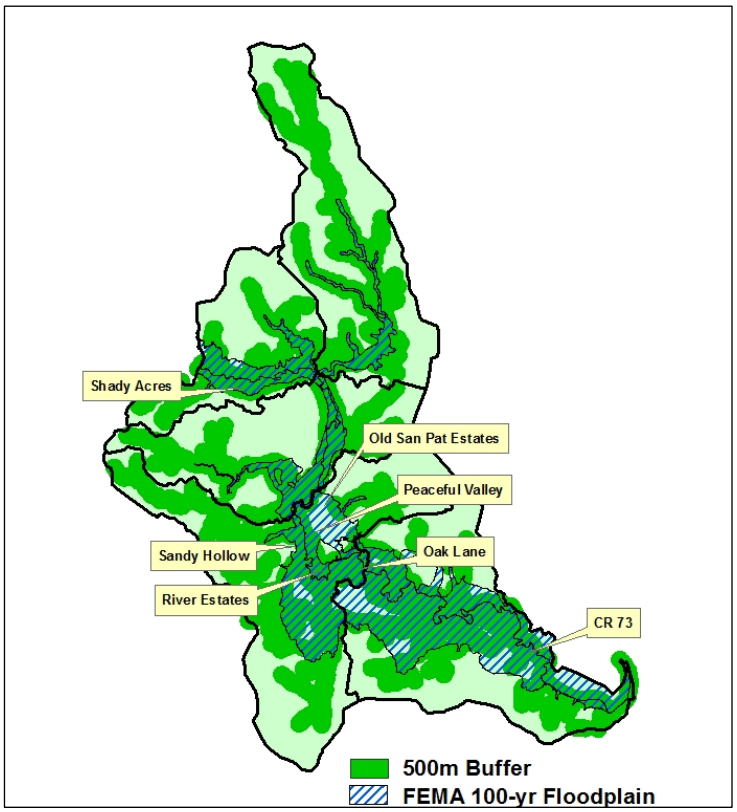


Figure F.1: Target Areas for OSSF Management Plan

The implementation of this plan is outlined in Table 9.1. The goal is to provide for 30 OSSF repairs and 30 OSSF replaces: 10 of each in years 1-3, 10 of each in years 4-6, and the final 10 of each in years 7-10. The estimated costs are $5,000 / repair and $10,000 / replacement. The potential *E. coli* load reduction for each OSSF repaired or replaced is estimated to be 2.6×10^{11} cfu/day.

A proposal for FYs 2017 – 2019 has been submitted to fund the first 10 repairs and 10 replacements, and inspection of 100 systems at an estimated $500 / inspection.

Appendix G: Hyacinth Control Management Plan

As discussed in Chapter 6, Management Measures, the need for the development of a hyacinth control management plan was based on documented hyacinth colonies completely covering parts of the river in the spring and early summer of 2011.

Water hyacinth, *Eichhornia crassipes*, is a native in the Amazon basin that has naturalized in the United States for at least twenty years. It is a free-floating perennial plant that can grow to a height of 3 feet. The dark green leave blades are attached to a spongy, inflated petiole (Figure G-1). Underneath the water is a thick, heavily branched, dark fibrous root system. The water hyacinth has striking blue flowers that make them popular for aquatic ornamental gardens. The plant is a very aggressive invader and can form thick mats, covering the entire surface of a slow moving river. It can cause problems for boating, fishing, and other water activities. Large mats also have the potential to substantially impede flow. An acre of water hyacinth can weigh more than 200 tons. Infestations have been known to cause oxygen depletions resulting in fish kills. Water temperature is altered from infestations as well. And the plant can clog raw water intake equipment and machinery.

Figure G-1. Water Hyacinth

Water hyacinth is found globally in the tropics and subtropics, but its spread is limited by severe cold. Leaves regrow after moderate freezes and the plant can grow very fast in warm weather. Populations can double in as little as six days. Within 70 years of reaching Florida, water hyacinth has come to cover 126,000 acres of waterways. It is now present across the southeast United States, California, Hawaii, the Virgin Islands, and in South Texas (Figure G-2).

Figure G-2. Water Hyacinth Infestation Extent (March 2001)

Figure G.3: Alligator Weed and Water Hyacinth

While there is some documented wildlife and aquatic habitat benefits provided by hyacinth it out-competes native vegetation that would otherwise provide these services.

Figure G-3 shows pictures of Alligator weed (on left) and Water hyacinth (on right); both plants are non-native and considered highly invasive.

Native plants, shown in Figures G-4 and G-5, are beneficial to fish and wildlife, and can be adversely affected by Water hyacinth.

Figure G.4: Diverse Group of Native Riparian and Aquatic Plants Colonizing Woody Debris on the Lower Nueces River

Figure G.5: Water Stargrass, *Herteranthera dubia*

Water hyacinth has been an issue on the Lower Nueces River since at least 1968. Texas Water Quality Board Report No. WQS 3 in 1978 noted that hyacinth control effortshad been on-going on for 10 years: "The Lower Nueces River has a history of severe overabundance of macrophytes, particularly Water hyacinths, *Eichornia crassipes*. More effort has been expended in plant eradication in the Lake Corpus Christ area than in any comparable area of the State." Other studies have noted the possible role of water hyacinth in nutrient retention within the reservoir.

An aerial survey was conducted by helicopter on February 5, 2015 from Lake Corpus Christi to the salt water barrier in Corpus Christi. The entire 39 miles were flown and GoPro® photographs taken every two seconds. One hundred twenty-five (125) colonies of Water hyacinth were documented by photograph and their GPS locations recorded (Figure G-6). Follow-up visits to several of these colonies revealed an average colony size of 1120 square feet. Based on these observations it is estimated that approximately 3.21 acres of Water hyacinth were present in the project area at this time.

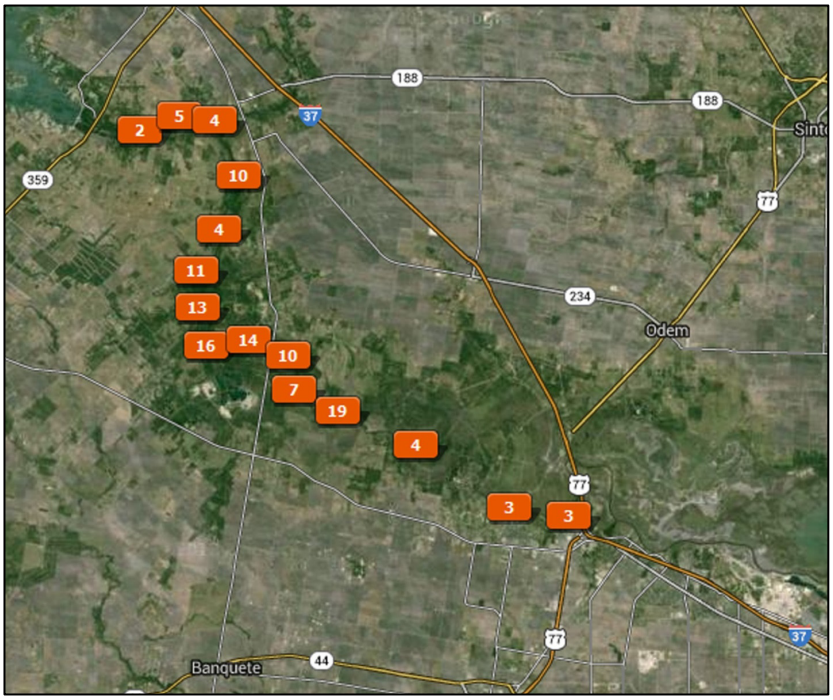


Figure G.6: Numbers and Locations of Water Hyacinth Colonies Documented by Aerial Survey in February 2015

Colonies observed in the February survey seemed to be most prevalent in the vicinity of subdivisions or groups of dwelling located near the river's edge (Figure G-7). Long stretches of undeveloped river banks harbored fewer colonies. Hyacinth growth is documented to be influenced by nutrients. Laundry detergents are a major known source of phosphorus inputs into waters. From the air a number of washing machine discharges are visible along the river banks where dwellings are located. Other possible nutrient sources include OSSFs, lawn and garden fertilizers, farm runoff, and livestock.

Figure G.7: Water Hyacinth Colony in February 2015

Water temperature and flows could also play a role in colony growth. Water temperatures for January – February 2015 in the project area averaged 38 °F for a low and 62 °F for a high. Water hyacinth colonies were observed completely blocking the river channel between SH 359 and FM 66 in March and May of 2011. Temperatures during January – February 2011 were 34 °F for a low and 65 °F for a high. High flow events, 1,200 – 10,000 cfs, occurred in October 2013, July 2014, and May of 2015. High flows and long term inundations are thought to have reduced Water hyacinth populations in the project area.

A second aerial survey was conducted on August 15, 2015 (Figure G-8). A dramatic reduction in number and size of hyacinth colonies was observed; only 53 colonies were documented within the same reach and they were very small in size. Colonies observed in August were much smaller and appeared to be only beginning to recolonize after flooding that inundated the area earlier in the summer

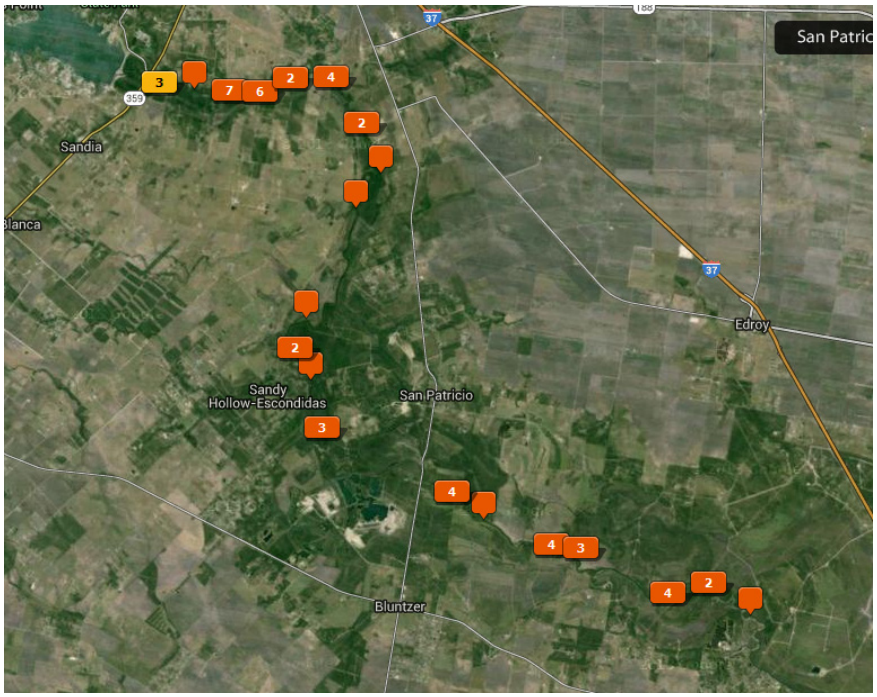


Figure G.8: Numbers and Locations of Water Hyacinth Colonies Documented by Aerial Survey in August 2015

(Figure G-9). It was estimated that the colonies identified were about ¼ of the average size of colonies observed in February. Based on this estimated average colony size of 280 square feet, approximately 0.34 acres of Water hyacinth were present in August 2015.

Figure G.9: Small Water Hyacinth Colonies Observed in August 2015

Water hyacinth has long been documented as a problem in Lake Corpus Christi and has been the subject of continued and ongoing control efforts by TPWD and the City of Corpus Christi. Because of the flooding, the hyacinth along the banks of Lake Corpus Christi is flourishing. City of Corpus Christi personnel from Wesley Seale Dam are currently spraying areas about twice a week. They are using Rodeo®, an aquatic herbicide, mixed with a surfactant.

From this information an organized control program could be created that focusses on regular coordinated efforts among and between groups. An existing contract between NRA and TPWD for invasive aquatic plant control work is being expanded to include the Lower Nueces River.

An additional survey above Lake Corpus Christi to try and locate the source / upper extent of the hyacinth is planned for the summer of 2016. The partnership will work the City to target the source, if found, and large colonies that might reform in the river, on an as-need basis.

Appendix H: Large Debris Removal Plan

A subcommittee of the Nueces River Watershed Partnership met on two occasions to review the side-scan sonar results and prioritize the items that needed to removed and /or further investigated. Of the 376 items documented during the survey, the subcommittee classified 16 as high priority targets and 39 as medium priority targets (Figure I.1).

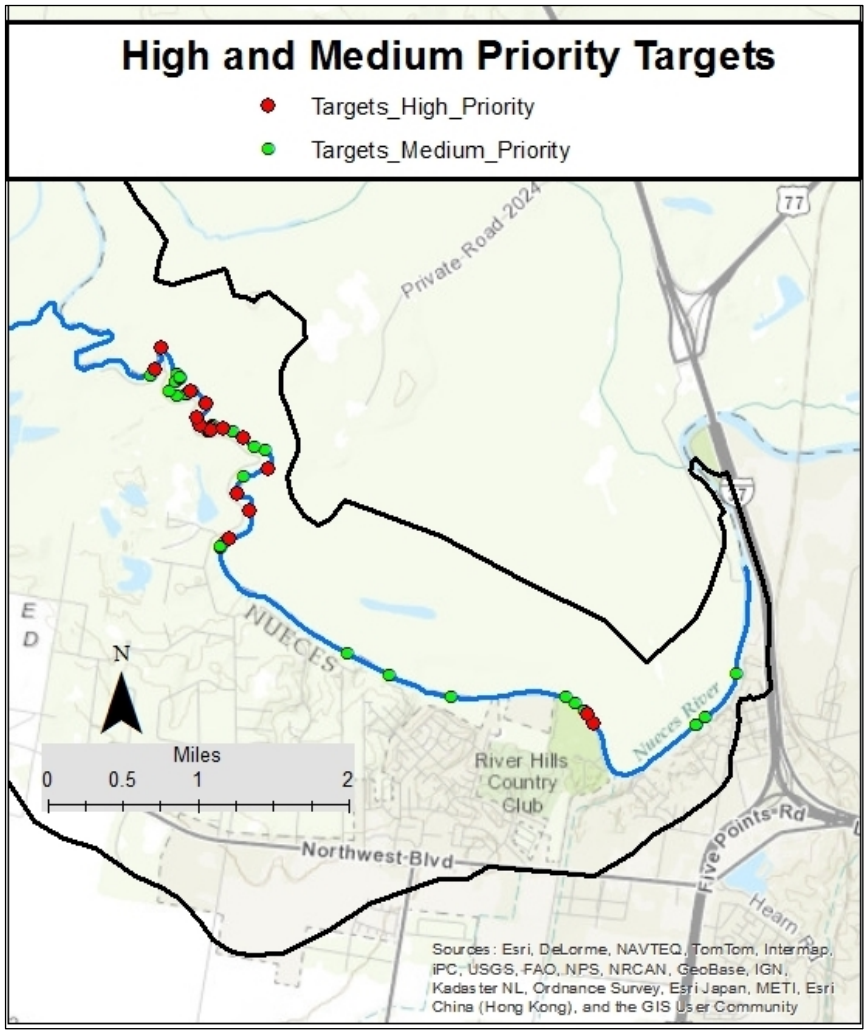


Figure I.1: Priority Target Locations Identified by Side-Scan Sonar

Some of the items need further investigation to determine what they actually are. The NRPA began this investigation in April, 2015, but the flooding in May and June put it on hold. The goals are to complete marking locations and verifying objects during Fall 2015, and to have the removal of items completed by the end of the year. CBBEP has committed to providing funds for the removal.

The high priority targets include 12 boats, 1 car or boat, 1 boat trailer, and 2 undetermined.

Three of the medium priority targets are identified as 'lot clearing debris.' The remaining 36 are undetermined and need to be investigated.