Wolf Bay Watershed Management Plan

Submitted to:

Mobile Bay National Estuary Program

Submitted by:

VOLKERT

ALLEN ENGINEERING AND SCIENCE

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Acknowledgments

The project team of Volkert, Inc. and Allen Engineering and Science would like to acknowledge the following individuals and organizations that have provided guidance, input, and resources during the preparation of this Plan:

Steering Committee Members

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Others

The City of Foley for providing the use of the Graham Creek Nature Preserve to hold Steering Committee and public involvement meetings.

All the citizens that attended the public involvement meetings as well as those who participated in the written and online surveys and provided their input.

Cover photography by Tommy Patterson and Leslie Gahagan.

Executive Summary

In 2018 the Mobile Bay National Estuary Program (MBNEP) executed a contract with the team of Volkert, Inc. and Allen Engineering and Science to develop a comprehensive Watershed Management Plan (WMP) for the Wolf Bay Watershed (Watershed) in Baldwin County, Alabama. The Wolf Bay Watershed comprises three sub-watersheds, including the Sandy/Wolf Creek, Miflin Creek, and Graham Bayou watersheds. The entirety of the Wolf Bay Watershed encompasses approximately 36,296 acres (**Figure ES-1**).

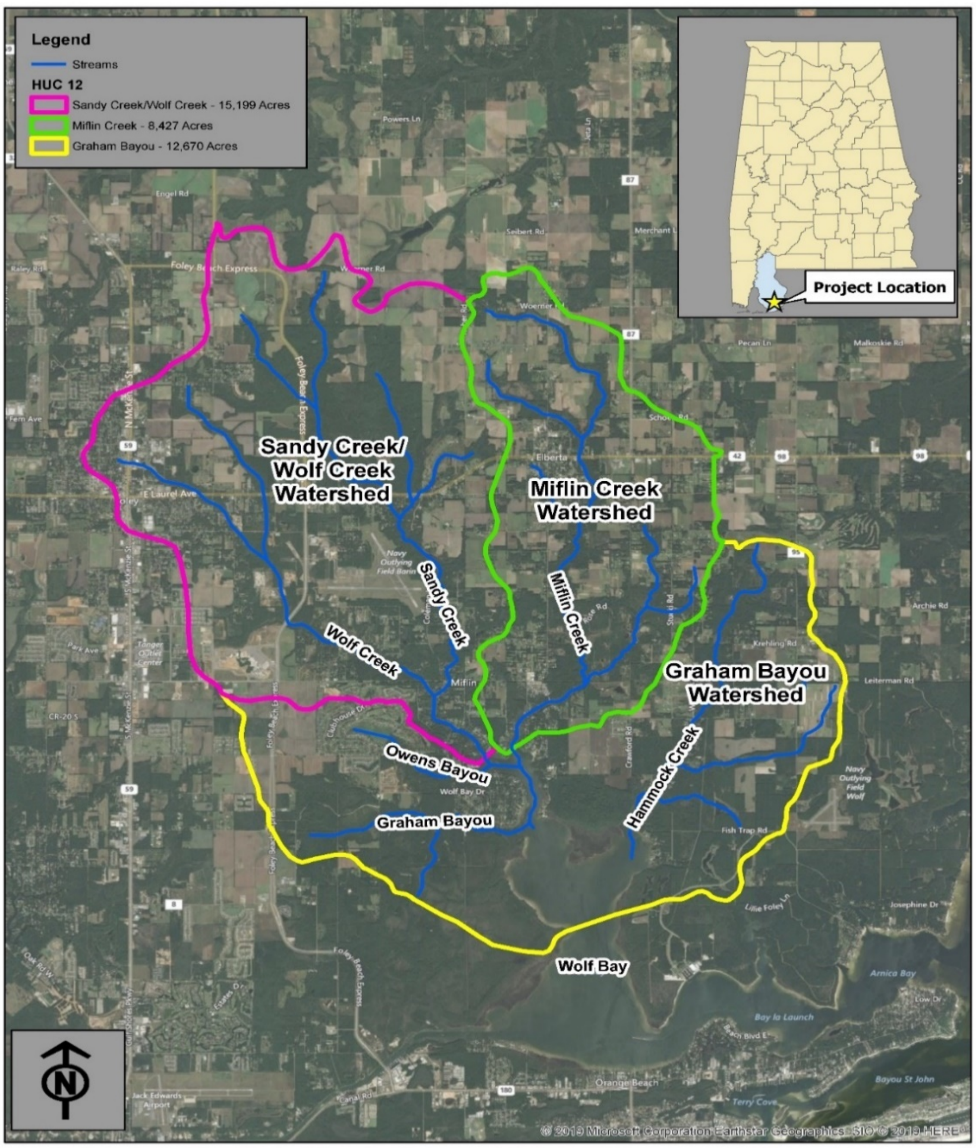

Figure ES.1 Wolf Bay Watershed Including Sub-watersheds

Plan Purpose and Vision

This WMP is meant to serve as a guide to resource managers, policy makers, stakeholder organizations, and citizens of the Watershed so that they might make informed decisions about potential actions that have a direct effect on the hydrological and biological integrity of the Watershed. With this purpose in mind, the WMP describes the current conditions of the Watershed, areas of concern within the Watershed, and potential management actions that could improve Watershed conditions and prevent future degradation. Because Wolf Bay is listed as an Outstanding Alabama Water (OAW), the vision of the WMP is to identify specific and achievable management measures to restore, protect, conserve, and preserve resources in the Watershed and maintain OAW status.

Public Participation

Public participation is a necessary part of the watershed management planning process. Not only was the community given the opportunity to voice concerns regarding known issues within the watershed, but they also had an opportunity to prioritize issues of concern and recommend potential strategies to address them.

One of the first steps in the Wolf Bay Watershed planning process was the formation of a 14-member Steering Committee which included residents, municipal representatives, community business leaders, recreational users, and other stakeholders. Throughout the process, the Steering Committee provided direction to the WMP Team on the priorities that needed to be addressed and provided insight about techniques and strategies that should be implemented. Three Steering Committee meetings were held during the planning process.

Other community outreach strategies employed by the WMP Team included attendance at several small community meetings and events as well as hosting one large community meeting to gather input. The Team developed an initial online survey to gather general perceptions of the Watershed and to gain input regarding known critical issues and areas, potential management measures, and recreational use. A second online survey was conducted to rank the critical issues and concerns that were previously identified.

Identification of Critical Issues

The WMP Team worked closely with the 14-member Wolf Bay WMP Steering Committee to determine goals and objectives for the Wolf Bay WMP. Their input, along with the input of numerous other stakeholders throughout the Watershed, was also solicited to identify issues and areas of concern that need to be addressed throughout this WMP. Through a series of meetings, surveys literature and field reviews, the following critical issues were identified to be addressed:

1. Maintenance and improvement of **water quality** throughout the Watershed was consistently ranked as the top priority. This includes identifying necessary steps to reduce inputs of nutrients from surrounding agricultural lands as well as residential areas through education of citizens and use of best management practices (BMPs). The identification of sources of pathogens entering the Watershed was also deemed a high priority. The targeting of sources contributing pathogens to surface waters and identification of steps needed to reduce or eliminate those inputs was deemed necessary. Another concern for stakeholders was litter, as it is unsightly in natural areas and degrades the quality of surface waters used for recreation. Litter reduction educational campaigns, as well as potential sites for litter traps were identified within the WMP. Invasive species pose a substantial risk to the overall ecological function of the Watershed and education regarding identification of invasive species and strategies for control of invasive aquatic and terrestrial plants and animals were a concern among Watershed stakeholders.
2. Baldwin County and particularly the area within the Wolf Bay Watershed are among the fastest growing areas in all of Alabama. Concerns that **future development** could have a detrimental impact on the streams and other surface waters of the Watershed were repeatedly expressed in surveys. Emphasis was placed on the amount of sediment entering the streams from erosion at construction sites not following proper BMP protocols. A review of standards and practices related to construction BMPs for each municipality within the Watershed as well as for Baldwin County was conducted to ensure proper regulations were in place to minimize sediment inputs from development activities. Another concern expressed related to future development was the increasing number of impervious surfaces created by development and the effects that increased runoff would have on the physical properties of riparian areas bordering streams and the stream channels themselves.
3. **Recreation** has always been a primary interest among the residents and stakeholders of the Wolf Bay Watershed. The Watershed contains beautiful streams and other natural areas that should be explored and utilized by people of all ages. However, due to a lack of boating access points throughout the Watershed, it has become difficult for people to explore this hidden treasure. Stakeholders feel that increased access to the Watershed will lead to an increased sense of ownership among users and will result in greater protection and management of the natural resources within it. Boat launches, blueway trails, and hiking trails were listed as improvements that could be made to increase recreational utilization.

Recommended Management Measures

The WMP Team, with input from the Steering Committee, developed a list of recommended Management Measures to address the Critical Issues identified through stakeholder input and field reconnaissance. Some of the recommend Management Measures include:

- Reduce the amount of sediments and nutrients entering streams and tributaries from agricultural lands through installation of agricultural buffers
- Installation of exclusion fencing to keep livestock out of riparian areas thereby reducing erosion and animal waste runoff
- Paving and/or installation of BMPs on dirt roads to prevent sediments from entering surface waters
- Developer and contractor education regarding construction BMPs that will provide long-term water quality benefits to the Watershed
- Identification of potential stream restoration projects targeting areas of unstable streambanks and sedimentation within stream channels
- Education of farmers and homeowners about timing of fertilization to prevent excess nutrient inputs to surface waters of the Watershed
- Establishment of an invasive species control program along road and transmission line rights of way as well as invasive species education for local landowners
- Reduction of litter entering waterways through signage and educational programs throughout the Watershed
- Protection of water quality and ecosystem function through strategic acquisition of conservation tracts
- Promotion of recreation throughout the Watershed leading to stakeholder “buy-in” for protection of water quality and natural resources

Implementation Strategies

Successful implementation of the previously discussed Management Measures will require a clear plan of action carried out by a collaborative group of stakeholders including members of the community and various government agencies. The prioritization of critical issues and areas, an estimation of associated costs pertaining to management strategies, and division into short and long-term goals are all necessary for success. The development of this WMP serves to build upon the existing interest in protection of the

Wolf Bay Watershed and will hopefully carry momentum through the implementation of the recommended management strategies.

Successfully addressing the critical issues identified in this WMP begins with the Wolf Bay Watershed Watch (WBWW). Many of the issues facing the Watershed extend beyond political and jurisdictional boundaries. The WBWW brings together stakeholders from different areas and backgrounds throughout the Watershed with a common goal of carrying out the implementation of the recommended management measures. The formation of the Steering Committee for this WMP brought together community leaders and stakeholders with a passion for improving the Watershed. Now is the time for Steering Committee members to carry their enthusiasm forward through the WBWW to ensure that the ideas and strategies identified in this WMP are carried out.

Management measures carried out in the short-term are designed to help build stakeholder confidence and build on momentum created through development of this WMP. These actions were chosen based on the likelihood of successful implementation within the next two years. Actions identified for the short-term include:

- Municipal and county staff as well as public training regarding Low Impact Development (LID)/Green Infrastructure (GI) practices and post-construction BMPs
- Construction BMP education for the public
- Public education on nutrients
- Municipal and county staff, local utilities, and public education and training in regards to invasive species
- Installation of signage at various locations in the Watershed to raise awareness among citizens about their individual and accumulated effects on the Watershed
- Stream-specific projects including engineering and design for the restoration and stabilization of the Wolf Creek headwaters
- Monthly monitoring for pathogens in Hammock, Sandy, and Miflin Creeks

Not all the critical issues identified within this WMP can be addressed within a two-year timeframe. Some projects will require additional analysis, planning, and data collection before implementation; therefore, classifying them as long-term management measures. For the Wolf Bay Watershed, these measures include:

- Comprehensive post-construction BMP inventory for the entire watershed

- Invasive species control plan for the entire watershed
- Implementation of agricultural buffers bordering riparian areas
- Installation of exclusion fencing and alternative water sources to keep livestock out of stream channels
- Rehabilitation of 8.6 miles of aging sanitary sewer mains within the City of Foley
- Construction of four aquifer storage recovery wells to connect reuse water from the Riviera Treatment facility to the wells for groundwater injection
- Septic tank inventory for Baldwin County
- Stream restoration and stabilization projects including engineering and design and construction at various stream reaches throughout the watershed
- Property acquisition for conservation and management along with development of public access
- Road paving of existing dirt roads
- Installation of litter traps

To ensure the long-term success of the management actions listed in this WMP, the WBWW should build on its current monitoring and reporting program. The group should develop criteria to judge success and submit an annual report documenting accomplishments and success stories and submit to MBNEP. The reports should include a summary of watershed conditions including monitoring and sampling results, an update on the status of management measures implemented to date, and a summary of anticipated management measures to be implemented in the coming year. More frequent reporting may be helpful in critical watershed areas where more frequent monitoring is needed to track success of specific management actions.

Chapter 1 Introduction

A watershed is a topographically defined area of land where the water within it flows to a common point such as a lake, stream, river, bay, or estuary. A properly functioning watershed provides quality waters, wildlife habitat, and protects homes and businesses from flooding. Everyone who lives in a watershed plays a role in protecting and sustaining the ecological features contained within it.

The Mobile Bay National Estuary Program (MBNEP) identified three goals in the Comprehensive Conservation Management Plan as part of its five-year strategy (2013–2018) for improving conditions within Mobile Bay: 1) improve trends in water quality in priority watersheds that discharge into priority fishery nursery areas; 2) improve ecosystem function and resilience through protection, restoration, and conservation of habitats, including beaches, bays, backwaters, and rivers; and 3) restore and/or expand human connections to Alabama's coastal resources. To achieve these goals, the MBNEP identified a need for comprehensive watershed planning within the Mobile Bay estuary. To assist the MBNEP in achieving this objective, the National Fish and Wildlife Foundation (NFWF) and the Gulf Coast Ecosystem Restoration Council (Council) provided funding to the MBNEP to develop a comprehensive management plan for the Wolf Bay Watershed.

For the purposes of this Plan, the boundaries of the Watershed are defined as the three northern Hydrologic Unit Code (HUC_12) sub-watersheds that include the Sandy/Wolf Creek Watershed (HUC_12 031401070201) with an area of 15,199 acres (23.75 square miles), Miflin Creek Watershed (HUC_12 031401070202) that contains 8,427 acres (13.17 square miles), and the Graham Bayou Watershed (HUC_12 031401070203) with an area of 12,670 acres (19.8 square miles).

1.1 Plan Overview

This WMP has been written in a concise manner to be understandable by all citizens within the Watershed, yet it provides enough technical detail to allow the WMP to be used to support financial grant applications. The WMP charts a conceptual course for improving and protecting the things that people value most about living in coastal Alabama, including:

- Water Quality
- Fisheries and Wildlife

- Environmental Health and Resilience
- Access
- Culture and Heritage
- Beaches and Shorelines

A particular focus in the WMP has been placed on strategies for conserving and restoring coastal habitats identified by MBNEP's Science Advisory Committee as most threatened by anthropogenic stressors. These habitat types include freshwater wetlands; streams, rivers, and riparian buffers; and intertidal marshes and flats. The WMP is divided into individual components and is organized into the following chapters:

Chapter 2: Literature Review provides a summary of pertinent scientific information about the Watershed which is useful in the development of the WMP.

Chapter 3: Community Engagement provides a summary of the public engagement program established to inform the public about the Watershed planning effort, communicate the importance of stakeholder involvement, identify stakeholder issues, and prioritize issues to be addressed.

Chapter 4: Watershed Characterization provides background information about the Watershed to characterize its geography, hydrology, wetlands, soils, biology, land use, demographics, and cultural history and heritage to provide an understanding of current conditions within the Watershed.

Chapter 5: Watershed Conditions includes an evaluation of existing conditions within the Watershed such as potential sources of pollutants, surface water flow, sediment transport, water quality, biological conditions, habitat conditions, and shoreline assessments.

Chapter 6: Climate Vulnerability Assessment provides an assessment of vulnerabilities associated with climate change and sea level rise within the Watershed.

Chapter 7: Identification of Critical Issues and Areas identifies the critical issues and areas within the Watershed to be addressed by the WMP based on public input, review of literature, results of field reconnaissance, and professional judgement.

Chapter 8: Management Measures provides recommended management measures for each critical issue challenging the Watershed, including suggestions for initial organization to coordinate WMP implementation, public education, engagement and involvement, and methods to measure success.

Chapter 9: Implementation Strategies provides ways to address the critical issues identified for the Watershed by implementing recommended management measures and identifies associated costs and effective organizational approaches. It provides temporal guidance to achieve success for management measures that can be implemented immediately versus those that will take more time.

Chapter 10: Regulatory Review presents regulatory drivers and constraints to effective implementation of the WMP, including regulatory inconsistencies and deficiencies that need to be addressed. It also identifies enforcement mechanisms.

Chapter 11: Financing Alternatives identifies potential sources of funding and examines innovative mechanisms and alternatives for leveraging funding sources.

Chapter 12: Monitoring explores methods to track the performance of implemented management measures, tools for measuring success, how to adaptively manage as implementation commences, and recommendations for reporting.

1.2 EPA Nine Key Elements

This WMP was developed to conform to the United States Environmental Protection Agency's (EPA's) nine elements of watershed planning. These elements can be summarized as the following:

- Build partnerships, including identification of key stakeholders and solicitation of community input and concerns (Element 1)
- Characterize the watershed, including creation of a natural and cultural resource inventory, identification of causes and sources of impairments, identification of data gaps and estimation of pollutant loads (Element 2)
- Set goals and identify solutions, including determination of pollutant reduction loads needed and management measures to achieve goals (Elements 2-3)

- Design an Implementation Program, including an implementation schedule, interim milestones, criteria to measure progress, monitoring components, information/education programs, and the identification of technical and financial assistance needed to implement the plan (Elements 4-9)

1.3 Coastal Nonpoint Control Program

Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) requires states and territories with approved Coastal Zone Management Programs to develop a Coastal Nonpoint Pollution Control Program. This program is jointly administered by the National Oceanic and Atmospheric Administration (NOAA) and the EPA and establishes a set of management measures for controlling nonpoint source pollution problems in coastal waters. Management measures are defined in Section 6217(g) as "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, and other alternatives". The five main sources of nonpoint source pollution identified in coastal areas include:

- Agriculture
- Forestry
- Urban Areas
- Marinas and Recreational Boating
- Hydromodification (Channelization and Channel Modification, Dams, and Streambank and Shoreline Erosion.

This WMP provides recommended management measures that conform to Section 6217(g) guidance for coastal nonpoint source pollution control in the watershed.

Chapter 2 Literature Review

A literature review was conducted by searching online for available documentation on the Watershed, obtaining copies of historical data files maintained by the WBWW, and reviewing the current pre-restoration analysis study funded by the MBNEP which is included as **Appendix A** to this document. Thirteen different literature sources specific to the Watershed were identified and are summarized in the sections below.

2.1 Overview of the Wolf Bay Watershed

Worldwide, more than 40% of the population lives within 60 miles of the coast. The continental U.S. coastal zone represents 17% of the nation's land area but contains greater than 50% of the population (Alabama Coastal Foundation, 2005). Alabama and other southeastern states of the south Atlantic-Gulf region are the fastest growing areas in the United States. As population, agricultural, and industrial centers have expanded along seacoasts, demands for freshwater resources have resulted in widespread water depletion and contamination in coastal regions. Inevitable water supply and quality problems arise from population growth, underscoring the need to protect water resources from degradation (Lee et al., 2007). The implications of this growth, both short-term and long-term, indicate that management of growth with regard to resource protection will be a challenge in the Watershed (Wolf Bay Plan, 2005).

Baldwin County is among the fastest growing areas in Alabama, with a 43% increase in population from 1990 to 2000. From 2010 to 2016, Baldwin County experienced a 14.4% population increase compared to a 1.7% growth rate for the rest of the State during the same period. Much of the growth is due to the City of Foley's population rise of 20.5% from 2010 to 2016 (Alabama Water Watch, 2007; US Census, 2016; Cook, 2017). This rapid expansion of urban/suburban development contributes both point source and nonpoint source pollutants to Wolf Bay and its tributaries. Pollutants include eroded soils from construction sites and stormwater-impacted stream banks, increased volumes of municipal wastewater discharge, lawn chemicals, and oil from parking lots, among others (Alabama Water Watch, 2007).

Stream channels in the northern parts of the Watershed, including the headwaters of Wolf, Sandy, and Miflin creeks, are characterized by relatively high elevation (maximum 100 ft. MSL), with topography that decreases in relief from north (upstream) to south (downstream) towards Wolf Bay (Cook, 2017). The southern reaches of these tributaries experience daily tidal fluctuations of up to two feet. Wolf Bay itself flows into the Intracoastal Waterway, which flows into either Perdido or Mobile bay depending on winds and tides, and ultimately into the Gulf of Mexico (Alabama Water Watch, 2007).

Land use within the Watershed includes forests (23%), agriculture (27%), urban/suburban (27%), wetlands/water (16%) and other uses (7%) (Mobile Bay National Estuary Program, 2018). Since 1992, urban/suburban land use increased from 4% to 27%, while agricultural area has declined from 46% to 27%, and forestlands declined from 32% to 23% of the Watershed. Within the agriculture sector, there has been a significant shift from row crops to sod farms (Alabama Water Watch, 2007). Cook (2017) states that forests (including forested wetlands) are the most dominant land use/cover type in the Watershed. Agriculture is the second largest land use and dominates the headwaters and areas of higher elevations. Developed land is listed as covering roughly 16% of the Watershed.

The aquifer in the Wolf Bay Watershed is the Miocene/Pliocene Aquifer, comprising over 500 feet of inter-layered sands, gravels and clays. Baldwin County is unique in that the entire county serves as the recharge area of this aquifer (Wolf Bay Plan, 2005). However, the increase in urban/suburban land use and associated impermeable surfaces has reduced the amount of freshwater infiltration to the aquifer. This fact is especially pertinent in consideration that groundwater pumping for municipal, irrigation, and industrial use has increased six-fold since 1966. These increasing groundwater withdrawals along the coast of Baldwin County could lead to intrusion of seawater into freshwater-bearing aquifers (Lee et al., 2007).

Wolf Bay serves as a nursery ground for many types of commercially and recreationally important species of fish, crab, shrimp, and other organisms. Additionally, the U.S. Fish and Wildlife Service has documented several species listed as threatened or endangered, including Florida manatee (*Trichechus manatus latirostris*), Alabama red-bellied turtle (*Pseudemys alabamensis*), Gulf Sturgeon (*Acipenser oxyrinchus desotoi*), American bald eagle (*Haliaeetus leucocephalus*), wood stork (*Mycteria americana*), and the red cockaded woodpecker (*Picoides borealis*) (Mobile Bay National Estuary Program, 2018). Imperiled habitats within the Watershed include Gulf Coast pitcher plant bogs, Atlantic white cedar swamps, and long leaf pine savannahs (Wolf Bay Plan, 2005).

WBWW began the process of obtaining an “Outstanding Alabama Water” (OAW) classification for Wolf Bay in 2001. In April 2007, the Bay was designated an OAW by ADEM, the highest of seven levels of waterbody use classifications. Wolf Bay was one of five waterbodies statewide and the first bay in Alabama to attain OAW classification. Under OAW classification, the Wolf Bay is protected by higher water quality standards, including more stringent restrictions on wastewater and toxic substance discharge in the Bay, a higher minimum dissolved oxygen level, and lower acceptable year-round pathogen concentration (Alabama Water Watch, 2007). The classification extends from the Intracoastal Waterway to Moccasin Bayou (Mobile Bay National Estuary Program, 2018). The waterbody is also classified for swimming, fish and wildlife, and shellfish harvesting (Hydro Engineering Solutions, 2013).

Baldwin County has a mild but humid climate with average annual rainfall of around 61 inches (Hydro Engineering Solutions, 2013). In the contiguous United States, this region is second only to the Pacific Northwest in total annual rainfall, and the frequency of thunderstorms over coastal Alabama is exceeded only by the Florida peninsula (Wolf Bay Plan, 2005). The summer months are typically the wettest with driest months typically during the winter. Annual rainfall is generally well distributed although significant rain events can be experienced due to proximity to the coast and exposure to hurricanes and tropical storms. The warmest month is July with the coldest month being January (Hydro Engineering Solutions, 2013).

2.2 Discharge

In 2013, Hydro Engineering Solutions conducted a watershed study on Wolf Bay for the Baldwin County Commission and Highway Department. The purpose of the study was to gain an understanding of the Watershed and determine its sensitivity to land use changes in areas expecting future growth. The study projected that the main area of future development would occur along the Foley Beach Express. The Wolf Creek and Sandy Creek basins were the two sub-watersheds projected to experience the most impact from this development. Results indicate additional development around the municipalities of Foley and Elberta will increase peak discharges downstream if they are not detained and that development of each area will cause a negative impact to the downstream reaches of Wolf and Sandy Creeks. Without detention, peak discharges will occur earlier and increase discharge in local Bay tributaries. The existing regional ponds are not sufficient to handle discharge increases at the outlet of Wolf Bay and local detention needs to be employed in the upper portions of the Watershed. Protections from in-stream erosion can be accomplished by using local detention on smaller, more frequent rain events which will protect against stream degradation that could occur with increased runoff. The study used a drainage area of 56.06 square miles and determined that the 100-year peak discharge was 10,620 cubic feet per second (cfs).

Wang et al. (2014) predicted a slight increase in precipitation with high flows expected to increase and low flows expect to decrease. Monthly average streamflow and surface runoff were projected to increase in spring and summer but especially in fall. Land use/land cover change does not have a significant effect on monthly average streamflow, but would affect partitioning of streamflow, causing higher surface runoff and lower baseflow.

2.3 Sediment

When rainfall totals are high, the combination of flood runoff, erosion, and the destruction of trees and buildings along the shoreline results in the transport of large amounts of sediment and debris into parts of the Wolf Bay Watershed and into Wolf Bay itself (Wolf Bay Plan, 2005). In 2005, Alabama Soil and Water Conservation Committee reported that urban land use in the Watershed consisted of 14,000 acres, or 22% of the total land use. However, 63% of measured sedimentation in the Watershed (240,000 tons) originated from developing urban land. In comparison, forest land, which comprises 53% of the Watershed, contributes under 3% of total sedimentation, while agriculture uses 10% of the land and contributes less than 1% of total sedimentation (Lee et al., 2007).

Cook (2017) established 14 monitoring sites on 10 streams throughout the Wolf Bay Watershed (**Figure 2.1** and **Table 2.1**). Water samples were collected and analyzed for total suspended sediments (TSS) and showed that TSS loads were highest at Sandy Creek at U.S. Highway 98 (929 tons/year) and Wolf Creek at Swift Church Road (861 tons/year). For comparison, the next highest load was only 460 tons/year. It was also noted that, although the Wolf Creek sampling site on Swift Church Road is downstream from the Wolf Creek site on Doc McDuffie Road, the suspended sediment load is 8.7 times larger at the Doc McDuffie Road location. This is due to the proximity of the downstream sampling point to the reach of Wolf Creek with tidal influence (**Figure 2.2**). When sediment loads were normalized to negate the influence of drainage area size and stream discharge, the east and west unnamed tributaries to Sandy Creek had the largest suspended sediment loads in the Wolf Bay Watershed (**Figure 2.3**).

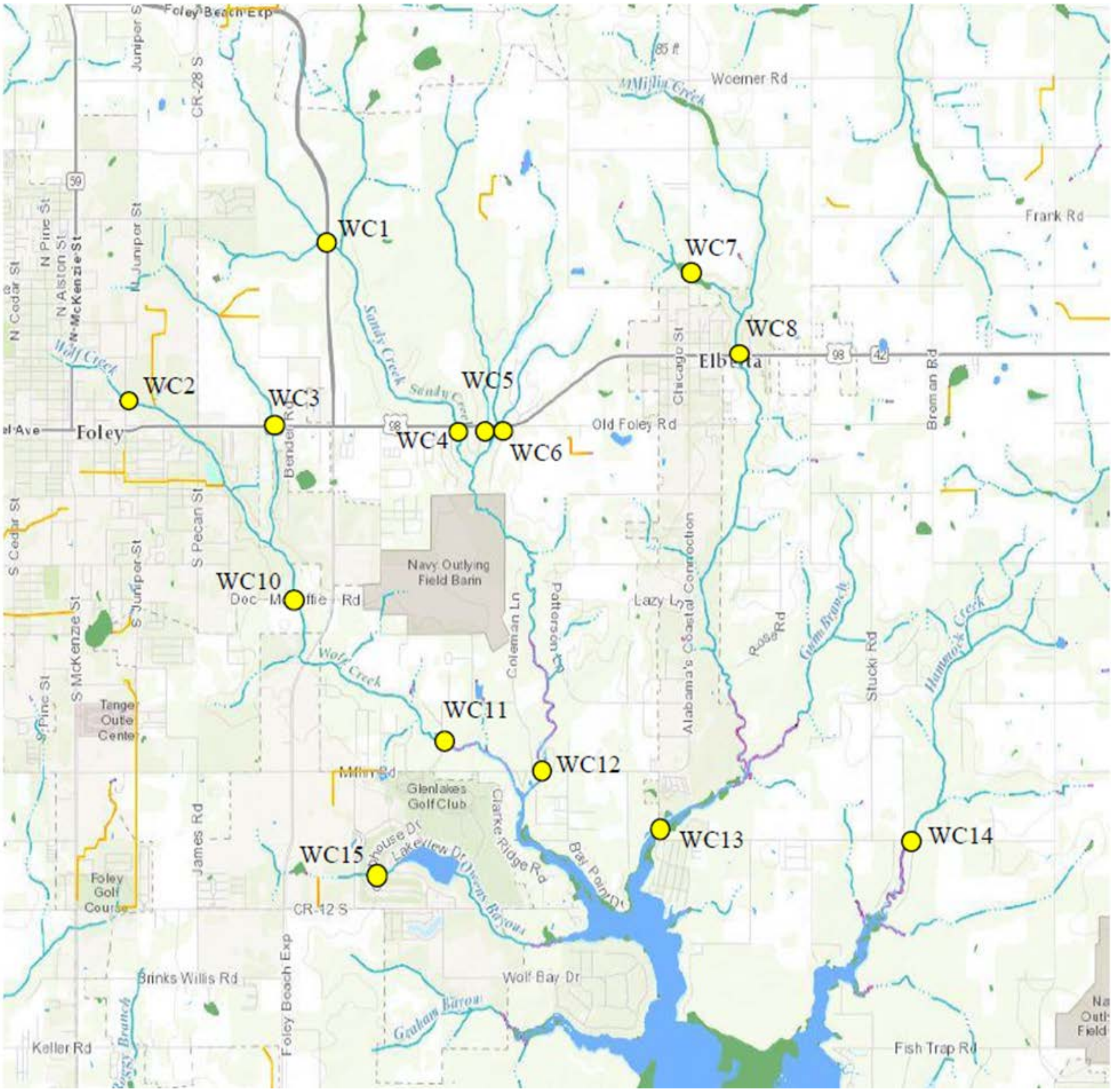

Figure 2.1 Cook (2017) Monitoring Sites for Streams in the Wolf Bay Watershed

Table 2.1 Corresponding Site Codes and Locations for Cook (2017) Monitoring Sites

Site Code	Location Description	Latitude	Longitude
WC1	Sandy Creek at Foley Beach Expressway	30.42614	-87.64850
WC2	Wolf Creek at North Poplar Street	30.40967	-87.67639
WC3	Unnamed tributary to Wolf Creek at US Highway 98	30.40690	-87.65579
WC4	Sandy Creek at US Highway 98	30.40684	-87.63024
WC5	Unnamed tributary at US Highway 98 1,200 feet from confluence with Sandy Creek	30.40667	-87.62627
WC6	Unnamed tributary to Sandy Creek at US Highway 98	30.40671	-87.62481
WC7	Elberta Creek at Baldwin County Road 83	30.42262	-87.59837
WC8	Miflin Creek at US Highway 98	30.41433	-87.59159
WC10	Wolf Creek at Doc McDuffie Road	30.38979	-87.65302
WC11	Wolf Creek at Swift Church Road	30.37350	-87.63262
WC12	Sandy Creek at Baldwin County Road 20	30.37041	-87.61852
WC13	Miflin Creek at Baldwin County Road 20	30.36395	-87.60249
WC14	Hammock Creek at Baldwin County Road 20	30.36303	-87.56769
WC15	Owens Bayou at Lakeview Drive	30.35980	-87.63927

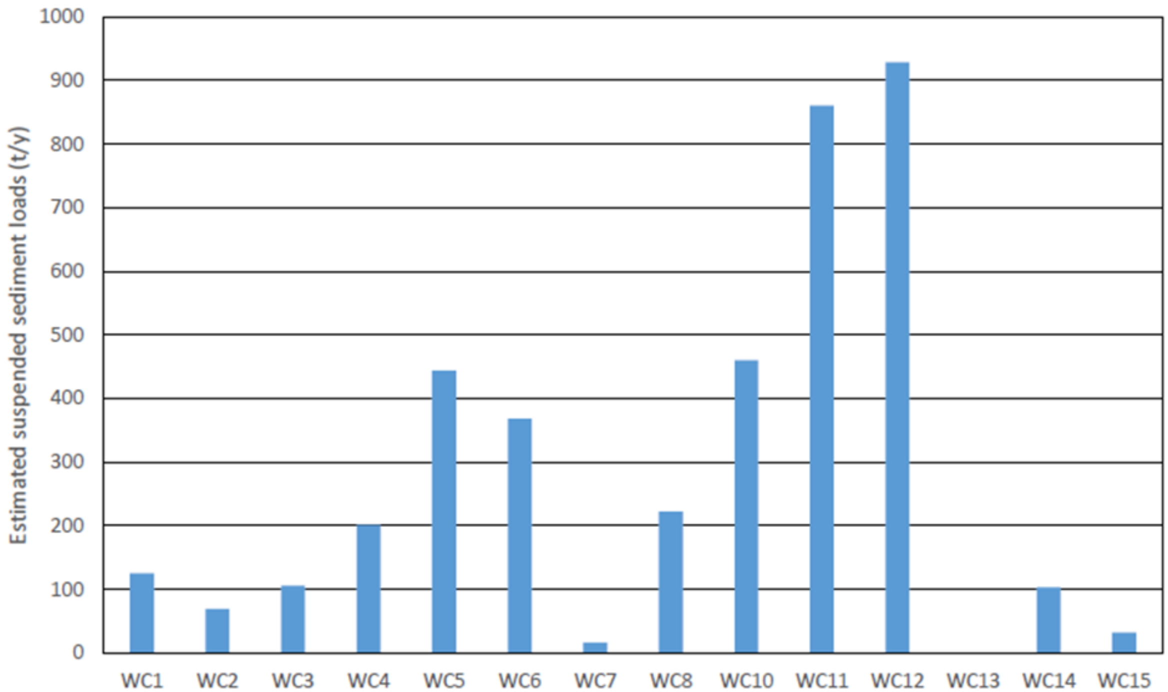

Figure 2.2 **Estimated Annual Suspended Sediment Loads for Wolf Bay Watershed Monitored Sites (Source: Cook, 2017)**

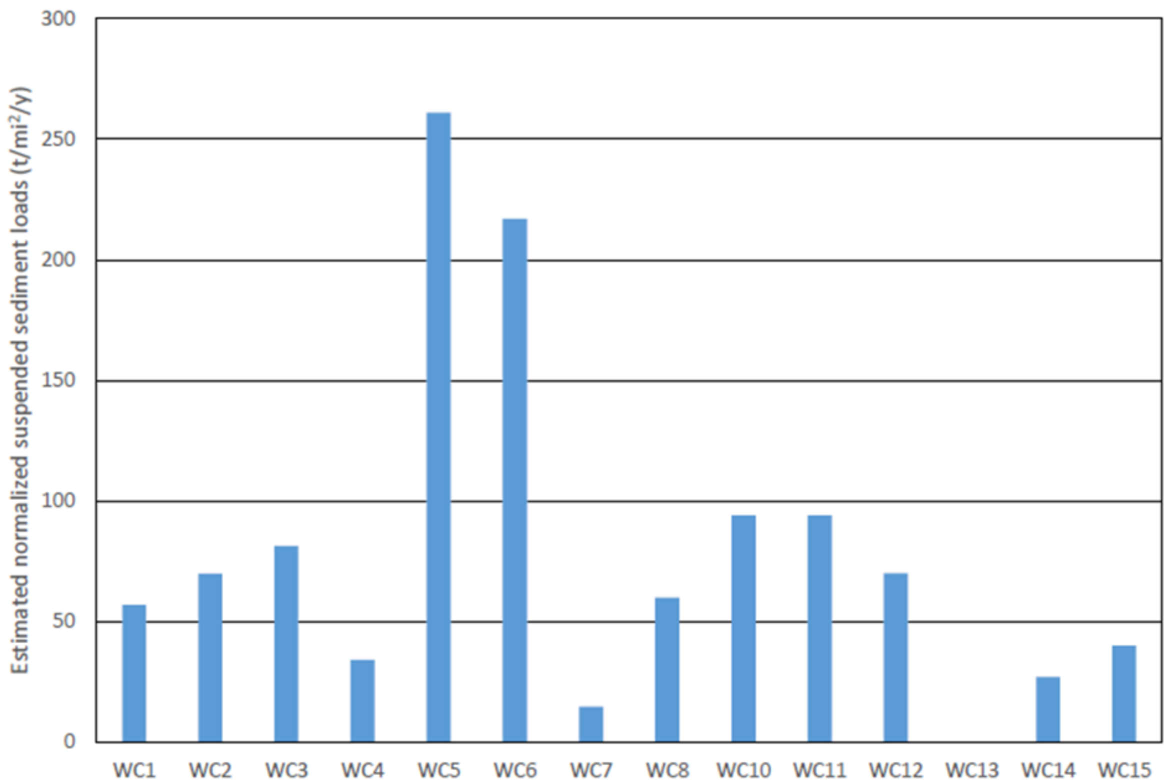

Figure 2.3 **Estimated Normalized Suspended Sediment Loads for Wolf Bay Watershed Monitored Sites (Source: Cook, 2017)**

Bed sediment loads are composed of particles that are too large or dense to be carried in suspension by stream flow. The sample site on Wolf Creek at Doc McDuffie Road showed bed sediment loads (10,471 tons/year) that were six times larger than the next largest load. Even after normalization relative to drainage area, Wolf Creek at McDuffie Road had more than twice the load of the next largest site sampled. These results are due to excessive upstream erosion, which contributes a disproportionately large amount of bed sediment (Cook, 2017).

For total sediment loads, data normalized to negate the influence of drainage area size and stream discharge showed that Wolf Creek at Doc McDuffie Road exhibited the highest levels of total sediment load. The west and east unnamed tributaries of Sandy Creek had the next highest amounts but were still half that of the Wolf Creek at Doc McDuffie Road site. On average, bed sediment makes up 72% of the total sediment loads for streams with measurable suspended and bed sediment. Without human impact, watershed erosion rates, called the geologic erosion rate, would be 64 t/mi^2/yr (Maidment, 1993). Normalized sediment loads show that 9 of 13 monitored watersheds were from 1.1 to 34.9 times greater than the geologic erosion rate (**Figure 2.4**) (Cook, 2017).

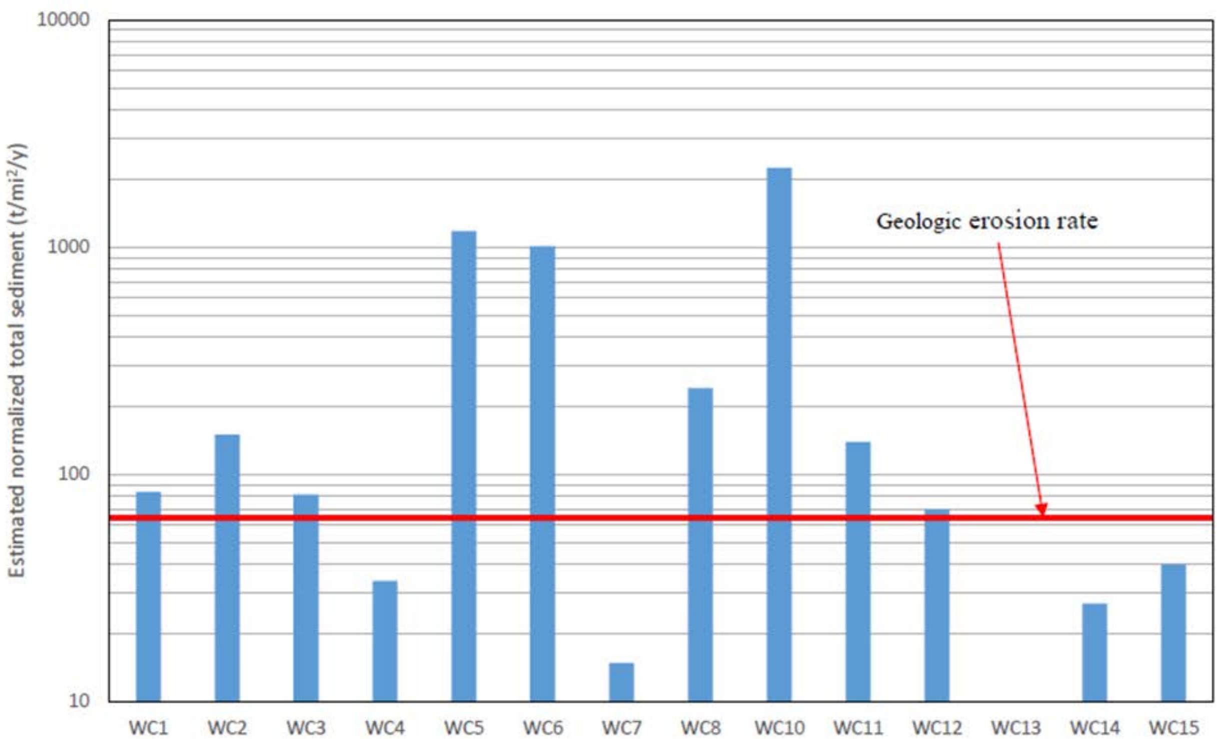

Figure 2.4 Estimated Normalized Total Sediment Loads for Wolf Bay Watershed Monitored Sites (Source: Cook, 2017)

2.4 Turbidity

Sampling conducted from 2004-2007 showed an increasing trend in turbidity in Wolf Bay. It was suggested that the upward trend was likely from a combination of eroded soils washing off the Watershed into the Bay along with increased levels of nutrients which stimulated the growth of algae (Alabama Water Watch, 2007).

Cook (2017) found that sampled turbidity values were highest at the unnamed tributary at US Highway 98, Wolf Creek at Swift Church Road, and another sampling site on the unnamed tributary at US Highway 98 which exhibited NTUs of 110, 77 and 75, respectively. Although land-use data indicates that watersheds with dominant urban development and/or agriculture are more likely to exhibit higher turbidity concentrations in streams, that was not necessarily the finding in this case. The Wolf Creek sampling point off Poplar Street in Foley had the highest percentage of residential development (84.8%) but showed average turbidity in the lower 40 NTU range. Average turbidity for all Wolf Bay Watershed sites exceeded the ADEM standard of 9.7 NTU by three to 24 times (**Figure 2.5**) (Cook, 2017).

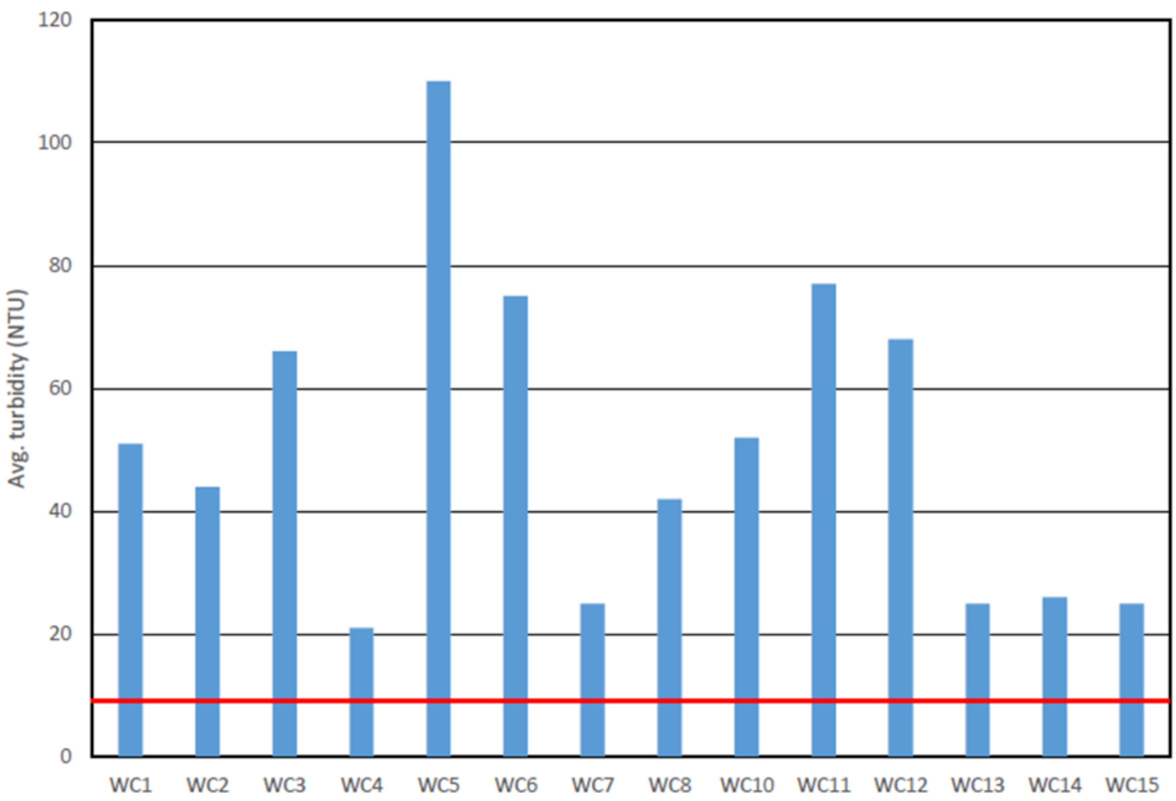

Figure 2.5 Average Turbidity for Wolf Bay Watershed Monitored Sites with ADEM Reference Value (Source: Cook, 2017)

Residents have reported that following rain events, Sandy Creek turns a milky color. While the exact cause is unknown, it is believed that the increase in development has led to an increase in the erosion rate which has uncovered a white clay layer within the stream banks. Another common complaint is related to the turbidity of Wolf Creek. Much of the land under construction in the City of Foley drains into Wolf Creek, providing a potential cause. The City recently passed an ordinance requiring low impact development to reduce runoff into streams. This, coupled with the required water quality component of treating the first inch of rainfall prior to discharge, should result in better water quality (Wolf Bay Watershed Watch, 2017).

2.5 Water Chemistry

2.5.1 pH

Monitoring by the WBWW showed an increase in alkalinity and pH from 1998-2000. Scientists believe this trend can be attributed to the drought cycle occurring at that time (Alabama Coastal Foundation, 2005). Since the drought subsided, 10 years of data show a trend that the water in Wolf Bay is becoming more acidic (Singleton, 2016).

2.5.2 Nutrients

Excessive nutrient enrichment can cause blooms of algae and associated bacteria that can cause taste and odor problems in drinking water and decrease oxygen concentration to eutrophic levels. Certain toxins can also be produced during blooms of particular algal species (Cook, 2017). In 2012, ADEM collected water quality samples from designated sampling points in Miflin Creek, Sandy Creek, Wolf Creek, and Wolf Bay during the growing season of March-October. Mean total nitrogen values at the Wolf Creek station were the lowest for those sites since 2005 but were still the highest among all stations sampled (ADEM, 2014). Cook (2017) found the highest total nitrogen concentrations in sampling locations in Miflin and Sandy creeks. Both of these watersheds are dominated by row crop and turf agricultural land use. The ADEM reference concentration for total nitrogen was exceeded in 83% of samples collected (**Figure 2.6**).

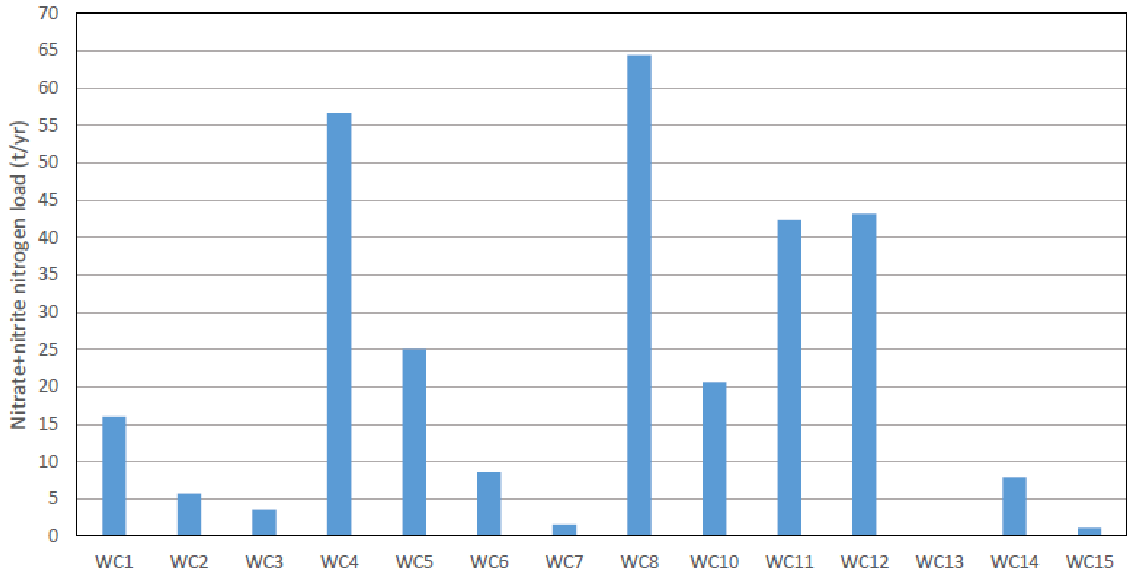

Figure 2.6 Estimated Nitrate+Nitrite Nitrogen Loads for Wolf Bay Watershed Monitored Streams (Source: Cook, 2017)

ADEM (2014) found that total phosphorous values at the Wolf Creek site increased from 2005-2008 but were lower from 2009-2012. Total phosphorous values were still highest for the Wolf Creek site compared to other sites in the 2012 sampling. Cook (2017) found that two of the Wolf Creek monitoring sites exhibited the highest levels of phosphorous among 14 sample sites throughout the Watershed. It was also noted that 10 of the 14 sites had average phosphorous concentrations above the 0.04 mg/L reference established by ADEM (**Figure 2.7**) (Cook, 2017).

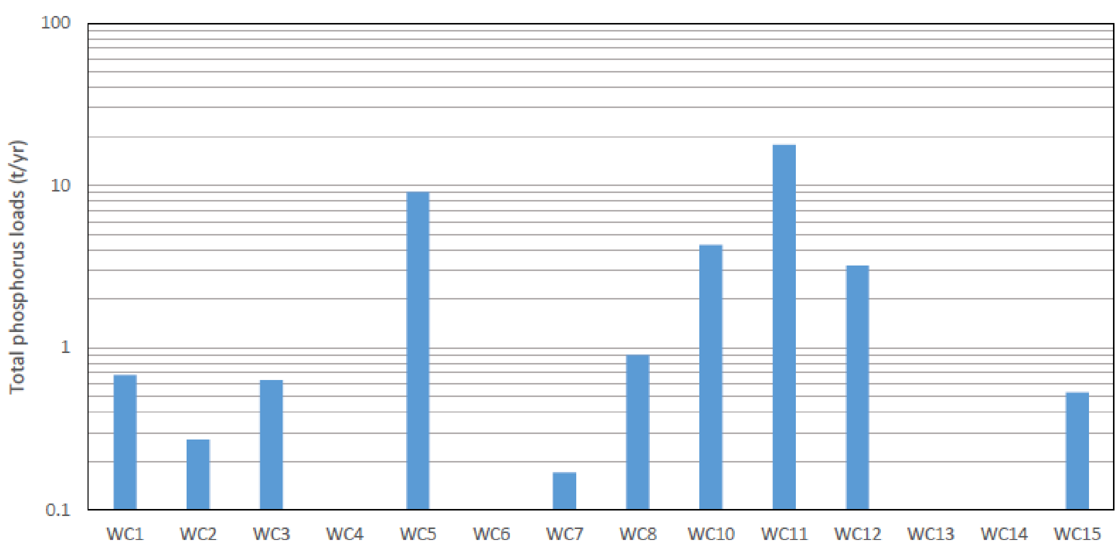

Figure 2.7 Estimated Total Phosphorous Loads for Wolf Bay Watershed Monitored Streams (Source: Cook, 2017)

Relatively high average concentrations and loadings of nitrogen and phosphorus in most of the monitored Wolf Bay Watershed streams originate from sources related to urban, residential, and agricultural land use that dominate specific parts of the Watershed (Cook, 2017).

2.5.3 Dissolved Oxygen

Biological processes contribute to depletion of dissolved oxygen (DO) in surface water. DO concentrations in the Wolf Bay Watershed are significantly affected by water temperature, stream discharge, and concentrations of organic material in the water. The ADEM reference standard for dissolved oxygen is 5.0 mg/L in although the Wolf Bay Watershed is held to a higher standard of 6.94 mg/L, due to its OWA status (Cook, 2017).

In the summer of 2000, citizen data documented a sharp decline in DO in Wolf Creek that was likely due to low flows and stagnancy caused by drought. Data also indicated that DO levels increased to around 6-9 ppm later in the year, when water temperatures decreased and flow increased (Alabama Water Watch, 2002). Growing season averages in 2005 and 2006 indicated poor water quality with dissolved oxygen concentrations of 2.2 ppm in Wolf Creek headwaters in the City of Foley, but they recovered to 7.7 ppm downstream where the Creek empties into Wolf Bay. The low oxygen levels were believed to be the result of contributions of spring water (which are low in oxygen) and discharge from wastewater treatment plants, which depletes DO as organic matter decomposes (AWW, 2007). In 2010, the headwaters of Wolf Creek continued to consistently display extremely low oxygen. To address the issue, the City of Foley partnered with the Mobile Bay National Estuary Program (MBNEP) to perform a natural stream restoration in 2010. Since then, the stream has returned to normal ranges for oxygen (Wolf Bay Watershed Watch, 2017).

Sampling in 2012 showed DO concentrations in Miflin Creek were below the ADEM criteria limit of 5 mg/L for waters designated for “Fish and Wildlife” use in June, August and October. DO concentrations in Wolf Bay were below the criteria in June and July. Sandy Creek was below the criteria for all months sampled. All samples in Wolf Creek were above the ADEM criteria (ADEM, 2014).

Cook (2017) measured DO at 14 monitoring sites throughout the Wolf Bay Watershed from December 2016 through August 2017. During that time, the sampling site at Elberta Creek at Baldwin County Road 83 had the lowest average DO at 6.3 mg/L. Conversely, the sampling point on the unnamed tributary to

Sandy Creek at US Highway 90 had the highest average DO at 8.6 mg/L. Twelve of the 14 sites had measured DO values less than the ADEM reference standard for OAWs of 6.94 mg/L (**Table 2.2**).

Table 2.2 **Dissolved Oxygen Measured in Monitored Streams in the Wolf Bay Watershed (Source: Cook, 2017)**

Site	Dissolved Oxygen (mg/L)			Average DO saturation (% atmospheric saturation)
	Maximum	Minimum	Average	
WC1	9.5	6.1	7.8	89
WC2	8.5	4.9	7.5	88
WC3	8.4	3.8	6.6	76
WC4	9.6	6.6	8.2	94
WC5	9.6	7.9	8.6	97
WC6	9.3	7.0	7.9	89
WC7	7.9	4.5	6.3	71
WC8	8.2	5.5	6.9	77
WC10	8.4	5.2	6.9	77
WC11	9.1	5.4	7.6	85
WC12	8.3	4.5	6.9	77
WC13	9.1	4.8	7.2	81
WC14	8.3	4.2	6.6	74
WC15	N/A[1]	N/A	N/A	N/A

[1] Insufficient number of samples collected.

2.5.4 Pathogens

Five sampling events conducted by the WBWW from 1999-2002 showed that Wolf Creek had unsafe levels of *E. coli* (above 600 colonies/100 mL of water). Levels returned to “safe for frequent human contact” (less than 200 colonies/100 mL of water) after April of 2003 (Alabama Watershed Watch, 2007). Riviera Utilities is working on permitting a major upgrade to their wastewater treatment plant located on Wolf Creek. This upgrade should reduce occurrences of overflows from the plant. Other efforts to reduce pathogens in the Watershed include landowners on North Hammock Creek excluding cows from accessing the stream by installing exclusion fencing and a septic tank workshop was held to provide homes a free pump out voucher to prevent future septic tank failures (Wolf Bay Watershed Watch, 2017).

Cook (2017) collected samples during a low discharge event on August 3, 2017, since during low flow events, impacts of runoff are minimized and bacteria concentrations in streams are more likely to represent point sources, including municipal and industrial wastewater discharge and sewer line leaks. Wolf Creek at Swift Church Road and Wolf Creek at Doc McDuffie Road had the highest most probable number of *E. coli* colonies (mpn) for the low discharge event. The numbers recorded are relatively low for surface water and most likely do not represent any particular pathogen point source. It was noted, however, that when correlated to watershed area, the sampling site at Elberta Creek at Baldwin County Road 83 exhibited relatively high bacteria counts and may represent a source of pathogens above background levels.

2.5.5 Conductance

Generally, specific conductance (SC) was relatively low due to no significant contaminant sources in the Watershed, and most SC measurements were made immediately after precipitation events. Fluctuations of SC in streams with tidal influence correspond to tidal cycles, with relatively high SC at high tide due to salinity and relatively low SC at low tide or at times of large rainfall volumes. Median measured SC for all Watershed sites exceeded the ADEM standard of 20.4 mS/cm (Cook, 2017).

2.6 Conclusion

Cook (2017) concluded that when all parameters are considered with respect to water quality and potential remediation and restoration, watersheds upstream from Wolf Creek sites at Doc McDuffie Road and Swift Church Road and the unnamed tributaries to Sandy Creek from sites along US Highway 98 have the highest degree of impairment and should be considered primary targets for remediation and restoration.

Future research efforts by Dr. Chris Anderson (Auburn University) and others will provide data on the effects of management actions undertaken as a result of this WMP. Continued research is vital to determine which management actions are having a positive impact and which actions need to be modified to achieve the desired outcome or improvement.

Chapter 3 Community Engagement

3.1 Public Participation

Input from and participation of residents, municipal representatives, community business leaders, recreational users, and other stakeholders is a vital component in the development of a comprehensive WMP. People from various backgrounds bring different perspectives to the WMP planning and development process, which leads to a better, more robust plan. Participation by stakeholders leads to a feeling of ownership of the plan for managing the Watershed, resulting in a willingness to participate in actions and initiatives that protect the resources found within it. Public participation is invaluable to the WMP Team because it provides a local perspective on issues facing the Watershed that might not have been known otherwise. Similarly, community participation also provides critical insight about which management measures and implementation strategies should be prioritized and would have the best chance of success. The Wolf Bay Watershed Team made every effort to include the Watershed communities and other stakeholders in every phase of the planning and development process along the way.

3.1.1 Steering Committee Membership

The first step in our community engagement strategy was the formation of a Steering Committee representing the varied interests across the Watershed. A diverse and passionate committee of local, state, and federal representatives was engaged to form the Wolf Bay Steering Committee. **Table 3.1** includes the members and their affiliations.

Table 3.1 **Wolf Bay Steering Committee Members and Affiliated Organizations**

Name	Affiliation	Email Address
Ralph Hellmich	City of Foley	RHellmich@ogb.state.al.us
Phillip Hinesley	Sea Grant/Tourism	PHinesley@gulfshores.com
Tony Schachle	Riviera Utilities	tschachle@rivierautilities.com
Christian Miller	Mobile Bay National Estuary Program	cmiller@mobilebaynep.com
Leslie Gahagan	City of Foley and Wolf Bay Watershed Watch	lgahagan@cityoffoley.org
Jackie McGonigal	Wolf Bay Watershed Watch	jackie@gulfcenter.org

Name	Affiliation	Email Address
Shannon McGlynn	Alabama Department of Environmental Management	smcglynn@adem.alabama.gov
Casey Fulford	Baldwin County Soil and Water Conservation District	casey@alconservationdistricts.org
Patric Harper	U.S. Fish and Wildlife Service	Patric_Harper@fws.gov
Homer Singleton	Wolf Bay Watershed Watch	1fishawk@gmail.com
Paul Hopper	Town of Elberta	phopper@townofelberta.com
Caryn Woerner	Town of Elberta	cwoerner@townofelberta.com
Leah Tucker	Elberta High School	lktucker@bcbe.org
Will Underwood	Alabama Department of Conservation and Natural Resources	will.underwood@dcnr.alabama.gov

3.1.2 Steering Committee Meetings

The 14-member Steering Committee was the driving force behind the direction and focus of Wolf Bay WMP development. Throughout the process, the Steering Committee provided direction to the WMP Team on the priorities that needed to be addressed and provided insight about techniques and strategies that should be implemented. Three Steering Committee meetings were held during the planning process:

Steering Committee Meeting #1: The first Steering Committee meeting was held on June 18, 2018 at Graham Creek Nature Preserve. Agenda items for the meeting included:

- Introducing committee members to the project.
- Providing a project overview.
- Obtaining input on community engagement and outreach.
- Discussing known critical issues and concerns.

Steering Committee Meeting #2: The second Steering Committee meeting was held September 17, 2019 at Graham Creek Nature Preserve. Meeting highlights included:

- Review of plan progress to date including stakeholder engagement.
- Discussion on the findings of the Climate Vulnerability Analysis.
- Reporting on observations noted during field assessments.

Steering Committee Meeting #3: The third Steering Committee meeting was held on February 11, 2020 at Graham Creek Nature Preserve. Committee members were asked to provide input on:

- Prioritization of critical issues and concerns identified through stakeholder engagement, literature reviews, and field assessment.
- Potential management measures and projects to address critical issues and concerns.

See **Appendix B, Section I** for minutes from the Steering Committee meetings.

3.2 Community Engagement and Outreach

3.2.1 Stakeholder Involvement Meetings

Building on suggestions from the Steering Committee, the WMP team attended several small community meetings and events and hosted one large meeting to inform the community about the project and gather input. Small group meetings and community events attended are listed in **Table 3.2**.

Table 3.2 Small Group and Community Events Attended to Gather Input for the Wolf Bay WMP

Event	Location	Date
Voting/Polling Location	Graham Creek Nature Preserve	July 7, 2018
City of Foley Planning Commission Work Session	Foley City Hall	August 8,2018
PLAN Meeting	Graham Creek Nature Preserve	August 9, 2018
Town of Elberta Council Workshop Meeting	Elberta Town Hall	August 14, 2018
Wolf Bay Watershed Watch Annual Meeting	Graham Creek Nature Preserve	February 2, 2019
Wolf Bay Watershed Watch Annual Fishing Tournament	Graham Creek Nature Preserve	November 2, 2019
Wolf Bay Watershed Watch Annual Meeting	Graham Creek Nature Preserve	January 25, 2020

One large community meeting was held on October 2, 2018, at the Graham Creek Nature Preserve (**Figure 3.1**). Participants were asked to identify planning priorities within the Watershed. Priorities identified were:

- Conservation/restoration
- Water quality
- Stormwater management
- Sustainable development planning
- Flooding/wastewater overflows
- Retrofitting for green infrastructure
- Ecotourism and recreation
- Education
- Access to the Watershed
- Groundwater protection/recharge
- Sea level rise/climate change

Figure 3.1 Community Outreach Meeting held at Graham Creek Nature Preserve

Participants were then asked to vote for their top four priorities. The top priority to address in the WMP was to identify conservation/restoration opportunities; the second and third priorities were to improve water quality and stormwater management, respectively; and the fourth priority was to implement sustainable development planning concepts. Attendees were also asked to place stars on maps placed on tables around the room to identify potential critical issues or areas. Although pertinent information was gained from the meeting, a second meeting was not scheduled, due to the low attendance.

3.2.2 Community Outreach Tools

The WMP Team prepared and submitted an article that was included in the City of Foley Summer 2018 Newsletter that described the planning process and encouraged participation in the planning effort. The Team also developed a watershed fact sheet along with an online survey to be used during early community engagements. The survey was created to gather general perceptions of the Watershed and to gain input regarding known critical issues and areas, potential management measures, and recreational use in the Watershed. A link to the survey was emailed to numerous stakeholders and provided in hard copy form during community engagements. Over 100 survey responses were received. A summary of the findings is provided below.

- The majority of the respondents live in the Watershed.
- Approximately half of the respondents have lived in the Watershed for more than ten years.
- 59% of the respondents believe the Watershed is in good overall condition.
- 69% of the respondents believe the recreational opportunities need improvement.
- Most desired areas for recreational improvement include boat, canoe, and kayak launches; hiking/biking trails; parking; camping areas; and signage.
- 78% of the respondents use the Watershed for recreational fishing and would use a public access point if provided.
- The prioritized desired management actions were as follows: 1. Land Preservation, 2. Regional Detention, 3. Stream Restoration, 4. Living Shorelines, 5. Stream Buffers, 6. Litter Traps, 7. Nutrient Reduction, 8. Invasive Species Control, and 9. Public Access Improvements.
- 47% of respondents would support a permit or user fee, and 42% would support municipal bonds.
- 87% of respondents would attend a watershed educational workshop.

A link to a second online survey was distributed in January 2020 to rank the critical issues and concerns identified in the Watershed. The survey was also distributed to the Steering Committee and the email distribution list for the WBWW. According to the 20 respondents of the second survey, the issues facing the Watershed were ranked as follows:

1. Water Quality
2. Future Development
3. Litter
4. Invasive Species
5. Stream Navigability
6. Public Recreation

A Wolf Bay Watershed fact sheet along with survey questions and results can be found in **Appendix B, Section II**.

3.3 Conclusions for Community Engagement

Most stakeholders believe the Watershed is in good shape, overall. The majority of people who utilize the surface waters of the Watershed do so for recreational purposes. The primary concerns expressed by the Steering Committee and other stakeholders include maintaining a high level of water quality in the face of continued development throughout the Watershed. Stakeholders also felt strongly about improving access to the Watershed for recreation. The majority of stakeholders would support increasing public access and expanding recreational opportunities; would volunteer to monitor or serve on a watershed group; and would participate in educational workshops. In summary, the Wolf Bay Watershed is believed to be a treasured resource and stakeholders showed a strong desire for the WMP to focus on preserving the Watershed conditions and character.

Chapter 4 Watershed Characterization

Characterizing the Watershed is an important step in the watershed planning process. It provides information on the current conditions of the Watershed and provides a baseline to gauge the needs for corrective actions to address critical issues.

4.1 Watershed Boundary

The Wolf Bay Watershed is located in south-central Baldwin County, Alabama, between Perdido Bay to the east and Bon Secour Bay to the west. The focus of this WMP is a complex comprising the three northern 12-digit HUC sub-watersheds draining to Wolf Bay: the 15,199-acre (23.75 square mile) Sandy/Wolf Creek Watershed (HUC_12 031401070201, the 8,427-acre (13.17 square mile) Miflin Creek Watershed (HUC_12 031401070202), and the 12,670-acres (19.8 square mile) Graham Bayou Watershed (HUC_12 031401070203) (**Figure 4.1**).

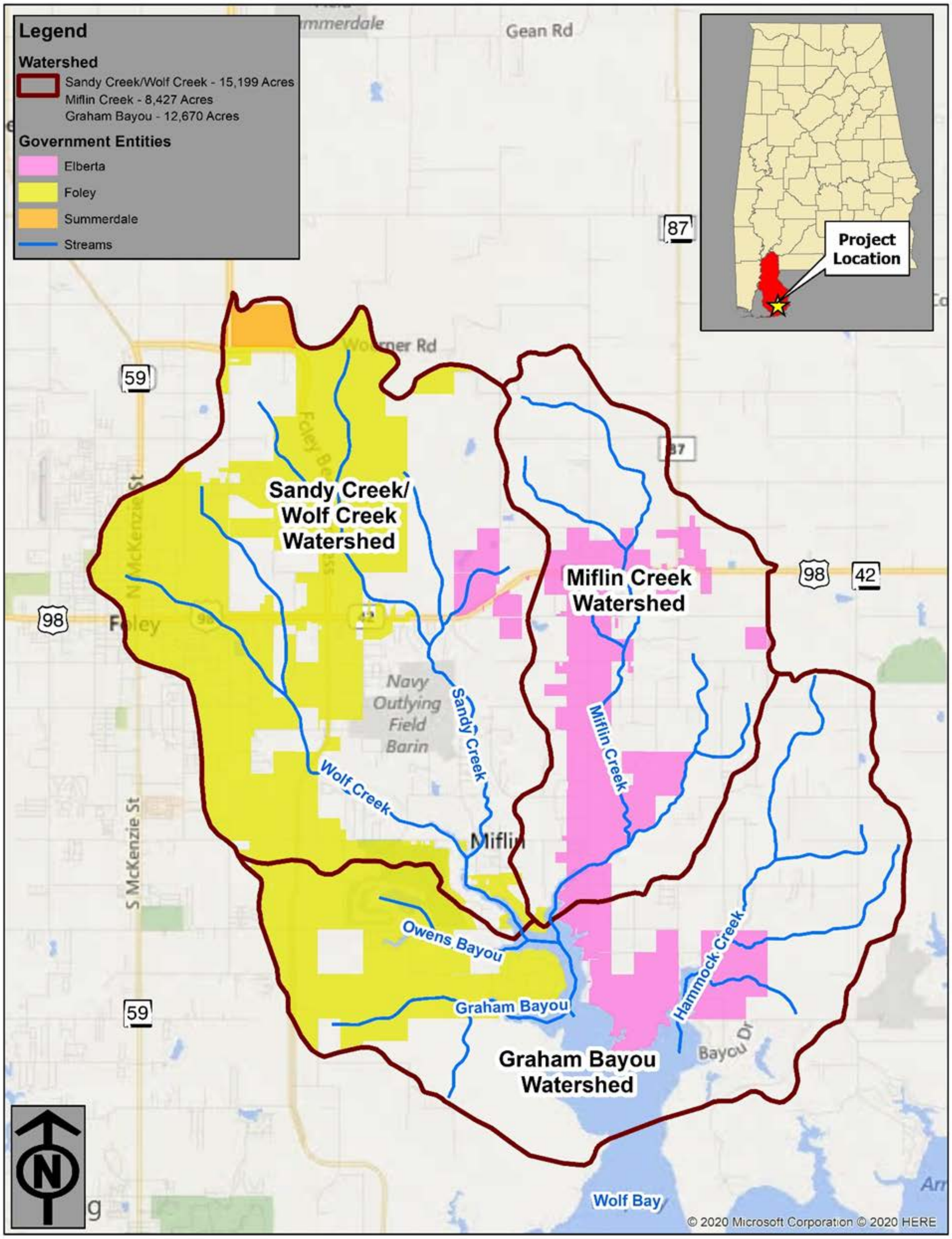

Figure 4.1 Boundary of the Wolf Bay Watershed Including Sub-Watersheds and Government Entities

4.2 Physical Setting

4.2.1 Physiography

The Watershed encompasses portions of the Southern Pine Hills and Coastal Lowlands physiographic provinces (**Figure 4.2**). The Southern Pine Hills physiographic province consists of mostly upland areas, while the Coastal Lowlands province is primarily flat with some very gently undulating areas. The boundary of the Coastal Lowlands and the Southern Pine Hills is defined by the Pamlico marine scarp (Jones 2004).

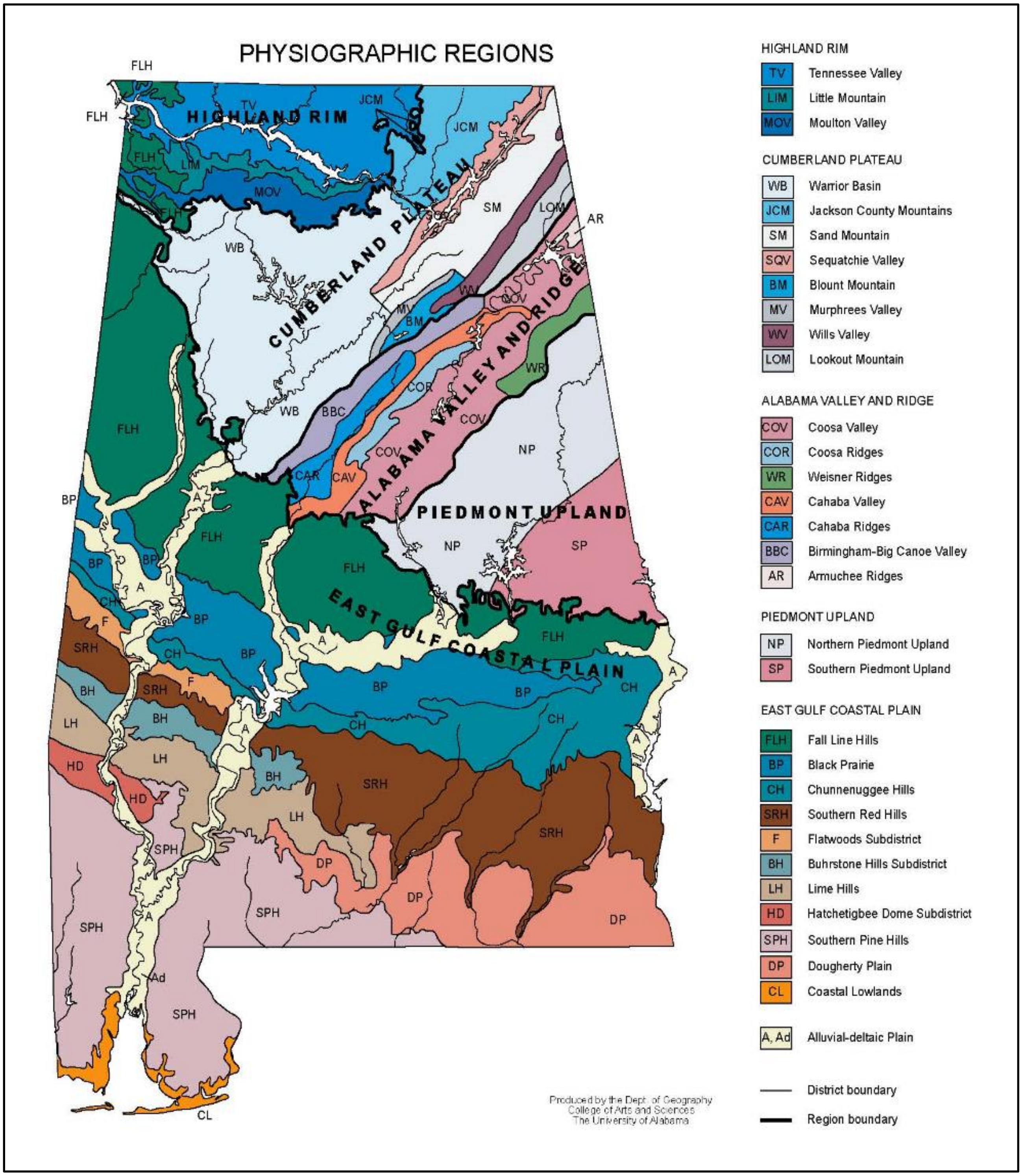

Figure 4.2 Alabama Physiographic Provinces (Source: University of Alabama, 2016)

4.2.2 Geology

Geologic formations are the underlying layers of rock beneath the earth's surface. These layers are defined according to their age and composition. Knowledge of underlying geologic formations is important for understanding watershed conditions and is used for sustainable land-use planning because the varying properties of geologic formations determine: 1) the quantity and quality of groundwater that can be withdrawn in an area and 2) the types of land use activities that occur in a given area (e.g., agriculture or urban development). This is largely due to the fact that each geologic unit is associated with certain aquifers and soil types. Two geologic formations underlie the Watershed—the Citronelle Formation and alluvial, coastal, low terrace deposits (**Figure 4.3**).

The Citronelle Formation ranges from middle Pliocene to pre-Nebraskan Pleistocene in age. Citronelle sediments consist of non-fossiliferous, moderate-reddish-brown, fine-to-very-coarse quartz sand; light-gray, orange, and brown sandy clay; and clayey gravel of non-marine origin. In many areas, layers of sandy clay and clayey sand, which range in thickness from 5 to 15 feet, are interbedded with gravelly sand. Sediment type, specifically clay content, often changes abruptly over short distances. Gravels of the Citronelle Formation generally consist of quartzite and chert (Gillett et al. 2000).

Alluvial, low terrace, and coastal deposits consist of very-fine-to-coarse sand that is gravelly in many exposures. Sediments consist of very-fine-to-coarse sand that is sometimes gravelly in nature, interbedded with clay and sandy clay. Thickness of the alluvial, low terrace, and coastal deposits is believed to range from zero to 200 feet (Gillett et al. 2000).

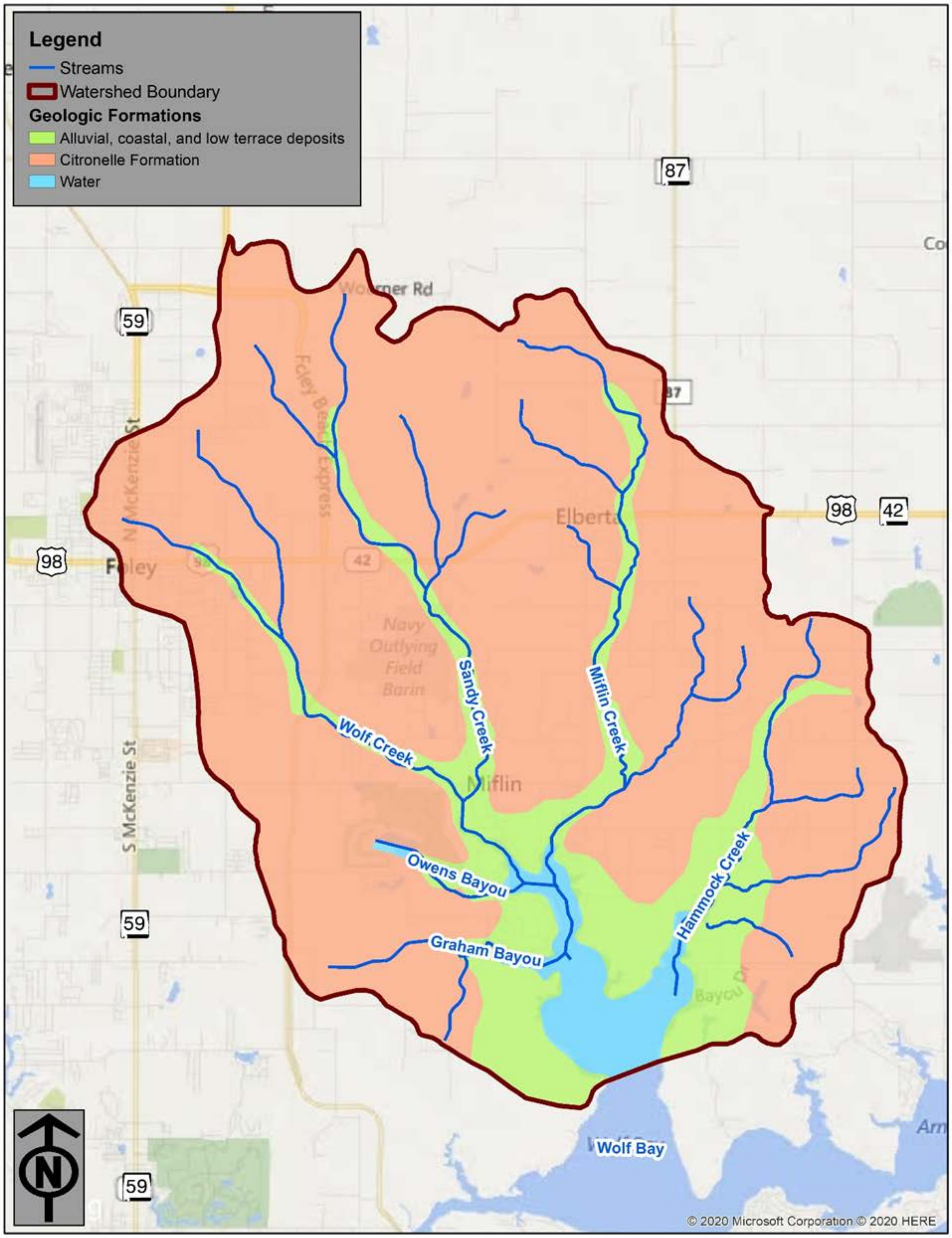

Figure 4.3 Geologic Formations of the Wolf Bay Watershed

4.2.3 Topography

The topography in the upper portion of the Watershed is relatively high, with the maximum elevation approximately 100 ft above mean sea level. Moving southward through the Watershed, the topography gradually declines, with the lower portion of the Watershed having minimal changes in elevation.

4.2.4 Soils

Soils are an important element of watersheds, because they influence surface water flow and groundwater recharge rates. Soil types also determine land uses within watersheds, because certain soil types are more suitable for specific uses, such as agriculture or urban and residential development, than others. Because a diverse range of soil types is often present within a given geographic area, soils have been grouped into soil associations and illustrated on a general map presented as **Figure 4.4**. This map is useful to people who want a general idea of soils, to compare different parts of a county, or to know the possible location of areas suitable for a certain kind of farming or other land use (USDA 1964).

Two soil associations encompass the Watershed – the Lakeland-Plummer association and the Norfolk-Klej-Goldboro association. The properties of and suitable land use for each of these soil associations are described in more detail below.

The Lakeland-Plummer association consists of nearly level, poorly-drained-to-very-poorly drained soils of bottom lands and of gently sloping to moderately steep, somewhat-excessively drained, loamy-fine sands of the uplands. These areas are along creeks and rivers in the southern and eastern parts of Baldwin County. In some places, the soils in this association developed in unconsolidated Coastal Plain material. In other places they developed in alluvium washed from soils formed in Coastal Plain material. A large acreage in this association is probably best suited to pines and has little potential for row crops (USDA 1964).

The Norfolk-Klej-Goldsboro association primarily consists of nearly level or very-gently sloping soils of uplands and of soils of the associated bottom lands. It is located in the southern and southeastern parts of Baldwin County near Foley and Elberta. In some places, the soils developed in unconsolidated Coastal Plain material. In other places they developed in alluvium that washed from soils formed in the Coastal Plain. This association is located within the second most important agricultural area in the County. It is well suited for row crops, as well as pastureland (USDA 1964).

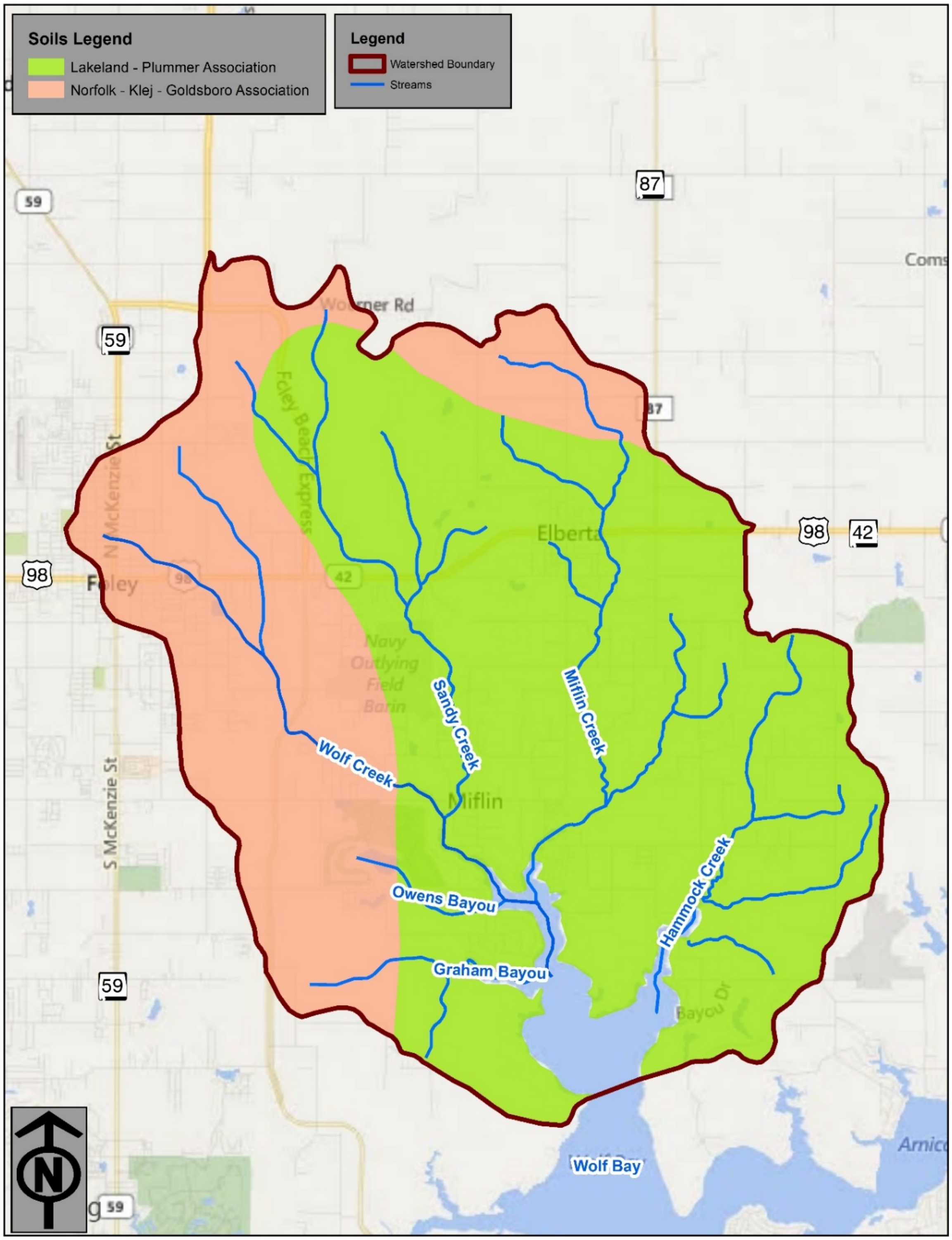

Figure 4.4 **USDA Soils Associations Map**

4.3 Hydrology

4.3.1 Climate & Rainfall

Baldwin County has a mild, but humid, climate with average annual rainfall of approximately 61 inches (Hydro Engineering Solutions, 2013). In the contiguous United States, the region is second only to the Pacific Northwest in total annual rainfall, with the frequency of thunderstorms over coastal Alabama being surpassed only by the Florida peninsula (Wolf Bay Plan, 2005). The summer months are typically the wettest, with the driest months typically in the winter. Annual rainfall is generally well-distributed, although significant rain events can be experienced due to proximity to the coast and exposure to hurricanes and tropical storms. On average, the warmest month is July, and the coldest is January (Hydro Engineering Solutions, 2013). **Table 4.1** shows the mean monthly temperature and precipitation values for the city of Foley, which is representative of the Watershed, as reported by Intellicast.

Table 4.1 **Mean Annual Temperature and Precipitation in Foley, Baldwin County, Alabama (Source: Intellicast, 2019)**

Month	High Temperature (°F)	Low Temperature (°F)	Precipitation (inches)
January	61	39	6.14
February	65	41	5.08
March	71	47	6.94
April	77	53	4.49
May	84	61	4.97
June	89	68	5.44
July	91	71	8.37
August	90	71	6.71
September	87	67	6.43
October	80	55	3.66
November	71	47	5.54
December	63	41	4.15

4.3.2 Surface Water Resources

Surface waters include bodies of water on the earth's surface (as opposed to underground), such as rivers, streams, lakes, and ponds. Surface waters are a critical resource within any watershed and may be used for drinking water supplies, agriculture, industrial uses, navigation, or recreation. The major surface water resources in the Watershed are the upper portion of Wolf Bay (also known as Moccasin Bayou), Wolf Creek, Sandy Creek, Miflin Creek, Graham Bayou, Owens Bayou, and Hammock Creek. Within the

Watershed, surface waters have a general flow pattern and direction, which channel waters within boundaries to the lower points of elevation. In the case of the Wolf Bay Watershed, Owen’s Bayou collects the water from Wolf, Sandy and Miflin creeks. From there, Owen’s Bayou, Graham Bayou and Hammock Creek discharge to the lowest point of elevation, Wolf Bay. Surface waters are replenished during precipitation events or by springs (points where groundwater flows to the surface). **Figure 4.5** shows the major surface water resources within the Watershed.

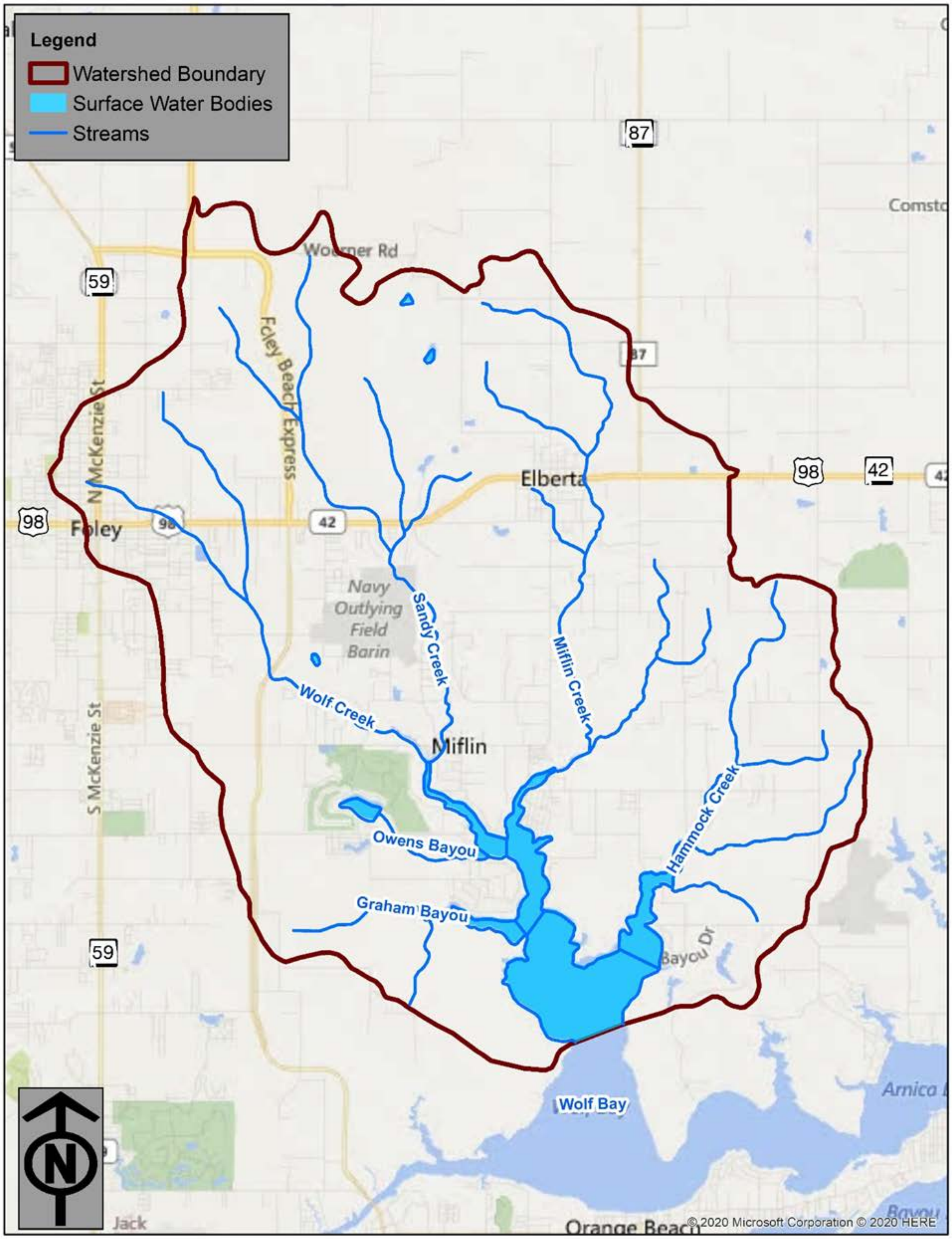

Figure 4.5 Surface Waters Within Wolf Bay Watershed

4.3.3 Ground Water Resources

Groundwater resources are critical to understanding watershed conditions and for sustainable land use planning, because they affect surface water features and can are useful in determining the types and intensities of specific land uses in the watersheds.

This Watershed is underlain by two major aquifers—the Miocene-Pliocene aquifer and the watercourse aquifer (sometimes referred to as the Beach Sand aquifer), shown in **Figure 4.6**. The Miocene-Pliocene aquifer is associated with the Citronelle Formation and is approximately 3,400 feet thick in southern Baldwin County. Groundwater from the Miocene-Pliocene aquifer is generally soft and low in dissolved solids but may contain iron in excess of 0.3 milligram per liter (mg/L) and be corrosive. However, dissolved solids and chloride content generally increase closer to the coastal areas of the Watershed. The Miocene-Pliocene aquifer may yield more than 2 million gallons of water per day at each well. According to the Alabama Department of Environmental Management's (ADEM's) GIS database, there are eight permitted public drinking water wells located within the Watershed.

The watercourse aquifer is associated with alluvial, low-terrace, and coastal deposits. Groundwater from the watercourse aquifer is generally much harder than that of the Miocene-Pliocene aquifer and is high in iron, chloride, and dissolved solids, particularly in extreme coastal areas. It is also highly acidic and may be corrosive. Wells in this aquifer may yield up to 10 gallons per minute.

The recharge areas for both aquifers include all of Mobile and Baldwin counties and parts of Washington County. Rainfall is the major source of recharge for these aquifers. The Miocene-Pliocene and watercourse aquifers are considered to be unconfined, because they are hydraulically connected to the land surface by sand and gravel beds. Because sand units between the two aquifers are not completely separated by clay lenses, the watercourse aquifer locally provides recharge for the underlying Miocene-Pliocene aquifer (Gillett et al. 2000).

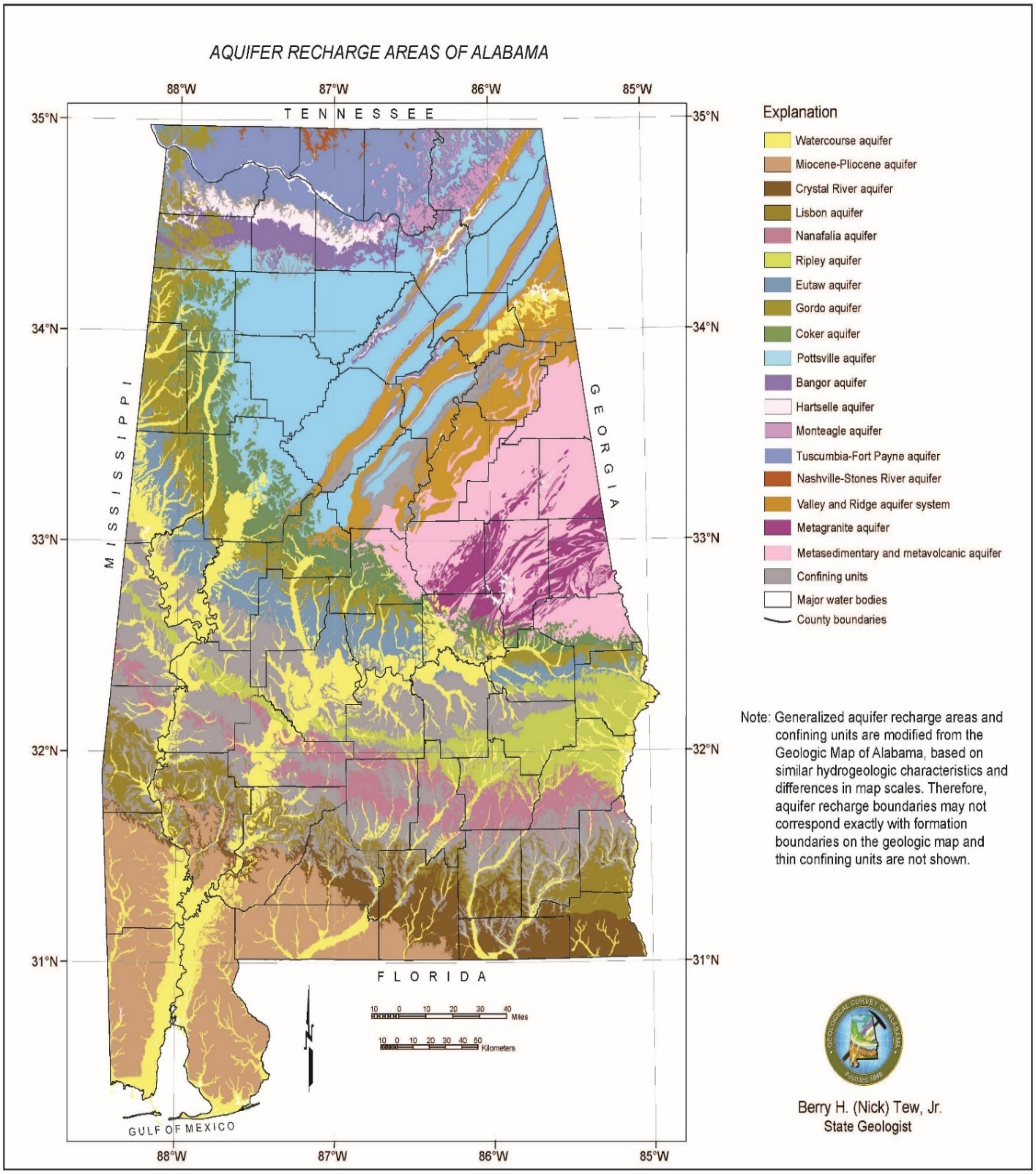

Figure 4.6 Aquifer Recharge Areas (Source: Geological Survey of Alabama, 2018)

4.4 Floodplains and FEMA Flood Zones

Floodplains are low-lying areas adjacent to rivers, bays, or other waterbodies that are subject to periodic flooding. The Federal Emergency Management Administration (FEMA) designates flood zones based on the frequency and probability of flooding. **Figure 4.7** shows the 500-year, 100-year, and regulated floodway designations for the Watershed. Areas located within the 500-year flood zone have a 0.2% annual chance of flooding. Areas within the 100-year flood zone have a 1% annual chance of flooding. Regulated floodways are the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights (FEMA 2019).

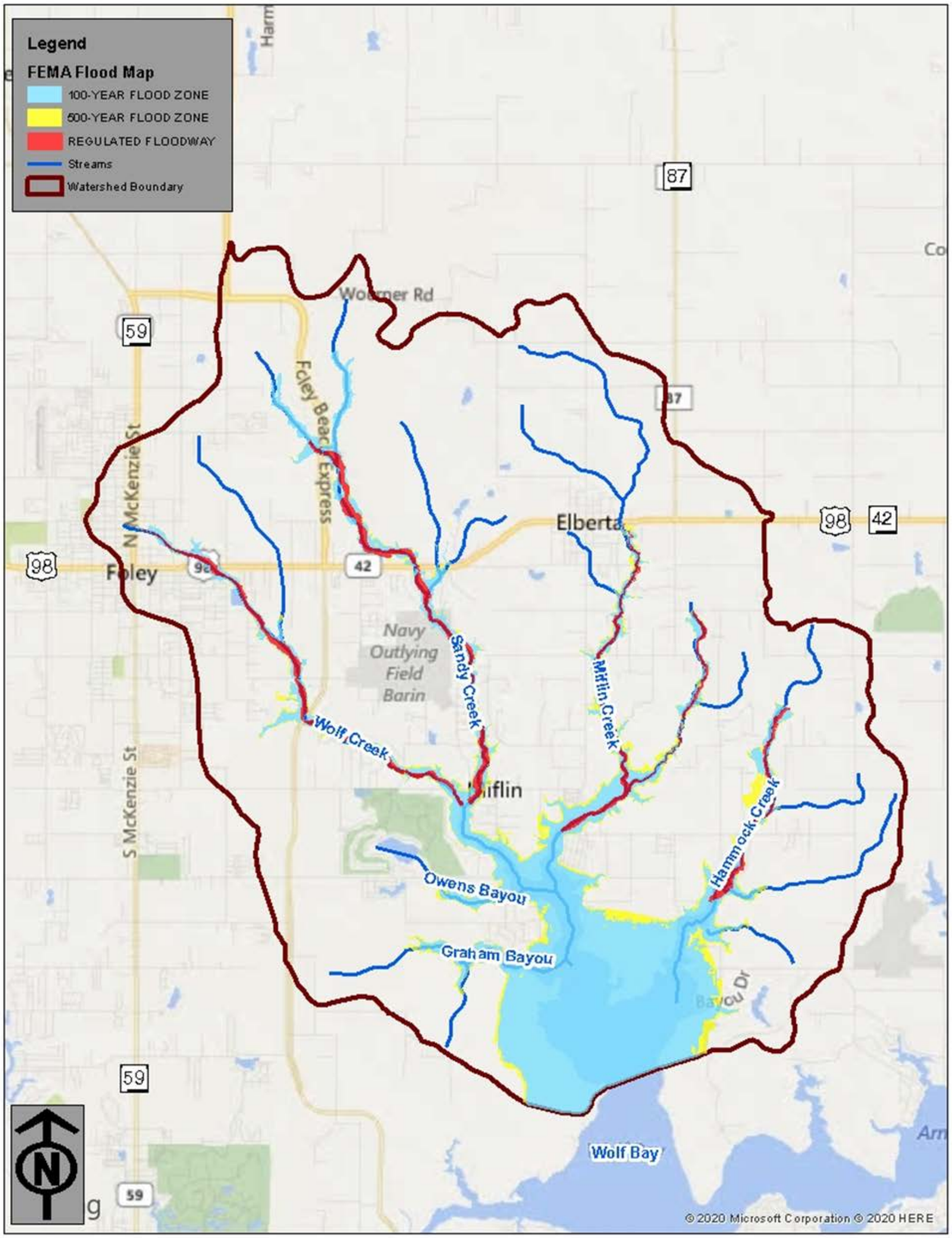

Figure 4.7 FEMA Flood Zones Within Wolf Bay Watershed

4.5 Streams

As discussed previously in Section 4.3.2, there are six major streams in the Watershed. These streams are perennial and can be characterized as low-gradient, sandy-bottom streams with broad floodplains. **Table 4.2** reflects the length of each stream and the drainage areas associated with each one.

Table 4.2 **Watershed Stream Lengths and Associated Drainage Areas**

Stream	Length (ft)	Drainage Area (ac)
Wolf Creek	49,166	6,184
Sandy Creek	42,368	8,579
Owens Bayou	12,029	1,442
Hammock Creek	32,805	3,676
Graham Bayou	15,041	2,061
Miflin Creek	50,603	8,438

4.6 Habitats

A habitat is a type of natural environment characterized by physical and biological factors and utilized by resident fauna. Physical factors include soil type, humidity, range of temperature, hydrologic and geological features. Biological components can include availability of food, refuge, nursery area, or the presence/absence of predators. Habitats are not necessarily geographical locations, and they change over time.

4.6.1 Uplands

A vast majority of the forested uplands in the Watershed have historically been cleared for agriculture or development. According to National Land Cover Database (NLCD) 2016 land cover imagery, forested upland areas that remain intact include evergreen forest, shrub/scrub, mixed forest, and deciduous forest making up 23% of the Watershed.

4.6.2 Wetlands

Wetlands, as defined by the U.S. Army Corps of Engineers (33 CFR 328.3) and the U.S. Environmental Protection Agency (40 CFR 230.3), are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and other similar areas. Wetlands found in coastal Alabama provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. They also help improve surface water quality by filtering and retaining residential, agricultural, and urban wastes, as well as providing a buffer against storm and wave damage and helping stabilize shorelines (USEPA, 2019). The four types of wetlands found in the Watershed include palustrine wetlands, estuarine wetlands, riverine wetlands, and lacustrine wetlands as shown in **Figure 4.8**. These four wetland types are described below.

4.6.2.1 Palustrine Wetlands

The palustrine system includes all nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand (ppt) (USFWS, 2019a). According to USFWS's National Wetland Inventory (NWI) data, there are approximately 2,969 acres of palustrine wetlands found in the Watershed. Of these wetlands, 2,544 acres (86%) are considered freshwater forested/shrub wetlands, 253 acres (9%) are considered freshwater ponds, and 172 acres (6%) are considered freshwater emergent wetlands.

4.6.2.2 Estuarine Wetlands

The estuarine system consists of deep-water tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (USFWS, 2019b). According to the USFWS's NWI data, there are approximately 284 acres of estuarine wetlands located in the Watershed.

4.6.2.3 Riverine Wetlands

The riverine system includes all wetlands and deep-water habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 ppt (USFWS, 2019c). According to the USFWS's NWI data, there are approximately 233 acres of riverine wetlands found in the Watershed.

4.6.2.4 Lacustrine Wetlands

The lacustrine system includes wetlands and deep-water habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergent vegetation, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 hectares (ha) (~20 acres) (USFWS, 2019d). According to the USFWS's NWI data, there are approximately 54 acres of lacustrine wetlands in the Watershed.

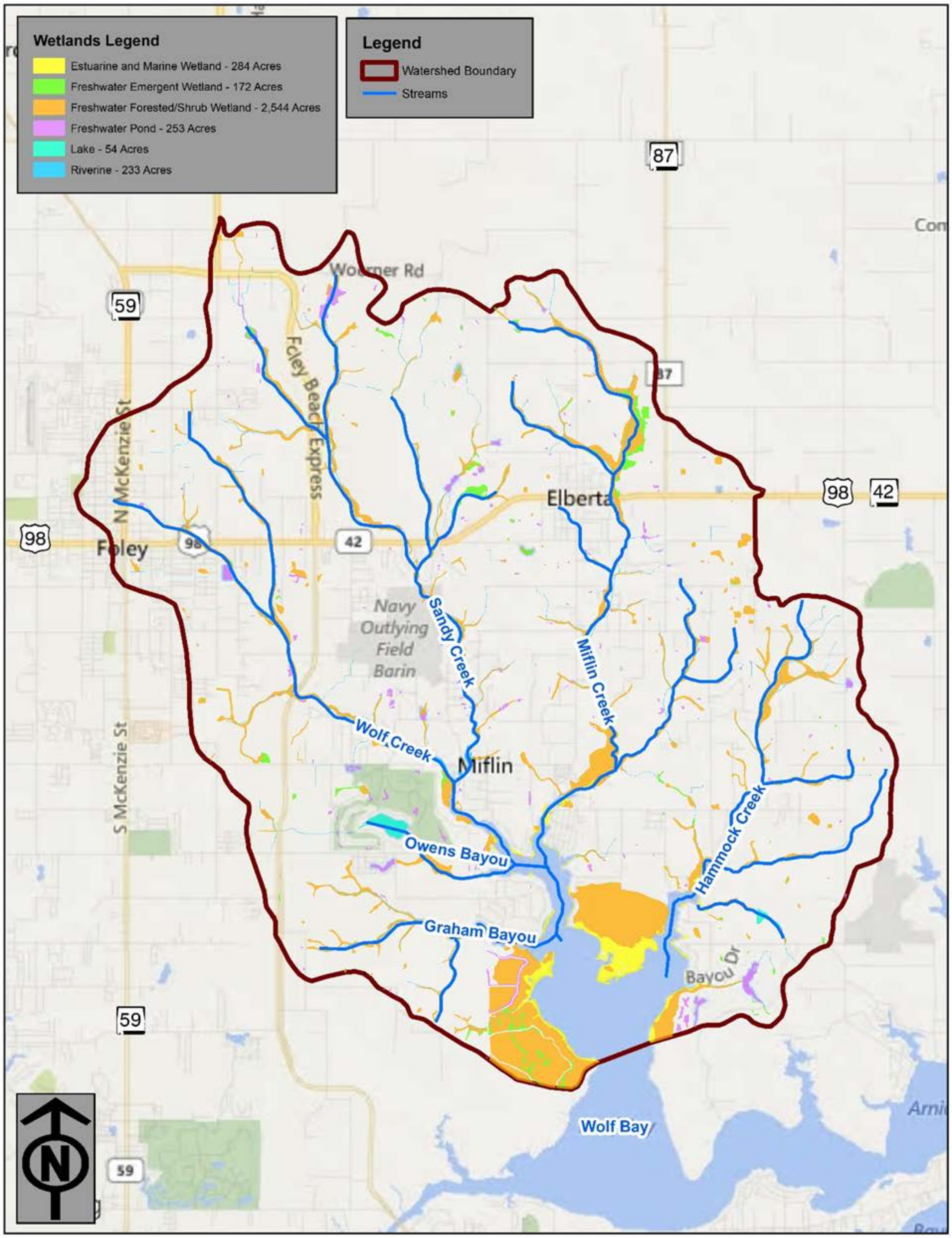

Figure 4.8 USFWS National Wetland Inventory Map

4.7 Biological Resources

4.7.1 Flora

Native vegetation typically found within the upland forests of the Watershed include longleaf pine (*Pinus palustris*), loblolly pine (*Pinus taeda*), southern magnolia (*Magnolia grandiflora*), live oak (*Quercus virginiana*), yaupon holly (*Ilex vomitoria*), sparkleberry (*Vaccinium arboretum*), American holly (*Ilex opaca*), and bracken fern (*Pteridium aquilinum*).

Native vegetation found in wetlands varies, depending on wetland habitat type. Wet pine flats typically contain wiregrass (*Aristida spp.*), pitcher plants (*Sarracenia spp.*) (**Figure 4.9**), yellowed grass (*Xyris spp.*) sedges, *Carex spp.*, pipewort (*Eriocaulon spp.*), foxtail (*Lycopodium spp.*), and pine (*Pinus spp.*). Bayhead drain wetlands consist of sweetbay magnolia (*Magnolia virginiana*), red maple (*Acer rubrum*), swamp titi (*Cyrilla racemiflora*), wax myrtle (*Myrica cerifera*), slash pine (*Pinus elliottii*), water oak (*Quercus nigra*). Bottomland hardwood wetlands typically include bald cypress (*Taxodium distichum*), black gum (*Nyssa sylvatica*), tulip poplar (*Liriodendron tulipifera*), cinnamon fern (*Osmunda cinnamomea*), chain fern (*Woodwardia spp.*), and royal fern *(Osmunda regalis*). Freshwater emergent wetlands are mostly dominated by soft rush (*Juncus effuses*) and bulrushes (*Scirpus spp.*). Estuarine wetlands are typically dominated by black needle rush *(Juncus roemerianus*) and saltmarsh cordgrass (*Spartina alterniflora).*

Figure 4.9 Purple Pitcher Plant (*Sarracenia purpurea*) in the Wolf Bay Watershed

4.7.2 Fauna

Common mammal species known to occur in the Watershed include the common gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), rabbit (*Sylvilagus floridanus*), nine-banded armadillo (*Dasypus novemcinctus*), Virginia opossum (*Didelphis virginia*), and whitetail deer (*Odocoileus virginianus*). Herpetofauna species found in the Watershed include the black racer (*Coluber constrictor*), cottonmouth/water mocassin (*Agkistrodon piscivorus*), five-lined skink (*Eumeces fasciatus*), snapping turtle (*Chelydra serpentina serpentina*), yellow-bellied slider (*Trachemys scripta scripta*), and American alligator (*Alligator mississippiensis*). Common fish species include red drum (*Sciaenops ocellatus*), speckled trout (*Cynoscion nebulosus*), mullet (*Mugil cephalus*), and bream (*Abramis brama*).

The coastal region of Alabama is especially important for migratory birds, which use the area as stopover habitat during spring and fall migrations between North America and Central and South America. **Table 4.3** lists migratory birds likely to occur in the Watershed that are of priority concern.

Table 4.3 Migratory Birds of Concern in the Wolf Bay Watershed

Species
American Kestrel (*Falco sparverius paulus*)
American Oystercatcher (*Haematopus palliates*)
Bachman’s Sparrow (*Aimophila aestivalis*)
Bald Eagle (*Haliaeetus leucocephalus*)
Black Skimmer (*Rynchops niger*)
Bonaparte’s Gull (*Chroicocephalus philadelphia*)
Brown Pelican (*Pelecanus occidentalis*)
Cerulean Warbler (*Dendroica cerulea*)
Clapper Rail (*Rallus crepitans*)
Common Ground-dove (*Columbina passerine exigua*)
Common Loon (*Gavia immer*)
Common Tern (*Sterna hirundo*)
Double-crested Cormorant (*Phalacrocorax auritus*)
Dunlin (*Calidris alpine arcticola*)
Gull-billed Tern (*Gelochelidon nilotica*)
Herring Gull (*Larus argentatus*)
Kentucky Warbler (*Oporornis formosus*)
Least Tern (*Sterna antillarum*)
Lesser Yellowlegs (*Tringa flavipes*)
Northern Gannet (*Morus bassanus*)
Prairie Warbler (*Dendroica discolor*)
Prothonotary Warbler (*Protonotaria citrea*)
Red-breasted Merganser (*Mergus serrator*)
Red-headed Woodpecker (*M. erythrocephalus*)
Ring-billed Gull (*Larus delawarensis*)
Royal Tern (*Thalasseus maximus*)
Ruddy Turnstone (*Arenaria interpres morinella*)
Short-billed Dowitcher (*Limnodromus griseus*)
Swallow-tailed Kite (*Elanoides forficatus*)
Willet (*Tringa semipalmata*)
Wood Thrush (*Hylocichla mustelina*)

4.7.3 Threatened and Endangered Species

The Endangered Species Act of 1973 (ESA) provides for the conservation of species designated by USFWS as endangered or threatened throughout all or a significant portion of their range and the ecosystems upon which they depend. The ESA prohibits take of any endangered or threatened species, where “take” is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” When a species is listed as endangered or threatened under the ESA, USFWS can also designate critical habitat, which is defined as “a specific geographic area(s) that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection."

The USFWS Information for Planning and Consultation (IPaC) project planning tool identified 10 species listed as endangered or threatened that could potentially occur in the Watershed (**Table 4.4**). There are no designated critical habits within the Watershed.

Table 4.4 Federally Listed Threatened and Endangered Species

Common Name	Scientific Name	Status
Birds		
Piping plover	*Charadrius melodus*	Threatened
Red knot	*Calidris canutus rufa*	Threatened
Wood stork	*Mycteria americana*	Threatened
Mammals		
West Indian manatee	*Trichechus manatus*	Threatened
Reptiles		
Alabama red-bellied turtle	*Pseudemys alabamensis*	Endangered
Eastern indigo snake	*Drymarchon corais couperi*	Threatened
Gopher tortoise	*Gopherus polyphemus*	Candidate
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Fish		
Gulf sturgeon	*Acipenser oxyrinchus*	Threatened

4.7.4 Essential Fish Habitat

Essential Fish Habitat (EFH) includes all types of aquatic habitat where fish spawn, breed, feed, or grow to maturity. It covers federally managed fish and invertebrates, but it does not apply to strictly freshwater species (NOAA Fisheries). In this Watershed, EFH is managed by NOAA National Marine Fisheries and the Gulf of Mexico Fishery Management Council (GMFMC). Using the GMFMC's Essential Fish Habitat Portal (https://portal.gulfcouncil.org/EFHreview.html), eight aquatic species were identified to have EFH in the Watershed. **Table 4.5** lists these species and their life stages in the Watershed.

Table 4.5 Managed Fishery Species

Common Name	Scientific Name	Life Stage
Brown shrimp	*Farfantepenaeus aztecus*	Juvenile, postlarval
Cobia	*Rachycentron canadum*	Eggs, larvae
Gray snapper	*Lutjanus griseus*	Adult
Lane snapper	*Lutjanus synagris*	Larvae, postlarval
Pink shrimp	*Farfantepenaeus duorarum*	Larvae
Red drum	*Sciaenops ocellatus*	Larvae, postlarval, juvenile, adult

Common Name	Scientific Name	Life Stage
Spanish mackerel	*Scomberomorus maculatus*	Juvenile, adult
White shrimp	*Litopenaeus setiferus*	Postlarval, juvenile

4.7.5 Invasive Species

Invasive species are plants and animals that have been introduced to areas outside their native range by human activity or other means and have the potential to cause ecological damage and/or economic loss. The potential for harm distinguishes invasive species from non-native species, which have also been introduced outside their native range but do not pose an ecological or economic threat. The Alabama Invasive Plant Council maintains a list of plant species considered to be invasive within the State of Alabama. The statewide invasive plant list (most recently updated in 2012) contains 65 confirmed species and 26 additional species with the potential to become invasive in Alabama. The most common invasive species in the Watershed are described below:

- **Cogongrass (*Imperata cylinrica*)** is a fast-spreading invasive weed that has proven to be extremely difficult to eradicate. Cogongrass poses a threat to both wildlife habitat and economic interests within the Watershed. It affects agriculture by interfering with crop production and degrades wildlife habitat by displacing or outcompeting native vegetation. Cogongrass is also highly flammable, posing a potential fire hazard to nearby homes. Cogongrass has expanded rapidly since it was first introduced into the United States in Mobile County in 1911 (ALIPC, 2004).

- **Chinese privet (*Ligustrum sinense*)** is an invasive shrub first introduced into the United States as an ornamental plant in 1853. Chinese privet spreads rapidly and commonly occupies fence rows, forested creek bottoms, and upland forests. The dense, stemmy infestations can reach 30 feet in height, displace most native species, and prevent regeneration of bottomland hardwood and upland pine forests (ALIPC, 2019).

- **Chinese tallow (*Triadica sebifera*)** (or popcorn tree) is a deciduous species that is spread by seed dispersal from birds and water. It was first brought into South Carolina in the 1700s, before spreading widly by federally sponsored plantings along the Gulf Coast during the early 1900s. This species is common throughout south Alabama and infests stream banks, riverbanks, and wet areas, as well as upland forests. Chinese tallow is an aggressive species with the potential to rapidly replace native bottomland forest vegetation (ALIPC, 2019).

- **Kudzu (*Pueraria montana*)** is an extremely fast-growing invasive vine that can cover trees, buildings, fences, road signs, and telephone and utility poles. Kudzu is one of the most notorious invasive species in the south and has proven nearly impossible to eradicate. It was intentionally introduced into the United States from the 1930s to the 1950s for erosion control, before its potential risk as an invasive species was recognized (ALIPC, 2019).

- **Japanese Climbing Fern (*Lygodium japonicum*)** is a perennial viney fern that was introduced into the United States in the 1930s. Although it dies back each winter, prior year's vines provide a trellis for expansive new growth that eventually covers shrubs and trees. Native plant species are displaced, wildlife habitat is destroyed, and access to lands is denied by this species (ALIPC, 2019).

- **Alligator Weed (*Alternanthera philoxerodies*)** is an herbaceous freshwater perennial invader that forms dense mats in water bodies, wetlands, and low-lying, as

well as upland areas. The thick mats in water replace native species, accelerate succession from open water to marsh, cause fish kills, and prevent recreational use. By slowing drainage, it also exacerbates flooding (ALIPC, 2019).

- **Feral Swine (*Sus scrofa*)** are omnivorous wild boars with high reproductive rates. They lack natural predators and display destructive rooting behavior. This animal likely originated in Southeast Asia and was introduced to the Americas by early colonization. The feral hog's ability to adapt and survive has created one of the greatest pests in North America. The U.S. Department of Agriculture estimates that feral hogs cause more that $800 million of agricultural damage annually (USDA, 2020).

4.8 Political Institutions

Four local governmental entities have jurisdictional control within the Watershed. These include the City of Foley, the towns of Elberta and Summerdale, and Baldwin County. **Figure 4.10** shows that of the total Watershed area, the City of Foley maintains jurisdiction of approximately 28%, the town of Elberta approximately 10%, and the town of Summerdale less than 1%, leaving Baldwin County with jurisdiction of the remaining approximately 61% of the Watershed.

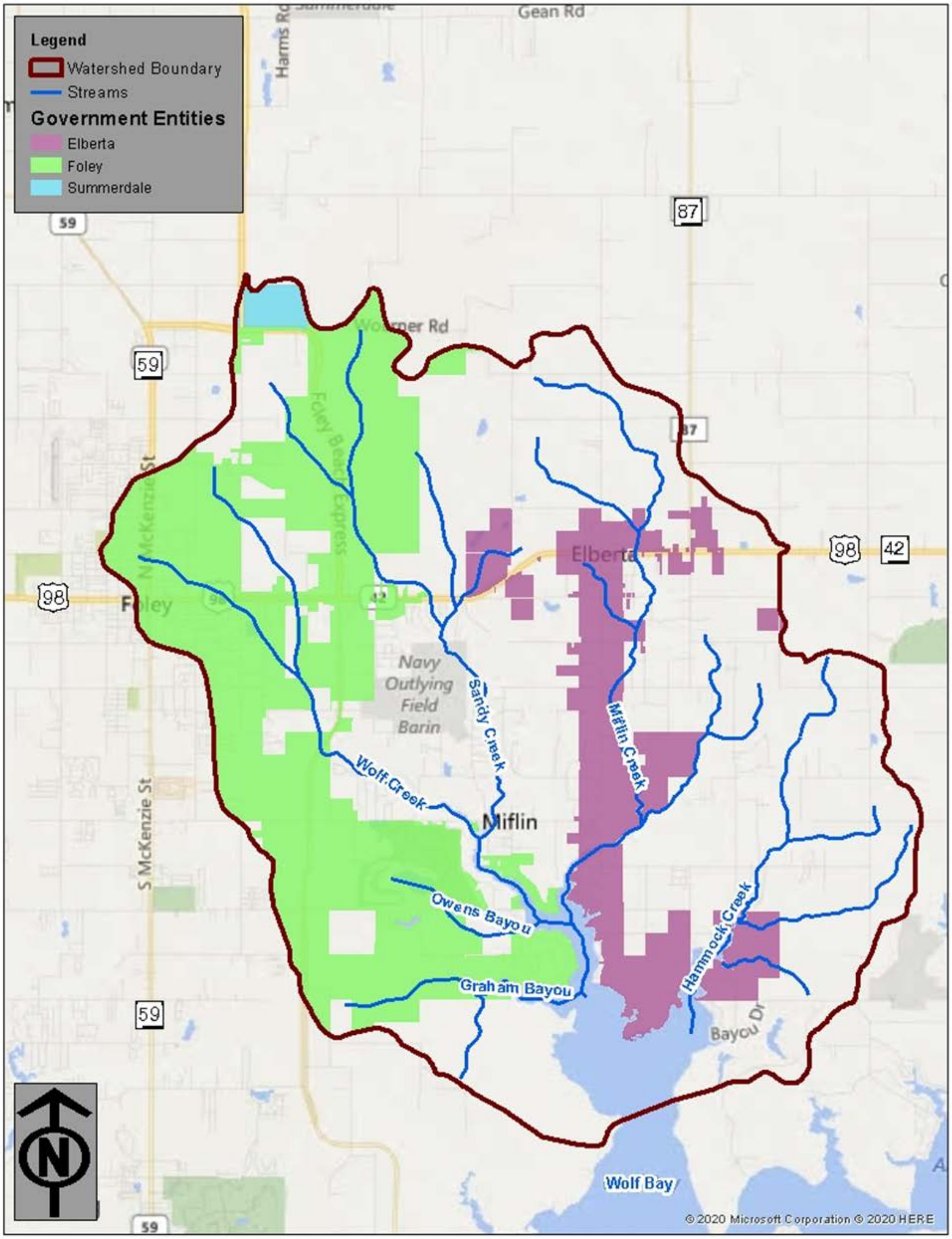

Figure 4.10 Government Entities Within Wolf Bay Watershed

4.9 Population and Demographics

Population and population growth are important considerations in watershed planning because population growth is intrinsically tied to land use, development, and various environmental stressors on a watershed, such as increased stormwater runoff, nutrient loading, and flooding. Current and projected populations for Baldwin County and the Watershed are assessed in this Plan.

Other demographic characteristics, such as ethnic composition, age distribution, income and poverty levels, are important for characterizing populations of watersheds. Each of these characteristics are assessed within the Watershed as well as Baldwin County and are described in this section.

4.9.1 Population

Baldwin County is the largest county in Alabama by land area and among the most populated counties in the State. The population of Baldwin County increased by approximately 30% from 2000 to 2010, according to the U.S. Census Bureau. **Table 4.6** shows the population and growth rates (% change over 10-year periods) in Baldwin County from the years 2000 and 2010 and projections of population growth through 2040. County-level population growth projections are published by The University of Alabama's Center for Business and Economic Research (UACBER) (UACBER 2019).

Table 4.6 Baldwin County Past, Current, and Future Population (Source: U.S. Census Bureau and Center for Business and Economic Research, The University of Alabama, April 2019)

	U.S. Census Population		Projected Population		
	2000	2010	2020	2030	2040
Baldwin	140,415	182,265	222,554	261,777	300,899
Percent Increase	--	30	22	18	15

4.9.2 Population Trends and Projections

Demographic data was collected from the U.S. Census Bureau's American Fact Finder website (U.S. Census Bureau, 2016). The data collected is broken down into specific levels of geographic units: tracts, block groups, and blocks, with tracts the largest unit and blocks the smallest. Block groups and blocks were used to collect data for the three sub-watersheds within the Watershed complex. Block groups, as defined by the U.S. Census Bureau, generally contain between 600 and 3,000 people, from a cluster of blocks. Blocks are typically bounded by existing physical features, natural features, or political boundaries (e.g., roads, rivers, or state boundaries), but the U.S. Census Bureau does not use watershed boundaries to define census block boundaries (U.S. Census Bureau 2010). As a result, select census blocks exist partially within and partially outside one or more of the project sub-watersheds.

Population growth projections from UACBER are published at the county-level only, and projections for smaller geographic units are not currently available. To estimate future population trends for the sub-watersheds, the percent change that UACBER projected for the county-level population was applied to the estimated 2010 population (**Table 4.7**). The resulting calculations estimate the future population in the sub-watersheds through 2040. However, because factors influencing population trends at the county level may differ from those in each of the sub-watersheds, these watershed level projections should be considered in coordination with local regulations, demographics, and geographic features that may alter future trends from the projections.

Table 4.7 Population Projections by Sub-Watershed (Source: U.S. Census Bureau and Center for Business and Economic Research, The University of Alabama, April 2019)

Watershed	U.S. Census Population	Projected Population		
	2010	2020	2030	2040
Graham Bayou	3,515	4,288	5,060	5,313
Miflin Creek	3,443	4,200	4,956	5,204
Sandy Creek/Wolf Creek	8,825	10,767	12,705	13,340

4.9.3 Ethnic Composition

4.9.3.1 Baldwin County Ethnic Composition

Figure 4.11 shows the ethnic composition of Baldwin County based on 2010 census data. Baldwin County is numerically dominated by individuals who identify themselves as white alone, followed by individuals who identify as black/African American, with all other ethnicity groups representing 5% of the population.

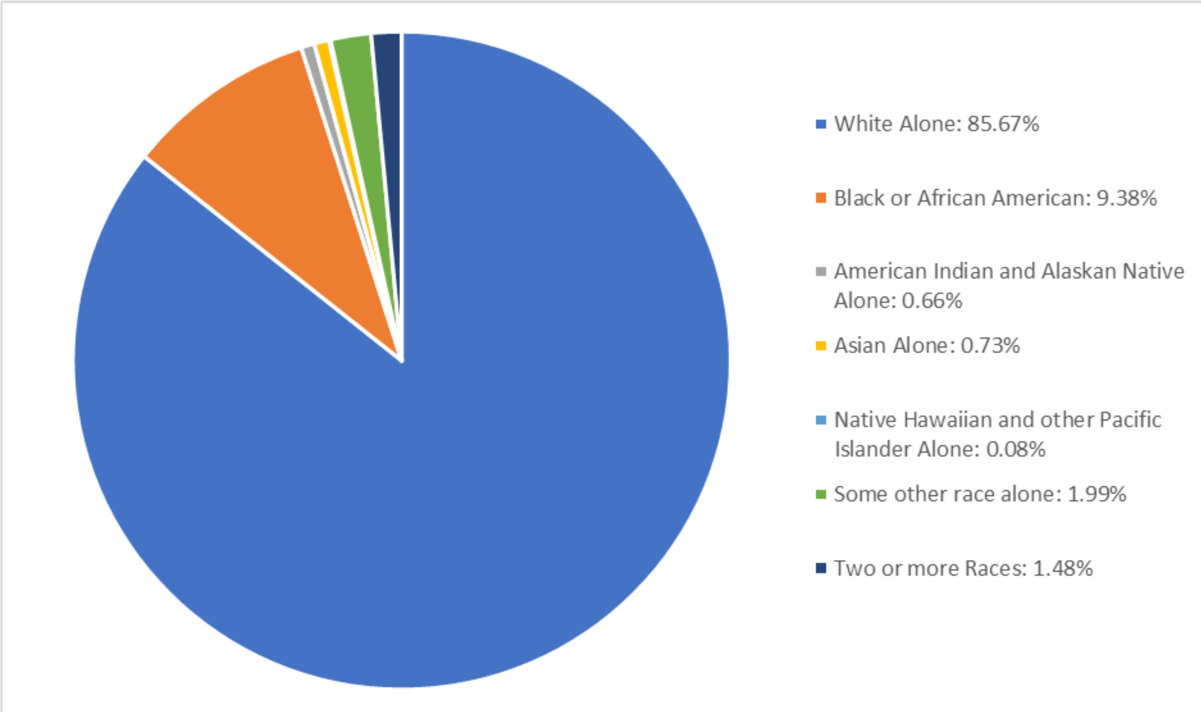

Figure 4.11 Ethnicity Composition of Baldwin County (Source: 2010 U.S. Census Bureau)

4.9.3.2 Ethnic Composition by Sub-Watershed

Table 4.8 shows the ethnic composition of the three sub-watersheds. The composition was calculated based on the census blocks that are within each sub-watershed. The ethnic composition of the three sub-watersheds differ slightly compared to Baldwin County. All three sub-watersheds are predominantly composed of individuals who identify themselves as white alone, followed by those who identify as black/African American or other minorities. Compared to Baldwin County, the sub-watersheds have a lower total minority percentage, except for Sandy Creek Watershed which is slightly higher than Baldwin County.

Table 4.8 **Ethnicity Composition by Sub-Watershed (Source: 2010 U.S. Census Bureau)**

Geographic Area	Population Total	Ethnicity (%)							
		White Alone	Black or African American	American Indian and Alaskan Native Alone	Asian Alone	Native Hawaiian and other Pacific Islander Alone	Some other race alone	Two or more Races	Total Minority
Graham Bayou	3,515	94.77%	1.42%	0.40%	0.97%	0%	1.11%	1.34%	5.23%
Miflin Creek	3,443	92.80%	0.93%	0.64%	0.67%	0.03%	2.79%	2.15%	7.20%
Sandy Creek/ Wolf Creek	8,825	80.53%	10.73%	0.93%	1.08%	0.07%	4.95%	1.71%	19.47%

4.9.4 Age Distribution

4.9.4.1 Baldwin County Age Distribution

Table 4.9 presents the age distribution of Baldwin County and the State of Alabama, based on the 2010 census data. The majority of the Baldwin County population falls within the age group of 30 to 49, followed closely by 17 and under age group, and then 50 to 64 age group.

Table 4.9 **Age Distribution of Baldwin County and the State of Alabama (Source: 2010 U.S. Census Bureau)**

Geographic Area	Population Total	Population Age (Percent of Population)				
		17 and Under	18 to 29	30 to 49	50 to 64	65 and Older
Alabama	4,779,736	24%	16%	27%	20%	13%
Baldwin County	182,265	23%	13%	26%	21%	17%

4.9.4.2 Age Distribution by Sub-Watershed

Table 4.10 represents the age distribution of the population within the three sub-watersheds. The age distribution of the sub-watersheds is mostly consistent with the overall age distribution of Baldwin

County. However, Graham Bayou Watershed has a slightly higher population of people ages 65 and older (25%) compared to Baldwin County (17%).

Table 4.10 **Age Distribution by Sub-Watershed (Source: 2010 U.S. Census Bureau)**

Geographic Area	Population Total	Population Age (Percent of Population)				
		17 and Under	18 to 29	30 to 49	50 to 64	65 and Older
Graham Bayou	3,515	18%	12%	21%	24%	25%
Miflin Creek	3,443	21%	18%	24%	22%	15%
Sandy Creek/Wolf Creek	8,825	21%	15%	23%	21%	20%

4.9.5 Income and Poverty

Table 4.11 shows the average household size and median household income compared to the standard HHS Poverty Guidelines in Alabama, Baldwin County, and each of the three sub-watersheds. Median household income is estimated based on block groups that completely or partially intersect each sub-watershed. The median income in each sub-watershed is lower than that of Baldwin County. Sandy Creek has the lowest median income of the three sub-watersheds, but it is not below the poverty guidelines for household size. Overall, the median income of the three watersheds compare similarly to Baldwin County.

Table 4.11 **Income and Poverty Levels (Source: 2010 U.S. Census Bureau, 2017 American Community Survey, and the U.S. Department of Health and Human Services)**

Geographic Area	Population Total	Average Household Size	Median Income (2017)	HHS Poverty Guidelines	Below HHS Poverty Guidelines
Alabama	4,779,736	3	$46,472	$21,330	No
Baldwin County	182,265	3	$52,562	$21,330	No
Graham Bayou	3,515	3	$49,016	$21,330	No
Miflin Creek	3,443	3	$50,355	$21,330	No
Sandy Creek/Wolf Creek	8,825	3	$44,211	$21,330	No

4.9.6 Economics

Because of the proximity of the Watershed to the Alabama Gulf coast, tourism plays an important role in the local economy. According to the Alabama Department of Tourism's calendar year 2017 Economic Impact Report, released April 16, 2018, Baldwin County's estimated 6.4 million visitors represented 24.1% of all visitors to the State. In 2017, travelers spent more than $4.4 billion in Baldwin County, an increase of $491 million from 2015, while total travel-related earnings (both direct and indirect) of $1.5 billion represented 30% of the Statewide total.

4.9.7 Education

Table 4.12 shows the educational attainment for the population aged 25 years and older in Alabama, Baldwin County, and each of the three sub-watersheds. The population totals for the sub-watersheds are higher than in previous tables because block group population totals were used to determine total population.

Table 4.12 Educational Attainment for the Population 25 Years and Over (Source: 2010 U.S. Census Bureau, 2017 American Community Survey)

	Alabama	Baldwin County	Graham Bayou Watershed	Miflin Creek Watershed	Sandy Creek/Wolf Creek Watershed
Total Population	3,276,637	143,022	8,881	3,892	16,944
No Schooling Completed	41,118 (1%)	1,131 (1%)	67 (2%)	46 (1%)	152 (1%)
12th Grade or Less	439,941 (13%)	12,866 (9%)	844 (10%)	326 (8%)	1,341 (8%)
High School Diploma	831,994 (25%)	32,709 (23%)	1,607 (18%)	1,188 (31%)	4,682 (28%)
GED	180,557 (6%)	7,062 (5%)	747 (8%)	249 (6%)	1,065 (6%)
Some College (less than 1 year, no degree)	198,453 (6%)	9,207 (6%)	567 (6%)	220 (6%)	1,239 (7%)
Some college (1 or more years, no degree)	513,751 (16%)	22,319 (16%)	1,833 (21%)	603 (15%)	3,012 (18%)

	Alabama	Baldwin County	Graham Bayou Watershed	Miflin Creek Watershed	Sandy Creek/Wolf Creek Watershed
Associate Degree	267,245 (8%)	13,760 (10%)	910 (10%)	348 (9%)	1,715 (10%)
Bachelor's Degree	503,930 (15%)	29,237 (20%)	1,630 (18%)	673 (17%)	2,641 (16%)
Master's Degree	216,001 (7%)	10,714 (7%)	549 (6%)	211 (5%)	940 (6%)
Professional School Degree	49,452 (2%)	2,885 (2%)	114 (2%)	15 (1%)	46 (1%)
Doctorate Degree	34,195 (1%)	1,132 (1%)	13 (0%)	13 (0%)	111 (1%)

4.10 History and Culture of the Watershed

There are three distinct communities within the Watershed: The City of Foley, the Town of Elberta, and the Miflin community. A brief history of each is discussed in the following sections.

4.10.1 City of Foley

The Forward City, as it is known today, lives up to its name. While some might have skipped over the area now known as Foley to develop closer to the pristine beaches of Alabama's Gulf coast, John B. Foley (of Chicago) purchased 50,000 acres north of the beach and formed the Magnolia Land Company in 1902. He recognized the economic value of the location between what is now Miflin and Bon Secour landings, rich soils perfect for farming, and the mild climate that would attract settlers looking to migrate from the Midwest. Business flourished after Foley and the Ham brothers constructed the Foley Depot and the accompanying railroad in 1905. This line connected Bay Minette and Fort Morgan. Trains from the Louisville and Nashville Railroad operated on this line (Outlaw and Taylor, 2013). Many accommodations, general stores, and real estate agencies were built near the depot to entice visitors to purchase land, the first of which was the Magnolia Hotel. Mr. Foley constructed a windmill to provide the hotel with running water and plumbing. The Magnolia Hotel changed hands many times but is still in use today. Since its opening, five U.S. presidents have passed through its front door (The Hotel Magnolia, 2019).

Figure 4.12 Foley Train Depot, Present Day

Because of the success of the community, the population of the area increased rapidly. As problems arose, the resilient and entrepreneurial people of South Baldwin County met every need. The Foley Municipal Airport was constructed in 1933, but with the start of World War II, the City released the airport for use by the Navy. Barin Field was used as an extension of Pensacola Naval Air Station for torpedo bomber and fighter training. The western portion of Barin Field was later purchased and is now occupied by the four lane Foley Beach Express. The eastern portion of Barin Field is still used as a satellite airport for Pensacola NAS flight practice. Baldwin County's first hospital, Sibley Holmes Memorial Hospital, opened in Foley in 1936 and was run by Mr. William C. Holmes. Today, the hospital is preserved as a museum with operating and waiting rooms, pharmacy, and medical equipment from the era in the Foley Downtown Historic District (Outlaw and Taylor, 2013).

Figure 4.13 Early Foley Cotton Gin, Grist Mill and Rice Huller Facility

4.10.2 Town of Elberta

On November 3, 1903, a group of German businessmen from Chicago created the Baldwin County Colonization Company for the purpose of starting a German settlement on 55,000 acres of land known as the "Elberta District." The settlers were amazed by the mild climate, long growing seasons, rich soil, and diversity of crops that could be grown there. They established a model farm and brought visitors from the north on the "Pine Knot Special" to see the opportunities that could be found in Baldwin County. They placed ads in northern newspapers that read, "Come to Baldwin County – The Land of Milk and Honey." Land was sold in 20-acre tracts, and a tract in Gulf Shores could be purchased for one dollar. Tracts in other parts of the County were sold for $5 to $50, depending on farming suitability. The town was incorporated in 1952, thanks to a movement sponsored by the Elberta Lion's Club, and the first mayor was elected in 1953.

Known as “The Town of Friendship”, the people of Elberta represent many nationalities and speak over 60 languages. The State Bank of Elberta (later renamed South Baldwin Bank) was one of the few banks in the United States that did not close during the national bank holiday of the Great Depression of the early 1930’s (The Gulf Telephone Company, 1983).

4.10.3 Miflin Community

Miflin bears the name of a gentleman who established his business in 1850 beside the creek that was also named for him. Not much is known of the founder, other than he raised sugar cane and operated a turpentine and grist mill. The creek was dammed to furnish power for the mill. In the early 1900’s, Miflin was a thriving logging community. Turpentine mills also flourished, as the sap harvested from pine trees was used for medicinal purposes, as well as building boats. Two hundred and fifty barrels of the resin and spirits would be taken to Mobile through the Gulf, because the intracoastal waterway had not yet been built. Logs were floated up and down Sandy Creek by rafts pulled by oxen. Railroad tracks were constructed to the edge of the creek from far into the pine forests. Believed to be the first railroad in Baldwin County, it connected the Southern States Lumber Company’s logging camp and their sawmill at Miflin. The logging camp building stood exactly where the center of the Town of Foley now exists. Once a week, a steamer transported the logs to a mill in Millview, Florida. Homes and a large commissary were also located on the bank of Sandy Creek. One of the largest sawmills was located on Wolf Creek. After the timber was cut out, the logging business moved to Seminole, Alabama, and most of the residents moved with it (Schmidt, 2012; The Foley Onlooker, 1959).

Peterson’s Point was a popular destination for dances on Saturday nights and all-night turtle hunts. The site later became home to the Wolf Bay Lodge. The first bridge across Miflin Creek was a turntable bridge built in 1909 to replace the hand-drawn ferry that previously existed. The turntable bridge permitted the passage of sloops and pleasure boats up the Creek. The first winery in Alabama was in Miflin, until a change in state law forced its closure (Schmidt, 2012; Fuller, Date Unknown).

Figure 4.14 Peterson's Point, Date Unknown

The creeks and Bay have always been an important part of the life of the community. Timber mills in the area were powered by water. Mail and goods where transported to and from the area via the waterways. It was reported that, prior to the construction of the intracoastal waterway, there were plentiful oyster beds along the banks of Miflin Creek. Fishing was also prevalent in the creek, with stories of one angler catching so many redfish that his boat sank under the weight. Prizes from many fishing rodeos were won from fish caught on Sandy or Miflin creeks. In that day, most people fished to provide food for themselves and their families, and not commercially (The Foley Onlooker, 1959, Mobile Press Register, 1987).

4.10.4 Historical Sites

A review was conducted of the Alabama Register of Landmarks & Heritage as well as the National Register of Historic Places. There are three known historically significant sites listed on the National Register of Historic Places located in the Watershed. A list of these sites is provided in **Table 4.13**.

Table 4.13 Historically Significant Sites Within the Watershed (Source: National Register of Historic Places)

Locale	Name	Date	Status	Comment
Foley	Foley Downtown Historic District	1907-1954	National Register of Historic Places	Listed 1/19/05. Contains parts of Alston, N&S; McKenzie; Highway 98E. & W.; Laurel; Myrtle; Rose & W. Orange
Elberta	St. Mark's Lutheran Church	1927	National Register of Historic Places	Listed 8/25/88. Rural Churches of Baldwin County
Miflin	Swift Presbyterian Church (**Figure 4.15**)	1907	National Register of Historic Places	Listed 8/25/88. Rural Churches of Baldwin County

Figure 4.15 Swift Presbyterian Church, Listed on the National Register of Historic Places

4.11 Public Access in the Watershed

Outdoor recreational activities in coastal Alabama are an important way of life for many. Some of these activities include fishing, hunting, boating, swimming, shrimping, and wildlife watching. There are currently two publicly owned recreational facilities that provide water access within the Watershed, Graham Creek Nature Preserve and Wolf Creek Park, as shown in **Figure 4.16**. Both facilities are owned and operated by the City of Foley.

The Upper Wolf Bay Savanna and Marsh Forever Wild Tract was acquired by the Alabama Forever Wild Land Trust in July 2017. Currently, there are no public recreational opportunities available on the site. It is anticipated, however, that future opportunities will be provided that are consistent with the protection of the property.

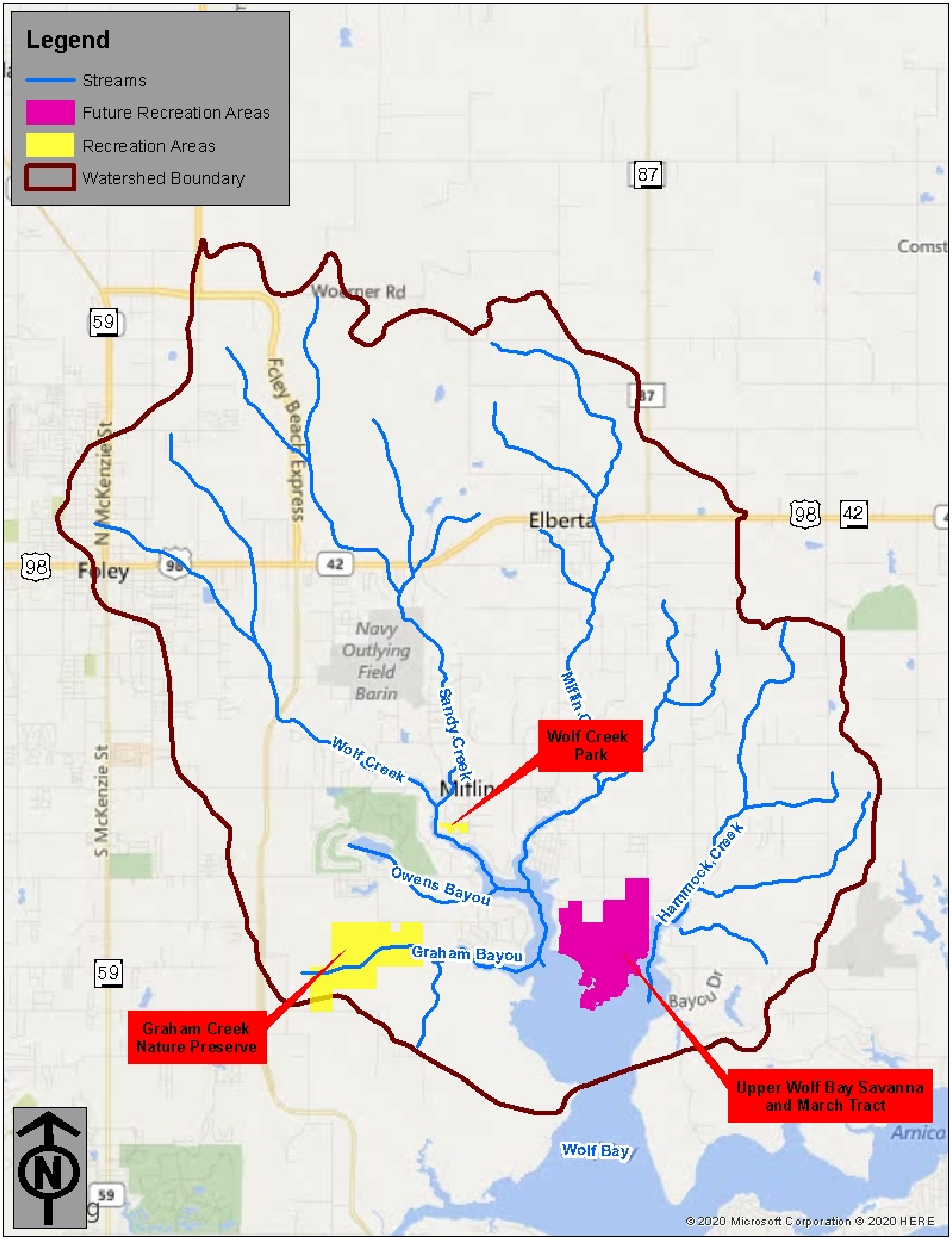

Figure 4.16 Publicly Owned Recreational Areas

The 484-acre Graham Creek Nature Preserve comprises abundant natural habitats, including pine savannahs, wetlands, and tidal marshes. Recreational features within the Preserve include a canoe and kayak launch (**Figure 4.17**), walking and hiking trails, picnic areas, bird watching, an archery park, three full disc golf courses, and a Nature Explore Outdoor Classroom. Throughout the Preserve, interpretive signage identifies populations of rare plant and animal species and their habitats. The 25-acre Wolf Creek Park provides recreational features such as a canoe and kayak launch, a fishing pier, and picnic areas. It has a noted shore bird rookery within the sheltered cove on the property.

Historically, water access in the Watershed for motorboats was provided through a privately owned and maintained boat launch. Members of the community were asked to provide a nominal fee to use the launch to help with maintenance and upkeep of the facility. This launch has been permanently closed. Some of the neighborhoods in the Watershed have launches, but they are not available to the public. The nearest public launches to the Watershed are Josephine Park in the Josephine community or Canal Park in the City of Gulf Shores. The Josephine Park launch has two ramps and approximately 10 parking spaces. The Canal Park has one ramp and approximately 34 parking spaces. Space availability at these launches is insufficient for the Wolf Bay Watershed community.

Figure 4.17 Graham Creek Nature Preserve Kayak Launch

4.12 Land Use and Land Cover

4.12.1 Historic Land Use

Land use is among the most important drivers of watershed conditions and often determines when, where, and which stressors occur. The Watershed has a long history of human use and has changed drastically over time. **Figure 4.18** is based on land use data collected between 1970 and 1985 and is intended to establish a baseline from which to measure growth and change in in recent decades. From 1970-1985, agriculture (approximately 46%) and forested areas including wetlands (approximately 42%) dominated the Watershed. Commercial, residential, and industrial development comprised approximately 3% of the Watershed and was primarily centered around the City of Foley, Barin Field, and the Town of Elberta.

Figure 4.19 reflects the National Land Cover Database (NLCD) land cover imagery collected in 2006. Agricultural land use (approximately 38% of the Watershed) declined 8% from 1970-1985, while development land use (approximately 14% of the Watershed) rose by 11%. Forested areas including wetlands (approximately 40% of the Watershed) decreased slightly by 2%.

Figure 4.20 is based on the NLCD 2011. Agricultural land use (approximately 37% of the Watershed) declined slightly by 1% from 2006 while development land use (approximately 15% of the Watershed) rose slightly by 1%. Forested areas including wetlands remained unchanged from 2006.

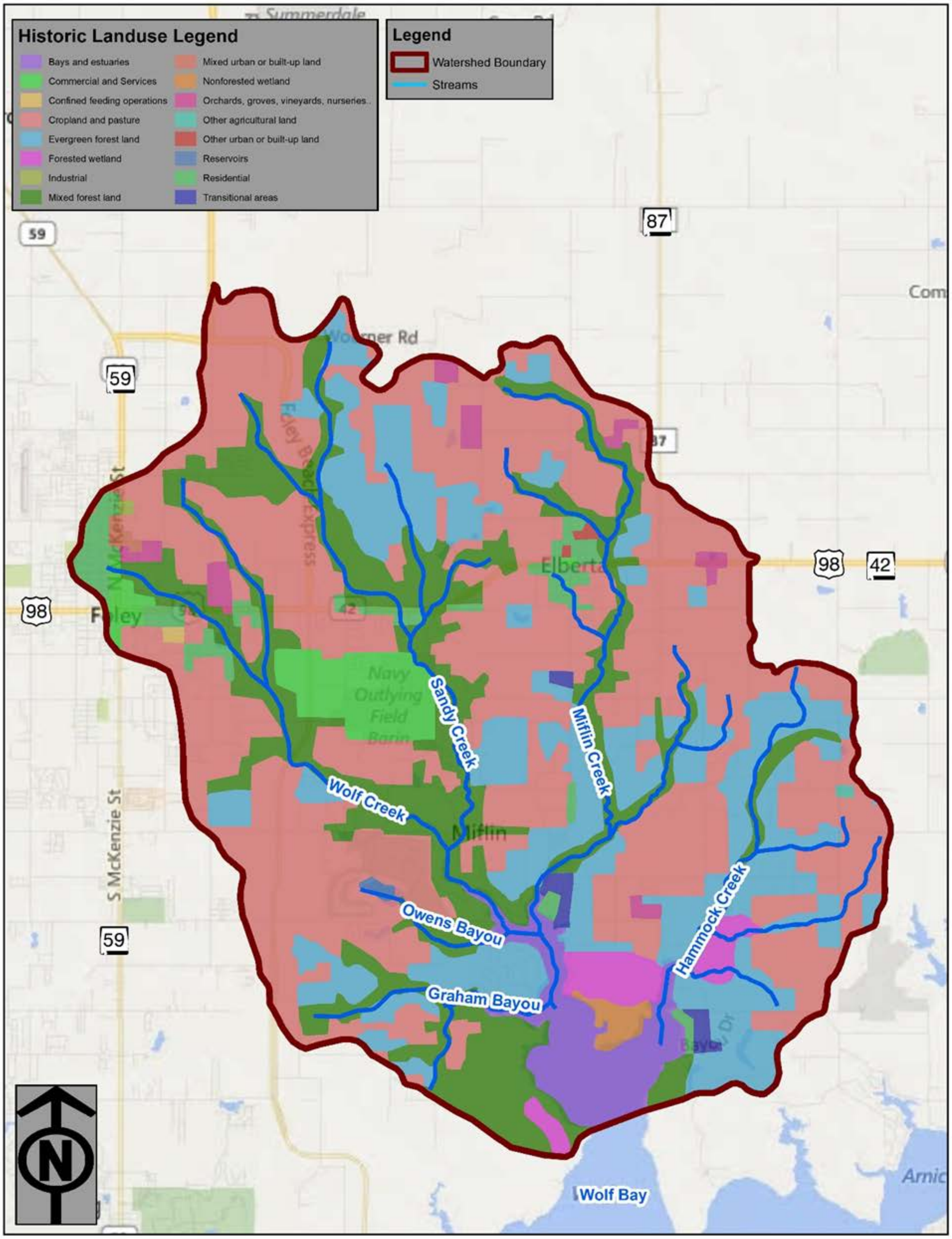

Figure 4.18 1970-1985 Land Use/Cover

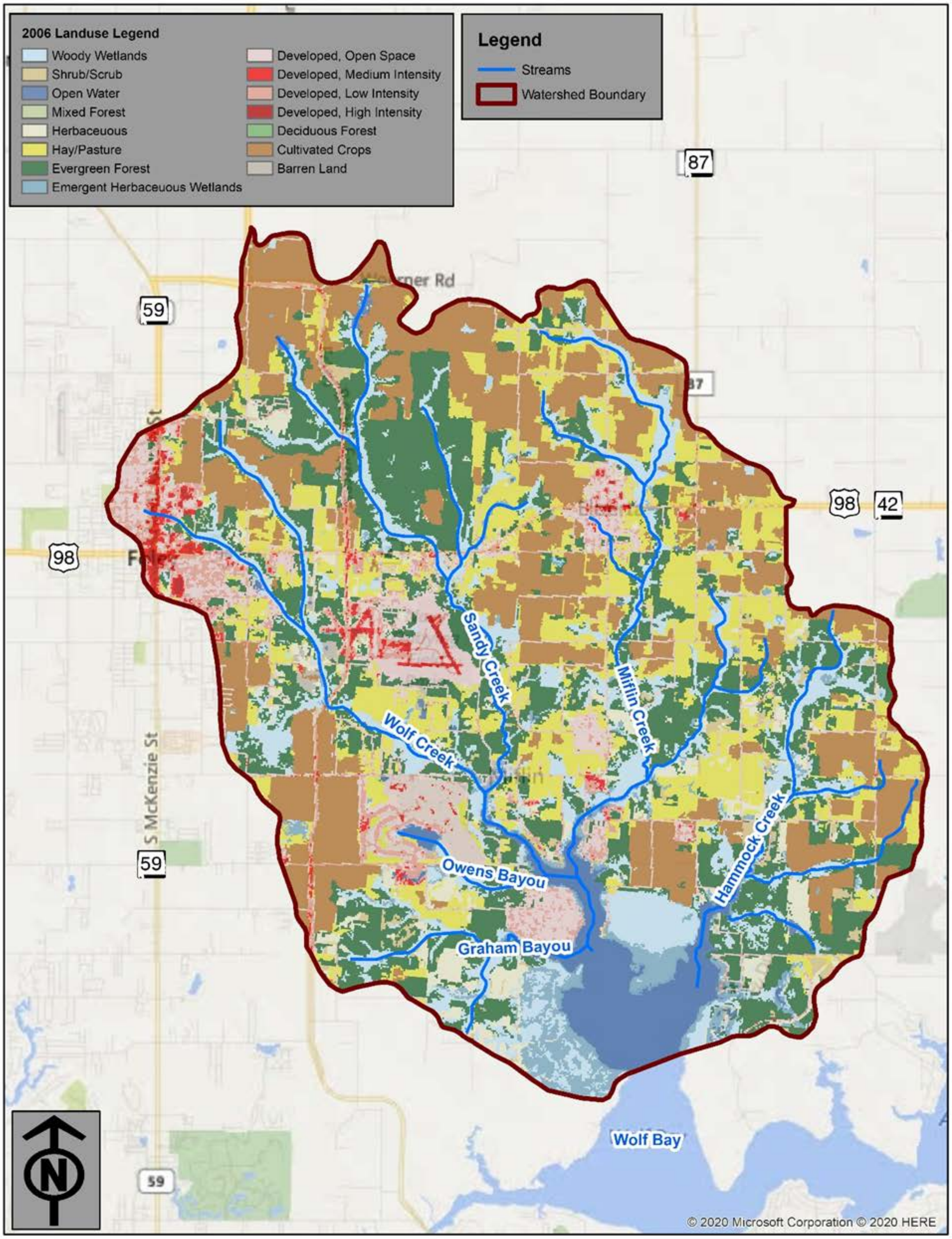

Figure 4.19 2006 Land Use/Cover

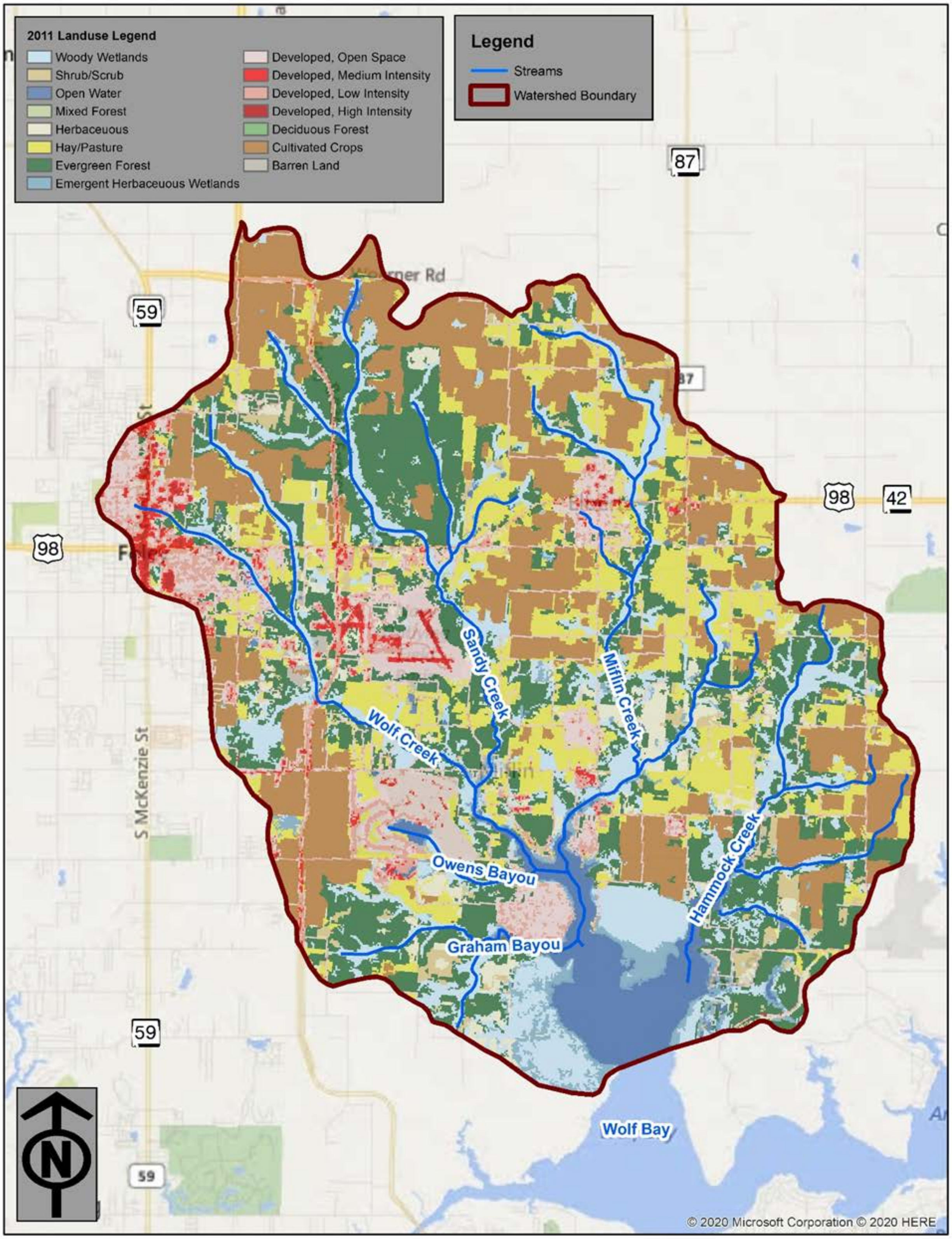

Figure 4.20 2011 Land Use/Cover

4.12.2 Current Land Use

Figure 4.21 reflects the NLCD 2016 land use data for the Watershed. In 30 years, agricultural land use decreased by approximately 11% to a coverage of 35% in the Watershed, while development has increased by approximately 12% to a coverage of 15% in the Watershed. Forested areas including wetlands have decreased slightly by approximately 3% to 39%. In comparing the historical data to the 2016 data, the decrease in agricultural land use and increase in development land use reflects the changing cultural and socioeconomic conditions in the Watershed.

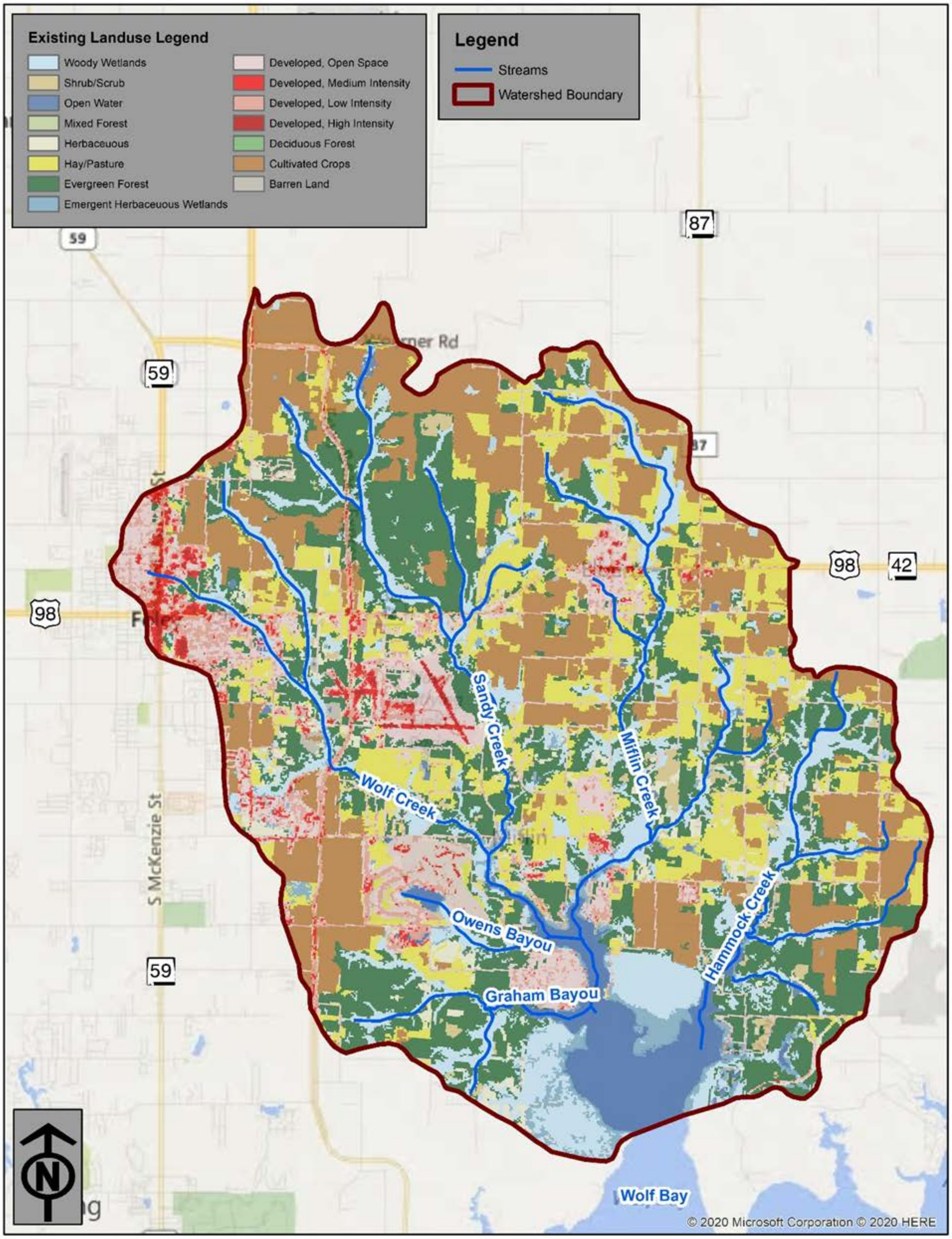

Figure 4.21 2016 Land Use/Cover

4.12.3 Future Land Use

Table 4.14 shows the predicted percent cover of land use types (agriculture, development, and forested areas/wetlands) within the Watershed through 2040. These estimates are based on the rate of change of each land use category within the Watershed from 1970-1985 to 2016 and coincides with the predicted increase in population (**Table 4.7** in Section 4.8.2).

Table 4.14 Future Land Use Projections

Land Use	1970-1985	2006	2011	2016	2020	2030	2040
Agriculture	46%	38%	37%	35%	33%	30%	26%
Development	3%	14%	15%	15%	18%	22%	26%
Forested Areas/Wetlands	42%	40%	40%	39%	39%	38%	37%

4.12.4 Impervious Cover

Impervious cover includes surfaces that do not allow precipitation to infiltrate into the ground, therefore, increasing the volume and velocity of storm water runoff to surface waters. Examples of impervious cover include paved roadways, and parking lots, sidewalks, and rooftops. Impervious surfaces can affect water quality by increasing the rates of erosion and sedimentation and the loading rates of nutrients and other pollutants transported by stormwater runoff. According to the 2016 NLCD impervious cover dataset, approximately 5,679 acres of the Watershed are currently encapsulated with impervious cover (**Figure 4.22**). Of that total, 2,613 acres (46.01%) is paved roadway. As the area continues to grow, the amount of impervious cover will increase.

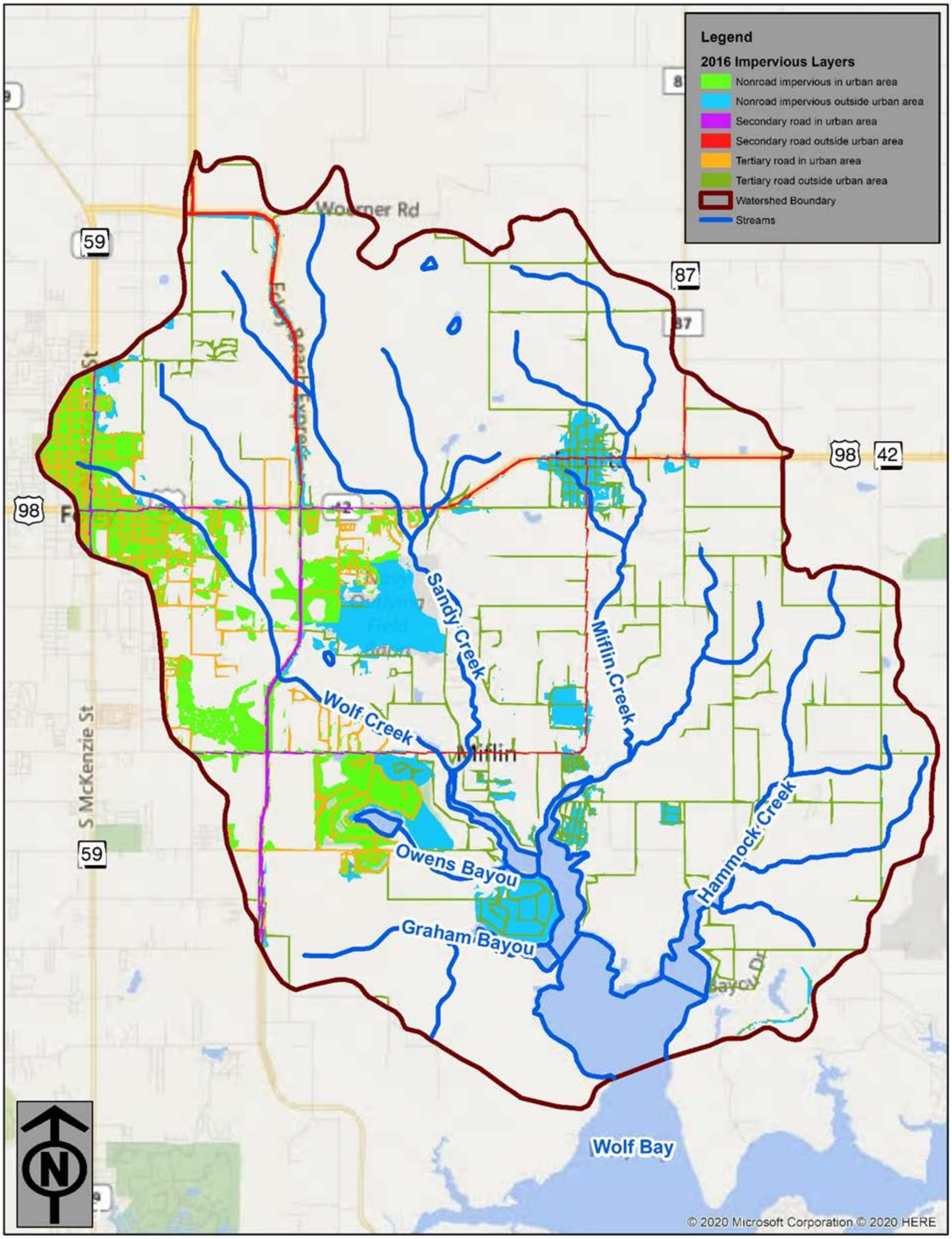

Figure 4.22 2016 NLCD Impervious Cover

Chapter 5 Watershed Conditions

5.1 Water Quality Standards

Discharge of pollutants into waterways within the Wolf Bay Watershed is regulated through federal and State programs administered by the Alabama Department of Environmental Management (ADEM). These programs include the Clean Water Act (CWA) Section 303(d) Impaired Waters and Total Maximum Daily Load (TMDL) program and the National Pollutant Discharge Elimination System (NPDES) program.

5.1.1 Water Use Classification and Water Quality Criteria

Under the guidance of the U.S. Environmental Protection Agency (USEPA), ADEM is responsible for establishing Water Use Classifications (WUCs) for waters in Alabama. Each WUC is accompanied by specific water quality standards. WUC, and associated water quality standards to support such uses, were established through public participation in the initial establishment and periodic review of water quality standards by ADEM (ADEM 2019). **Table 5.1** summarizes thresholds for water quality standards for each of the seven WUCs in Alabama.

Table 5.1 Alabama Water Use Classifications and Water Quality Standards (Source: ADEM 2018)

Water Use Classification	pH	Water Temp.	Dissolved Oxygen	Fecal Coliform Bacteria (geometric mean)[a]	Enterococci Bacteria (geometric mean)[b]	Turbidity (above background)
Outstanding Alabama Water	6.0–8.5[a] 6.5-8.5[b]	≤ 90°F	≥ 5.5 mg/L	126 colonies/ 100 ml	35 colonies/ 100 ml	≤ 50 NTU
Public Water Supply	6.0–8.5[a] 6.5–8.5[b]	≤ 90°F	≥ 5.0 mg/L	126 colonies/ 100 ml[C]	35 colonies/ 100 ml[C]	≤ 50 NTU
Swimming and Other Whole-Body Water-Contact Sports	6.0–8.5[a] 6.5–8.5[b]	≤ 90°F	≥ 5.0 mg/L	126 colonies/ 100 ml	35 colonies/ 100 ml	≤ 50 NTU
Shellfish Harvesting	6.5–8.5[b]	≤ 90°F	≥ 5.0 mg/L	N/A	35 colonies/ 100 ml[C]	≤ 50 NTU

Water Use Classification	pH	Water Temp.	Dissolved Oxygen	Fecal Coliform Bacteria (geometric mean)[a]	Enterococci Bacteria (geometric mean)[b]	Turbidity (above background)
Fish and Wildlife	6.0–8.5[a] 6.5–8.5[b]	≤ 90°F	>5.0 mg/L	126 colonies/ 100 ml[C]	35 colonies/ 100 ml[C]	≤ 50 NTU
Limited Warmwater Fishery	6.0–8.5* 6.5–8.5[b]	≤ 90°F	≥ 3.0 mg/L	548 colonies/ 100 ml	No geometric mean	≤ 50 NTU
Agricultural and Industrial Water Supply	6.0–8.5[a] 6.5–8.5[b]	≤ 90°F	≥ 3.0 mg/L	700 colonies/ 100 mla	No geometric mean	≤ 50 NTU

notes: mg/L – milligram per liter; ml – milliliter; NTU – nephelometric turbidity units

[a] Freshwater

[b] Marine and estuarine waters

[C] Incidental water contact and whole-body water-contact recreation months of May-October

WUCs in the Watershed include Outstanding Alabama Water (OAW), Swimming and Other Whole-Body Water-Contact Sports (S), Shellfish Harvesting (SH) and/or Fish and Wildlife (F&W). **Table 5.2** and **Figure 5.1** reflect the use classifications for each surface water body found in the Watershed. Streams with portions below +10 feet MSL are considered "coastal waters" and the portions above +10 feet MSL are considered "non-coastal waters".

Table 5.2 **Use Classifications of Surface Waters in the Wolf Bay Watershed (Source: ADEM 2019)**

Waterbody	From	To	Classification
Wolf Bay and all connecting coves and bayous	Intracoastal Waterway	Moccasin Bayou	OAW/SH/S/F&W
Wolf Bay and all connecting coves and bayous	Moccasin Bayou	Its source	SH/S/F&W
Miflin Creek	Wolf Bay	10 feet above MSL	S/F&W
Hammock Creek	Wolf Bay	10 feet above MSL	S/F&W
Wolf Creek	Wolf Bay	10 feet above MSL	F&W
Sandy Creek	Wolf Bay	10 feet above MSL	S/F&W
Miflin Creek	10 feet above MSL	Its source	F&W
Hammock Creek	10 feet above MSL	Its source	S/F&W

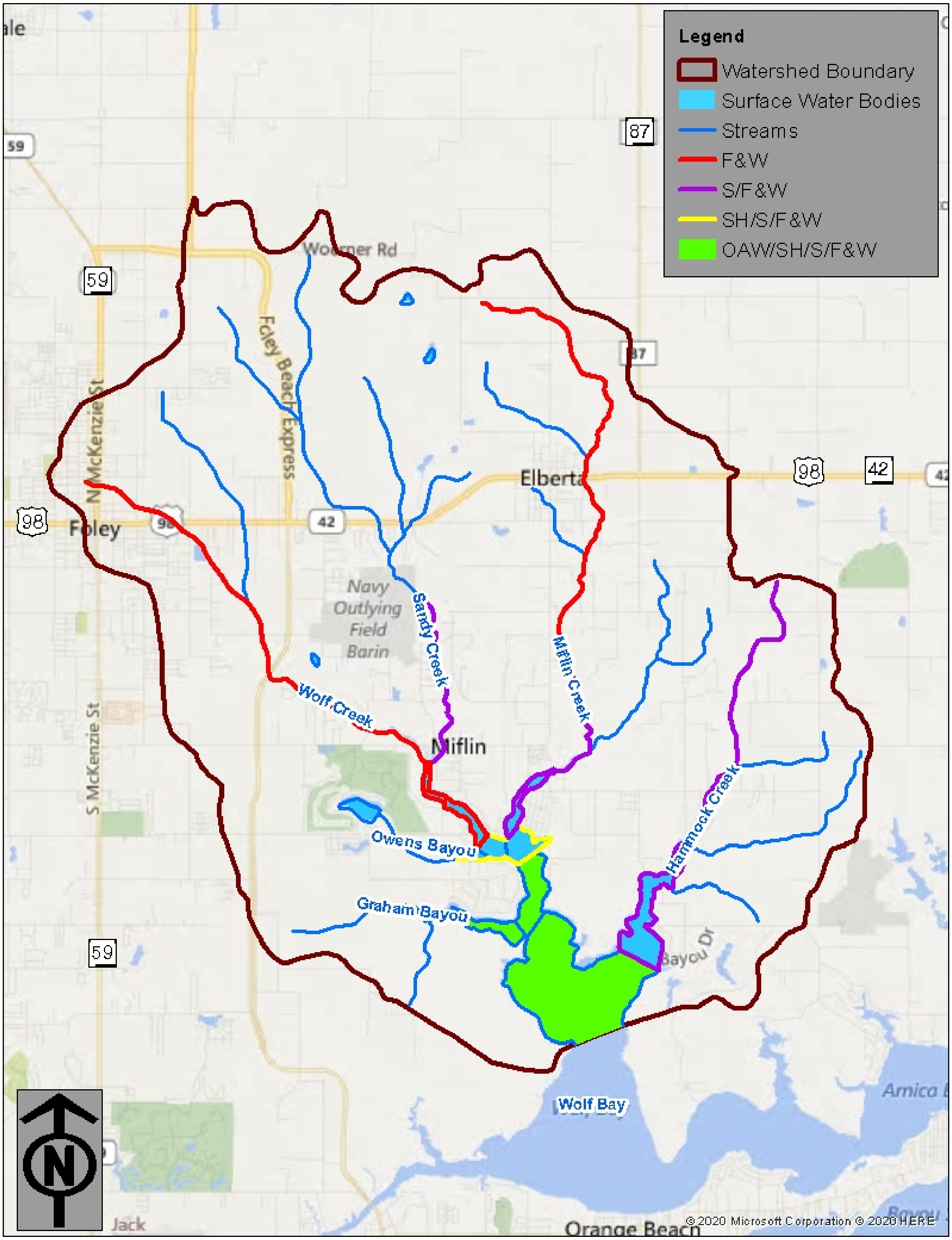

Figure 5.1 Use Classifications of Surface Waters

5.1.2 CWA Section 303(d) Impaired Waters and TMDL Program

The goal of the CWA, administered by the USEPA, is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 United States Code §1251[a]). Under Section 303(d) of the CWA, states are required to identify impaired waters and submit a list of these waters to the USEPA. These are waters that are too polluted or otherwise degraded to fully support their designated uses, based on water quality standards established by each state. In Alabama, ADEM is responsible for compiling and submitting a list of 303(d) impaired waters to USEPA. The 303(d) list includes the causes and sources of water quality impairment for each listed waterbody.

For waterbodies included on the 303(d) list, the state must calculate the maximum amount of each pollutant causing water quality impairment that can be allowed, such that the water quality standards for the waterbody are maintained. This calculation is known as a total maximum daily load, or TMDL. TMDLs are developed according to a specified schedule and must be approved by USEPA after an opportunity for public comment. Waterbodies can be removed from the 303(d) list after a TMDL is developed or after other changes have been made to correct water quality issues.

According to the Draft 2020 Alabama 303(d) list, there are three water bodies within the Watershed that have been declared impaired. Wolf Creek is listed for metals (mercury). Both Sandy Creek and Miflin Creek are listed for pathogens (enterococcus) and metals (mercury). No TMDLs have yet been developed for these waterbodies.

5.1.3 CWA Section 402 NPDES Permitting Program

Section 402 of the CWA established the NPDES permitting program to regulate discharges from all construction sites on an acre or greater of land, as well as municipal, industrial, and commercial facilities discharging wastewater or stormwater directly from a point source (pipe, ditch, or channel) into surface waters of the United States. Two types of permits are issued under the NPDES program. One is a general permit, and the second is an individual permit. The general permit covers a group of discharges with similar qualities within a given geographical location. An individual permit is a permit specifically tailored to an individual facility (USEPA, 2019).

Using the USEPA EnviroMapper database, seven municipal, industrial, or commercial facilities with general NPDES permits were identified within the Watershed. See **Figure 5.2** for NPDES facility locations.

These facilities include:

1. Ready Mix USA, LLC
2. Mobile Asphalt Company
3. Ascend Performance Materials
4. City of Foley, Public Works (Pesticide Permit)
5. Vulcan, Inc.
6. City of Foley, Foley Dirt Pit
7. Kelpet Dirt Pit

Due to the temporary nature of the discharges associated with the NPDES Construction General permit, those permitted sites are not identified on this map.

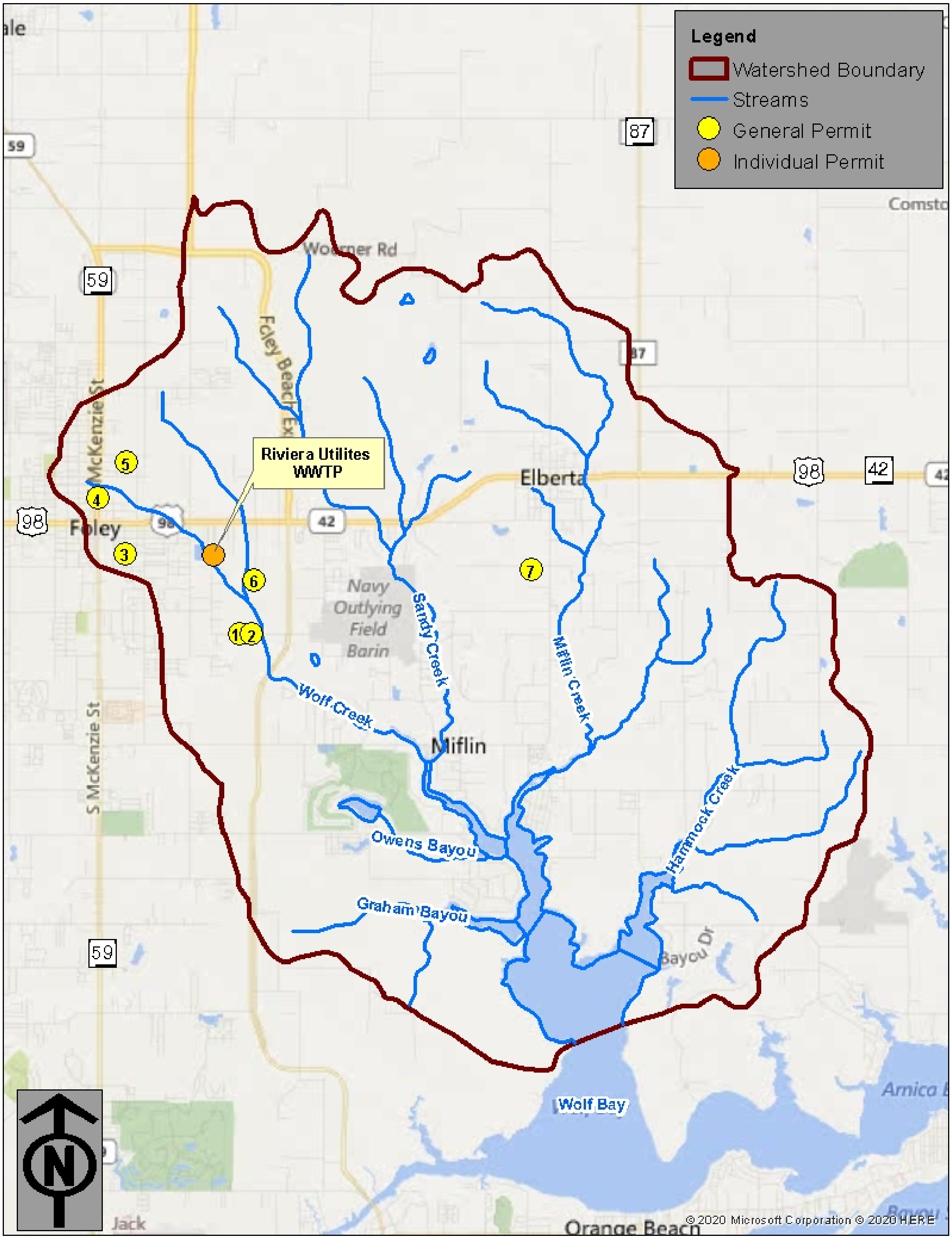

Figure 5.2 General and Individual NPDES Permits Within the Watershed

Riviera Utilities (**Figure 5.3**), also known as the Utilities Board of the City of Foley, has an individual NPDES permit (AL0049042) for biosolids and for stormwater discharge into Wolf Creek. They are currently in the process of upgrading the wastewater treatment plant to include:

- Increase from 2.0 million gallons per day (MGD) to 3.5 MGD permitted treatment capacity
- Design capacity of 4.0 MGD with a 10.0 MGD peak
- Installation of new:
    - Influent pump station
    - Headworks
        - Rotary drum screens
        - Vortex grit removal
    - Granular activated sludge treatment process
    - Tertiary filters
    - Septage receiving station
- Enhanced nutrient removal with a process guarantee of:
    - Phosphorus <1.5 mg/L
    - Total nitrogen <5mg/L

Figure 5.3 Riviera Utilities Wastewater Treatment Facility

5.1.4 NPDES Municipal Separate Storm Sewer Systems (MS4) Program

An MS4 is a conveyance or system of conveyances that is:

- owned by a state, city, town, village, or other public entity that discharges to waters of the United States,
- designed or used to collect or convey stormwater (e.g., storm drains, pipes, ditches),
- not a combined sewer, and
- not part of a sewage treatment plant, or publicly owned treatment works (POTW).

To prevent harmful pollutants from being washed or dumped into MS4s, certain operators such as cities, public universities, departments of transportation, hospitals, and prisons are required to obtain NPDES permits and develop stormwater management programs (EPA, 2019).

The 1990 Phase I regulation requires medium to large municipalities or certain counties with a population of at least 100,000 or more to obtain NPDES individual permit coverage for their stormwater discharges. The 1999 Phase II regulation requires small MS4s in the U.S. Census Bureau defined urbanized areas, as well as MS4s designated by the permitting authority, to obtain NPDES coverage for their stormwater discharges. Phase II also includes non-traditional MS4s such as public universities, departments of transportation, hospitals, and prisons (EPA, 2019). Phase II MS4s are covered by statewide general permits in Alabama.

Currently the City of Foley, the Town of Elberta, and the Town of Summerdale, along with the portions of the Watershed that fall under Baldwin County jurisdiction, qualify for an exemption under the NPDES MS4 program. However, due to rapid growth, the City of Foley is anticipating that the 2020 census results will require that they obtain a Phase II general permit. Phase II MS4 permittees are required to develop and implement a storm water management plan that includes programs on public education and public involvement on storm water impacts, illicit discharge detection and elimination (IDDE), construction site storm water runoff control, post-construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations.

5.2 Potential Nonpoint Source Pollutants

Nonpoint source (NPS) pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. NPS pollution can include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas.
- Oil, grease, and toxic chemicals from urban runoff and energy production.
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks.
- Salt from irrigation practices and acid drainage from abandoned mines.
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems.
- Atmospheric deposition and hydromodification (EPA, 2019).

5.2.1 Agriculture

According to the National Land Cover Database (NLCD) 2016, agricultural land use makes up approximately 35% of the Watershed. If conservation practices are not properly implemented, water quality can be greatly affected by agricultural runoff. Examples of improper agricultural practices include:

- Poorly located or managed animal feeding operations and manure
- Overgrazing
- Plowing too often
- Plowing at the wrong time
- Improper fertilizer application

Agricultural activities in the Watershed include row crops (such as corn, peanuts and soybeans), sod farming, and animal grazing. Based on aerial imagery, most of the row crop areas have agricultural buffer strips. Many farmers in the Watershed employ the use of cover crops, no till planting, conservation crop rotation, contour farming, and variable rate nutrient application. Precision agriculture is also commonly used to reduce the impacts on the natural resources. Irrigation of crops and turf in the Watershed is mixed between conventional irrigation and variable rate irrigation. Variable rate irrigation waters the crops based on plant moisture index and reduces the overall water demand.

There are several farms within all three sub-watershed that engage in cattle farming (either for dairy or beef production). Most of these cattle are allowed to roam about large pastures and even wade in or drink from creeks and drains. During field reconnaissance, cattle were observed in the riparian areas of the headwaters of Miflin, Sandy, and Hammock Creeks. This creates opportunities for streams or creeks to be impacted by animal waste. Despite the possibility, a recent study conducted by Cook (2017) suggests that the nutrient loads and bacterial concentrations that usually accompany large-animal farming are not yet present within the Watershed.

5.2.2 Forestry

Approximately 39% of the Watershed comprises forested area, including wetlands. Potential sources of pollution associated with timbering activities include:

- Removal of streamside vegetation
- Road construction and use
- Harvesting
- Mechanical preparation for tree planting

The Alabama Forestry Commission provides guidance on best management practices to the timber industry; however, they are not an environmental regulatory or enforcement agency. Our field investigations showed no evidence of impacts to the Watershed due to forestry operations.

5.2.3 Impervious Cover

Impervious cover is a large contributor to NPS pollution. During field reconnaissance, several large tracts of land along the Foley Beach Express in the northwest section of the Watershed were listed for sale. Also, the City of Orange Beach is working towards constructing a bridge that will connect Orange Beach to the eastern side of the Watershed. If this bridge is constructed, it is reasonable to assume that current undeveloped property and agricultural fields could potentially be converted to residential and commercial developments. Careful planning and management of future growth are essential in maintaining water quality and the overall health of the Watershed. Implementing low impact development techniques on new developments and redevelopments in the Watershed will help reduce water quality impacts from impervious surfaces.

5.3 Surface Water Flow

The nature of water flow in streams is greatly influenced by land use and the management of its contributing watershed. The conversion of natural area to farmland changes how water drains from the landscape, and this process is more pronounced when natural areas are converted to impervious surfaces. Stormwater that cannot be absorbed by these surfaces contributes to an increase in volume and velocity of runoff following storm events.

Stream channels in the northern part of the Watershed, including the headwaters of Sandy, Wolf and Miflin creeks, usually exhibit flashy discharge events due to relatively high elevations (maximum 100 feet MSL) with topography that decreases in relief from north to south towards Wolf Bay (Cook, 2017).

Within the Watershed, there is one United States Geological Survey (USGS) stream flow monitoring station (USGS 02378170) located on Wolf Creek at Doc McDuffie Road. This station monitors the general water flow characteristics of the northwest portion of the Watershed. It is reasonable to assume that general water flow characteristics of Wolf Creek are comparable to flow characteristics typical of the entire Watershed because of similarities in the land use, topography, and soils of the surrounding areas. During rainfall events, stream flows increase rapidly over several hours. Flows decrease relatively quickly during the first few hours after the event, then taper down slowly over days until resuming base flow conditions. This change in stream flow over time, or stream flow hydrography, is typical of partially developed watersheds. **Figure 5.4** depicts the peak discharge over an annual time period.

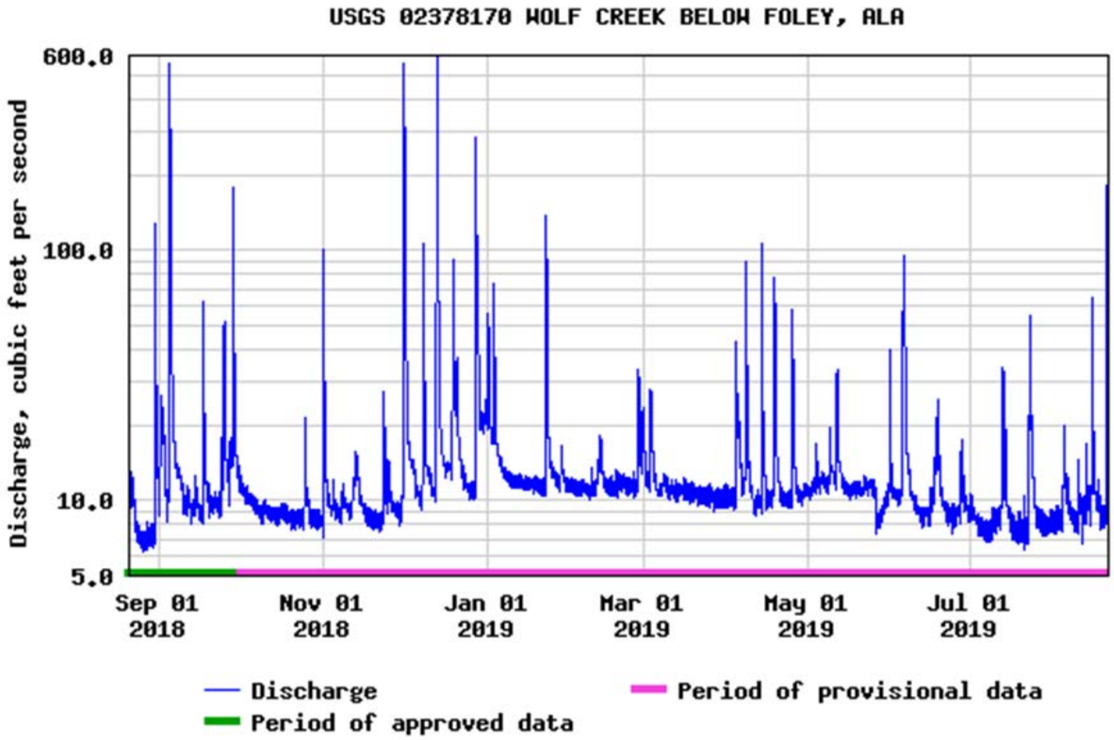

Figure 5.4 USGS Peak Discharge Over an Annual Time Period

Station data can be accessed using the following link:
https://waterdata.usgs.gov/al/nwis/inventory/?site_no=02378170&agency_cd=USGS

The smaller tributaries within the Watershed either become parched during dry weather conditions or convey low discharge rates and velocities, but during intense rainfall events, the tributaries are extremely flashy with high discharge rates and velocities occurring quickly (Cook, 2017). Impaired stream conditions during dry weather could be, at least in part, the result of reduced groundwater infiltration due to impervious cover.

5.4 Sediment Transport

Sediment is transported in watersheds by overland flow, which is concentrated in small depressions and gullies and eventually discharged into streams that transport the sediment with material eroded from the stream banks and bottom until it is ultimately deposited. Erosion rates are accelerated by human activity and poor land management practices that increase the volume and velocity of stormwater runoff, resulting in negative impacts to the habitats of the receiving waterbodies.

Results from the 2017 Cook study show that six of the 15 sites monitored within the Wolf Bay Watershed conveyed both suspended and bed load sediment. Of the six sites, Wolf Creek at Doc McDuffie Road, the west unnamed tributary to Sandy Creek at US Highway 98, the east unnamed tributary to Sandy Creek at US Highway 98, and Wolf Creek at Swift Church Road had the largest total sediment loads (10,931, 1,995, 1,715, and 1,257 tons per year [t/yr], respectively). During field reconnaissance, land use upstream and in the vicinity of these monitoring locations were surveyed to identify input sources that contribute to erosion and sediment in each of these stream locations. The headwaters of Wolf Creek above the Doc McDuffie Road site are characterized by urban (western headwater branch) and agricultural (eastern headwater branch) land use. Fern Avenue Extension is being constructed from State Route 59 to the Foley Beach Express (FBE) across the eastern headwater. With the addition of this new roadway, current agricultural land use has the potential to be converted to urbanized land use, therefore, increasing the potential of flashy, high-velocity flows in the eastern branch. Property access was granted at two locations downstream of the Doc McDuffie location and the monitoring site at Swift Church Road. Immediately downstream of the Doc McDuffie location, the streambanks were stabilized, and it appeared the stream was able to access the floodplain, **Figure 5.5**. Further downstream between the FBE and Swift Church Road, extensive stream bank erosion has occurred, **Figure 5.6**. Interviewing the property owner, who has owned the property for over 30 years, revealed that noticeable erosion did not occur until the April 2014 flood.

Figure 5.5 Stabilized Stream Segment Downstream of Doc McDuffie Road

Figure 5.6 Unstable Stream Segment Between FBE and Swift Church Road

Upstream of the west unnamed tributary to Sandy Creek is mainly forested with agricultural input, and upstream of the east unnamed tributary, home construction has started again in the Sandy Creek Farms Subdivision. Historical aerials were also reviewed for these two locations to help identify potential input sources. During the period between February 2017 and November 2017, upstream of the eastern unnamed tributary, a historic pond was drained, allowing the stream to reestablish. Erosion on the western unnamed tributary is highly visible in the February 2017 Google Earth aerial, **Figure 5.7**, and erosion on the eastern unnamed tributary is highly visible in the November 2017 Google Earth aerial, **Figure 5.8**.

Figure 5.7 February 2017 Google Earth Aerial Image

Figure 5.8 November 2017 Google Earth Aerial Image

5.5 Water Quality

Water quality is an important factor for healthy ecosystems, safe access to natural resources, and public health and safety. Water quality also determines the types of uses and activities for which a waterbody is suitable, as described in **Section 5.1.1**. Use of surface waters for public water supplies, fishing, swimming, and agriculture depends upon water quality. Poor water quality can render waters unsuitable for these uses and have detrimental effects on the natural environment. Many factors affect water quality, including land use, climate, groundwater, and geological resources. Water quality may be the single most important factor in determining the overall health of a watershed.

A water quality assessment was performed as part of the pre-restoration study conducted by Cook (2017) for the Watershed. Samples were collected and analyzed for nitrogen, total phosphorus, dissolved oxygen, and pathogens. The analysis concluded that for the 15 sites monitored, every site had an average nitrogen concentration above the ADEM established reference standard (0.3258 mg/L); ten of the 15 sites had an average total phosphorus concentration above the ADEM established reference standard (0.04 mg/L); and 12 of the 14 sites had average dissolved oxygen values less than the ADEM reference standard (6.94 mg/L).

Seven sites were sampled for pathogens during the low discharge event. Each site had relatively low numbers for surface water and most likely did not represent a particular point source. When the samples were correlated with watershed area, Cook (2017) suggested that the sample site located on Elberta Creek (tributary to Miflin Creek) had relatively high numbers and may represent a source of pathogens above background levels. Field reconnaissance identified cattle grazing upstream of the sample point.

5.6 Biological Conditions

The Graham Creek Preserve serves as a home to several State of Alabama-listed endangered and threatened plant species (**Table 5.3)**.

Table 5.3 **State of Alabama Listed Threatened and Endangered Plant Species**

Species	Status
Rush Featherling (*Pleea tenuifolia*)	Endangered
Shortleaf Rosegentian (*Sabatia brevifolia*)	Endangered
White Top Pitcherplant (*Sarracenia leucophylla*)	Endangered
White Arrow Arum (*Peltandra sagittifolia*)	Endangered
Pineland Bogbutton (*Lachnocaulon digynum*)	Endangered

In addition to many common animals, such as the common gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), rabbit (*Sylvilagus floridanus*), nine-banded armadillo (*Dasypus novemcinctus*), Virginia opossum (*Didelphis virginia*), and whitetail deer (*Odocoileus virginianus*), the Preserve also provides shelter for the gopher tortoise (*Gopherus polyphemus*) and the bald eagle (*Haliaeetus leucocephalus*). The gopher tortoise is currently listed as a candidate species for listing as a threatened species with the USFWS under the Endangered Species Act. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act.

5.7 Habitat Conditions

There are three habitat restoration/management areas located within the Watershed. The first site is a restoration site of approximately 2,200 feet of Wolf Creek between State Route 59 and North Poplar Street in an urbanized area. The historically channelized stream reach was restored by creating meanders in the stream and reestablishing the floodplain. The floodplain was then planted with native vegetation. The implementation of this project reduced streamflow velocities and helps limit erosion downstream.

The second area is the Graham Creek Preserve. The Preserve comprises 484 acres of natural habitat, including wet pine flats, bottomland hardwood wetlands, and tidal marshes. Habitat restoration activities at this park include prescribed burning and invasive species treatment in wetland areas.

The third area is referred to as the Upper Wolf Bay Savanna and Marsh Forever Wild Tract. This is a 568-acre tract that lies on the north shore of Wolf Bay. A management plan was prepared for this property in May 2018. In the plan, management goals set forth include inventorying, enhancing, restoring, and protecting the biodiversity of the natural communities currently on the property and those which may naturally succeed the existing communities, particularly sensitive populations which exist within the tract.

5.8 Stream and Shoreline Assessment

5.8.1 Shoreline Type Classification

Jones and Tidwell (2011) identified nine shoreline classification types within the Wolf Bay Watershed. **Table 5.4** shows that vegetated shorelines with a low bank were most frequently identified followed by marsh and open vegetated fringe organic shorelines. **Figure 5.9** provides a visual illustration of shoreline classification types throughout the Watershed.

Table 5.4 Wolf Bay Watershed Shoreline Classification Types

Shoreline Type	Length (ft)
Artificial	1,263
Inlet	1,155
Organic (Marsh)	34,480

Shoreline Type	Length (ft)
Organic (Open, Veg. Fringe)	56,864
Organic (Swamp Forest)	1,248
Pocket Beach	346
Sediment Bank (low)	6,404
Vegetated Bank (High)	9,315
Vegetated Bank (Low)	89,493
TOTAL	200,568

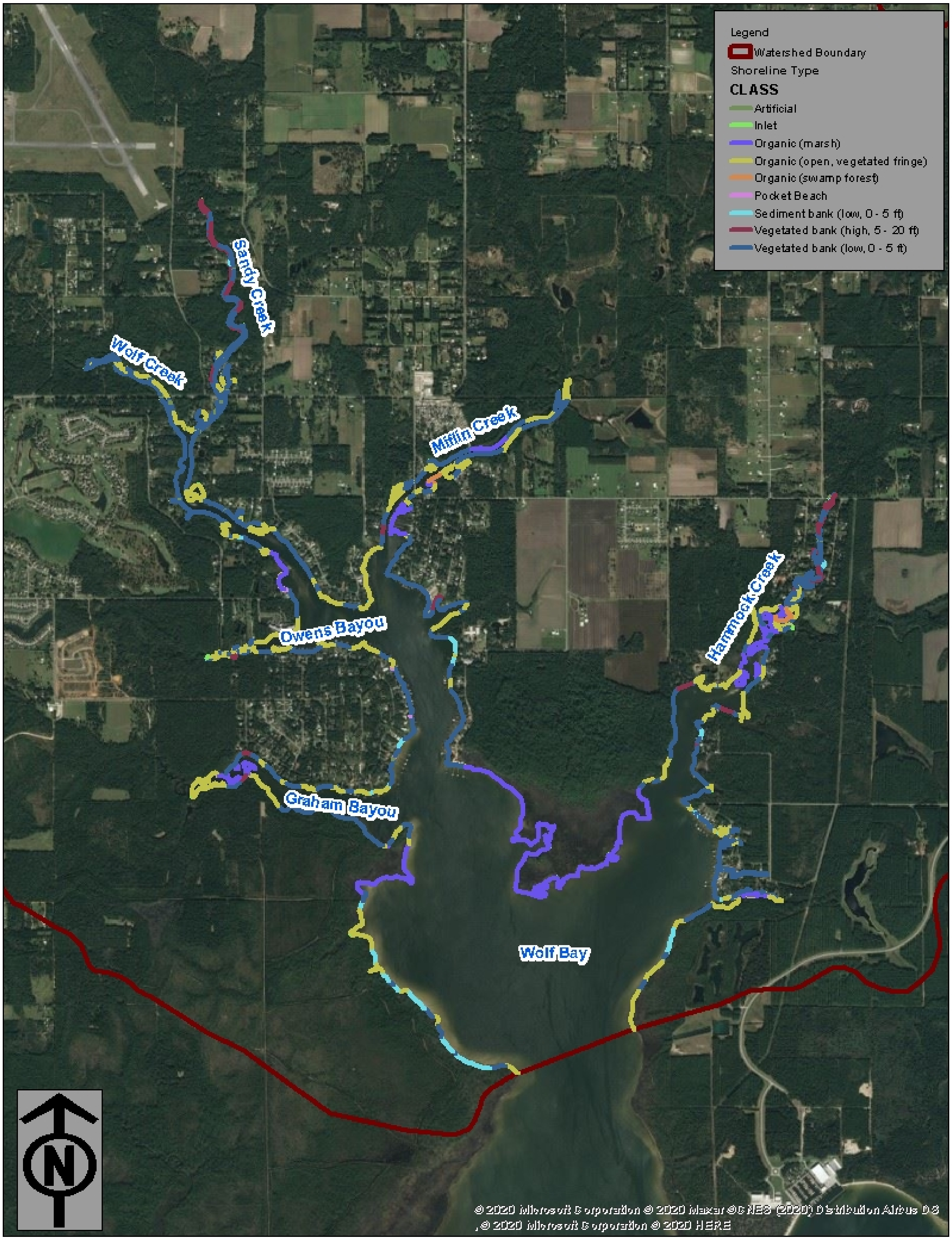

Figure 5.9 Shoreline Classification Types Along Water Bodies in the Wolf Bay Watershed

5.8.2 Shoreline Protection Methods

Jones and Tidwell (2011) also identified shoreline protection methods through field observations of approximately 63,190 linear feet of shoreline. throughout the Wolf Bay Watershed. Natural, unretained shorelines made up the majority of the shorelines throughout the Watershed followed by bulkhead protection strategies. **Table 5.5** lists shoreline protection methods and their corresponding lengths along surface waters within the Watershed. **Figure 5.10** provides a visual illustration of shoreline protection methods throughout the Wolf Bay Watershed.

Table 5.5 Wolf Bay Watershed Shoreline Protection Methods

Shoreline Protection Method	Length (ft)
Abutment	108
Artificial	28
Beach Nourishment	14
Boat Ramp	211
Bulkhead (concrete)	210
Bulkhead (cresote)	51
Bulkhead (steel, wood)	8,103
Bulkhead (w/groin)	35
Bulkhead (w/ retaining wall)	38
Bulkhead (w/riprap)	376
Groin	20
Natural	52,127
Rubble/Riprap	1,841
Sill (wood)	21
TOTAL	63,190

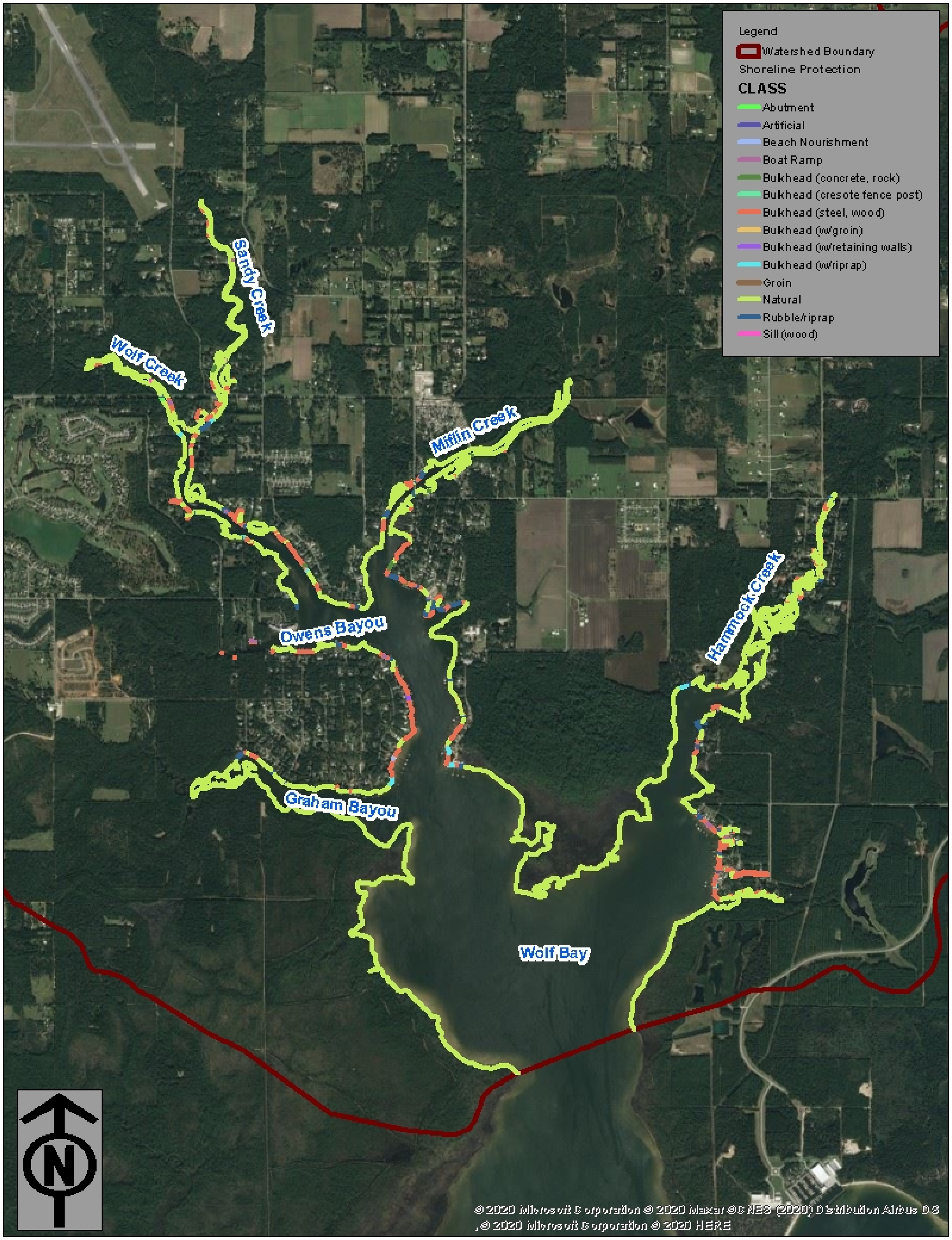

Figure 5.10 Shoreline Protection Methods Along Water Bodies in the Wolf Bay Watershed

5.8.3 North Wolf Bay (Moccasin Bayou), Graham Bayou, and Owens Bayou

The shorelines of northern Wolf Bay (Moccasin Bayou), Graham Bayou, and Owens Bayou are either emergent wetlands, are protected by bulkheads or rip rap, or are living shorelines. Currently, there are no known areas of concern for the shorelines along this portion the Bay.

5.8.4 Wolf Creek

Wolf Creek contained minimal amounts of litter. Invasive species noted included Chinese tallow, cogon grass, and alligator weed (**Figure 5.11**). Chinese tallow and cogon grass were observed at the County Road 20 bridge crossing. Areas of alligator weed were identified downstream of the Swift Church Road bridge. There were small areas of bank instability/sloughing observed and sediment deposition in the forms of sand bars along the channel throughout the stream (**Figure 5.12**). Overall, the stream was generally very shallow with many impediments to flow (fallen trees) throughout.

Figure 5.11 View of Alligator Weed in Wolf Creek

Figure 5.12 Example of Bank Instability/Sloughing Along Wolf Creek

5.8.5 Sandy Creek

Sandy Creek contained only minimal amounts of litter and invasive species, including Chinese tallow. Numerous trees were noted (mainly cedar) leaning out of the banks over the channel that could result in potential future bank failure and/or channel blockage, **Figure 5.13**. Some bank instability was observed primarily in the residential areas. There were several small pipe outfalls (some flowing) protruding out of the banks and bulkheads along the stream, **Figure 5.14**. The effluent water appeared to be clear and no odor was detected.

Figure 5.13 Example of Trees Leaning Over the Sandy Creek Channel

Figure 5.14 Example of Outfall Pipe Located Along Sandy Creek

5.8.6 Miflin Creek

There was no litter noted and there were few to no invasive species found along Miflin Creek. There were many log jams throughout the Creek that make it difficult to navigate by motorboat, as shown in **Figure 5.15**. Bank stability was satisfactory in all but two places, where head cutting was observed. The water in this reach was exceptionally clear, and more fish were observed in Miflin Creek than in any other water body surveyed.

Figure 5.15 Example of Log Jam Found in Miflin Creek

5.8.7 Hammock Creek

While no litter was observed in or along Hammock Creek, there were invasive species noted. Large privet thickets, such as those shown in **Figure 5.16**, along with Japanese climbing fern, were overserved along the stream banks, and cogon grass was found at the County Road 20 bridge crossing. The banks upstream of the County Road 20 bridge were extremely eroded, and there were numerous log jams observed in the stream as shown in **Figure 5.17**. Sand and sediment bars were present throughout the channel.

Hammock Creek south of the County Road 20 bridge is bordered by residences until it reaches Wolf Bay. There were some examples of bank erosion noted, but these were sparse and likely caused by neglected properties or home construction activities. The channel appears maintained to allow access to boaters.

Figure 5.16 Example of Privet Thicket Along the Shore of Hammock Creek

Figure 5.17 Example of Eroded Streambanks and Log Jams Found Along Hammock Creek

Chapter 6 Climate Vulnerability Assessment

6.1 Introduction to Climate Vulnerability

Given the significant amount of data collected and analyzed with respect to climate change, climate vulnerability, and sea level rise, it is important to analyze and discuss those impacts on a more local (watershed) scale. This chapter will provide an overview and analysis of the potential impacts of climate change, combined with an assessment of the Wolf Bay Watershed's vulnerability and potential resilience to climate change and, particularly, sea level rise. This issue has the potential to affect not only ecologic function and migration patterns but also patterns of man-made development. Particular issues of concern include the ability of natural habitats to migrate and adapt to changes effected by sea level rise and the need for local governments to plan accordingly when siting critical infrastructure, such as water and wastewater conveyances and treatment, public safety facilities, and emergency response facilities.

Through Chapter 6, we will review and discuss a number of analytical tools created by the Mississippi/Alabama Sea Grant Consortium, The Nature Conservancy, NOAA's Digital Coast website, along with other models, tools, and resources that provide information relevant to climate vulnerability in the Wolf Bay Watershed. Additionally, this Chapter will utilize existing models such as the Sea Level Affecting Marshes Model (SLAMM), the Coastal Resilience Index, and the Coastal Vulnerability Index.

6.2 Sea Level Rise Data Overview

Regional sea level trend data derived from the NOAA Tides and Currents website indicates an average sea level rise trend of approximately 3.07 millimeters per year. Data analyzed were collected from tide gauges at Dauphin Island, Alabama, and Pensacola, Florida, shown in **Figure 6.1**.

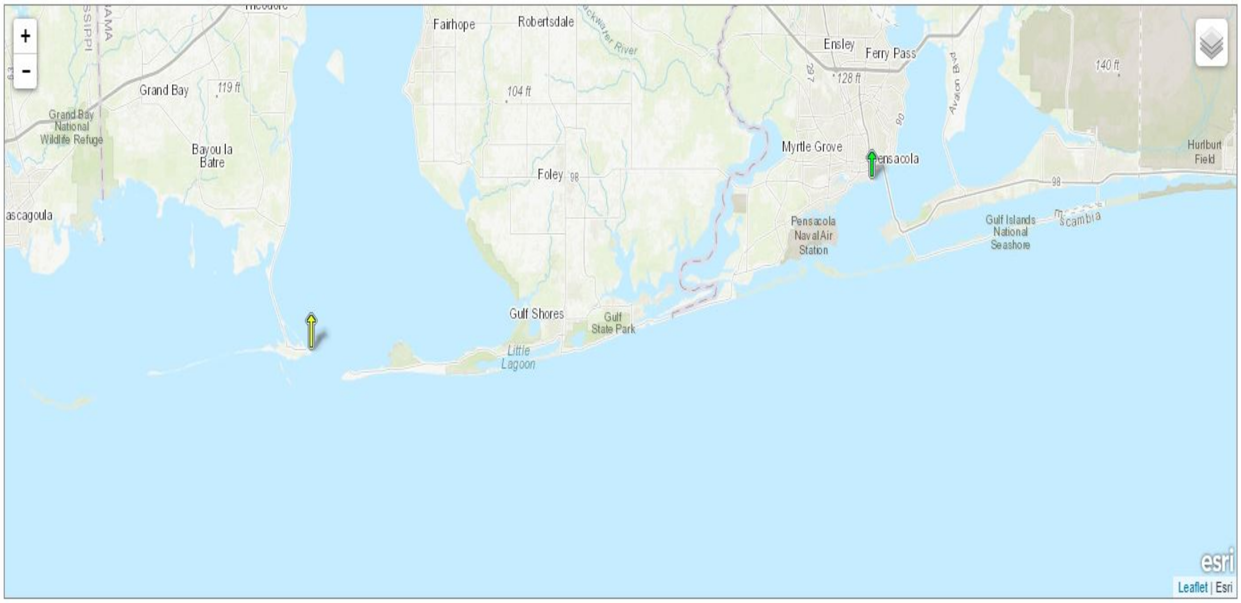

Figure 6.1 Locations of Tide Gauges Used for Data Analysis

The linear trend for Dauphin Island is 3.74 mm/yr while Pensacola is 2.40 mm/yr, with an average of 3.07 mm/yr between the two stations. This trend translates to 1.23 feet and 0.79 feet of sea level rise at the Dauphin Island and Pensacola Stations, respectively over 100 years with a regional average of approximately 1.01 feet of sea level rise. **Figures 6.2 and 6.3** depict the linear trend for the Dauphin Island and Pensacola tide gauges, respectively, from 1900 and projected through 2020.

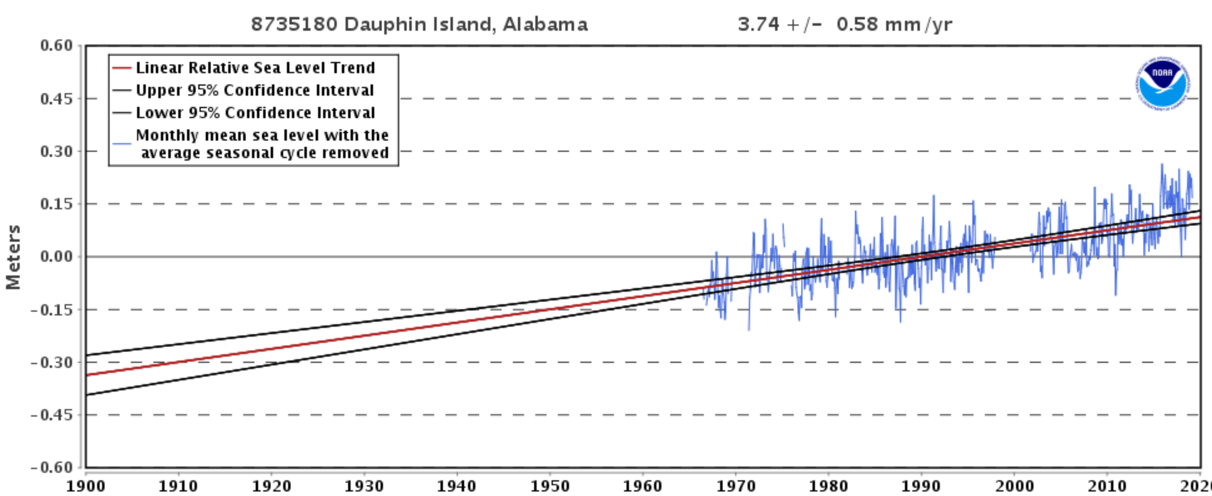

Figure 6.2 Sea Level Rise Trends for Dauphin Island, Alabama Through 2020 (Source: NOAA, 2020)

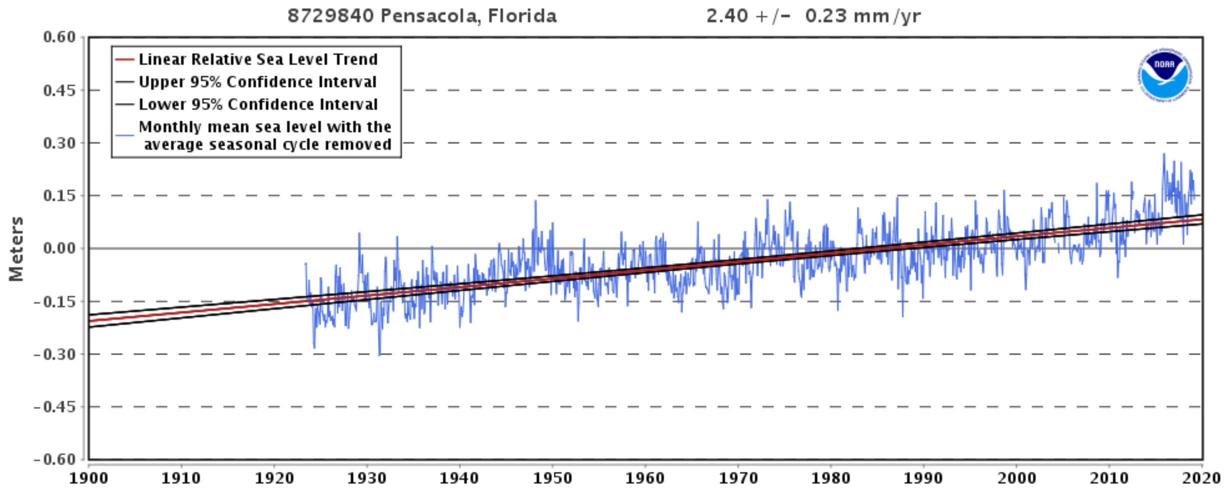

Figure 6.3 Sea Level Rise Trends for Pensacola, Florida Through 2020 (Source: NOAA, 2020)

Given the trends illustrated through these tide gauges, it is necessary to investigate the Watershed's resilience and vulnerability to sea level changes over time. The first step in this process is to utilize three specific tools: the Coastal Vulnerability Index, developed by the U.S. Geologic Survey (USGS); the existing SLAMM Model data prepared by Warren Pinnacle Consulting, Inc. through the U.S. Fish and Wildlife Service depicting a 0.5-meter sea level rise scenario; and the Coastal Resilience Index, developed by the Mississippi–Alabama Sea Grant Consortium. The following sections will provide descriptions of these tools.

6.3 Coastal Vulnerability Index

The USGS Coastal Vulnerability Index (CVI) is designed to analyze the relative susceptibility of coastal regions to sea level rise. The CVI and subsequent classifications are based on variables including geomorphology, regional coastal slope, tide range, wave height, relative sea level rise, and shoreline erosion and accretion rates. This combination of variables provides an overview of regions where physical changes are likely to occur due to sea level rise.

Table 6.1 Ranking of Coastal Vulnerability Index

Variable	Very Low 1	Low 2	Moderate 3	High 4	Very High 5
Geomorphology	Rocky, cliffed coasts, fiords	Medium cliffs, indented coasts	Low cliffs, Glacial drift, Alluvial Plains	Cobble beaches, Estuary, Lagoon	Barrier beaches, sand beaches, Salt marshes, Mud flats, Deltas, Mangrove, Coral reefs
Coastal Slope (%)	>11.5	11.5 to 5.5	5.5 to 3.5	3.5 to 2.2	<2.2
Sea Level Rise (in/yr)	<.07	.07 to .098	.098 to .12	.12 to .134	>.134
Shoreline Erosion/Accretion (ft/yr)	>6.56	3.28 to 6.56	-3.28 to +3.28	-3.61 to 6.56	>-6.56
Mean Tide Range (ft)	19.69	13.45 to 19.69	6.56 to 13.12	3.28 to 6.23	<3.28
Mean Wave Height (ft)	1.81	1.81 to 2.79	2.79 to 3.44	3.44 to 4.10	>4.10

The Coastal Vulnerability Index uses the variables as indicated in **Table 6.1** which are then applied to the formula as follows: $CVI=\sqrt{((a*b*c*d*e*f)/6)}$, where:

- a = geomorphology
- b = coastal slope
- c = relative sea-level rise rate
- d = shoreline erosion/accretion rate
- e = mean tide range
- f = mean wave height

The results of the index for Wolf Bay Watershed indicate that the lower end of the Watershed is at low-to-moderate risk of impacts from sea level rise. Identification of a low-to-moderate risk indicates that approximately 10 to 35% of the shoreline indicated in **Figure 6.4** is at risk of impacts to sea level rise. Anecdotally, recent events across the Gulf Coast reveal that combinations of high tide and storm events tend to result in more frequent flooding of roads and properties in close proximity to the shoreline. Low to moderate wave action along the northern coastline of Wolf Bay will serve to mitigate these high tide/storm event impacts. However, a significant tropical event directly affecting Wolf Bay would have the effect of magnifying flooding in the lower reaches of the watershed. **Figure 6.4** illustrates the results of the CVI for the Watershed based on USGS data utilizing the CVI calculations for Wolf Bay.

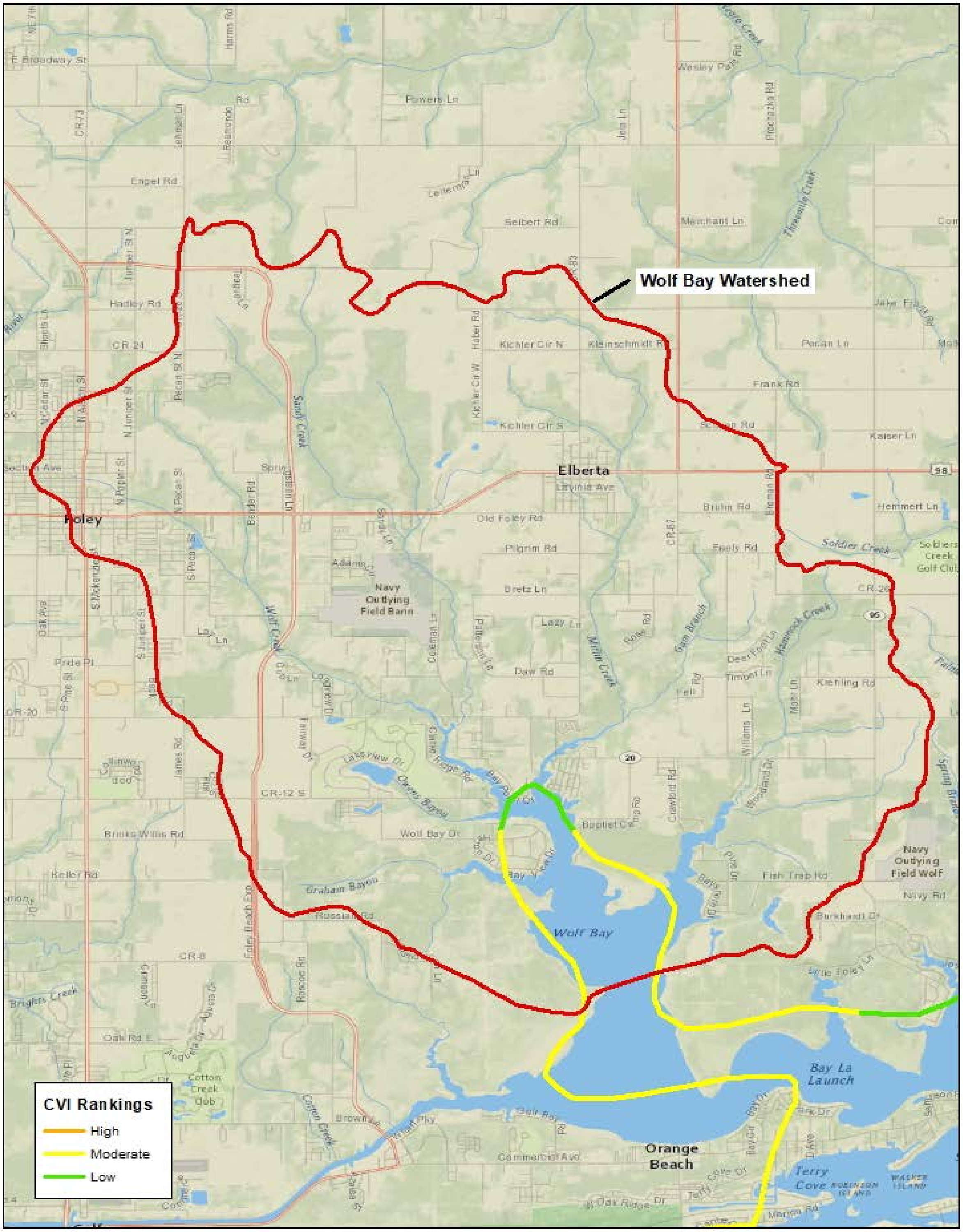

Figure 6.4 Coastal Vulnerability Index Map for Wolf Bay Watershed

6.4 SLAMM Model for Wolf Bay

Tidal marshes are some of the most vulnerable habitats to the effects of sea level rise. The Sea Level Affecting Marshes Model (SLAMM) was developed by EPA contractor Warren Pinnacle Consulting, Inc. to support planning efforts and management decisions related to sea level rise. The model simulates changes in tidal marsh area and habitat type in response to sea level rise. SLAMM simulates five primary processes that affect tidal marshes: inundation, erosion, overwash (when barrier islands are submerged), saturation (a rise in the groundwater table), and accretion (the rise of the marsh surface elevation as a result of sediment deposition). The model allows the user to input local data [i.e., local accretion rates and local subsidence rates (gradual lowering of the land surface)] and modify an array of parameters (i.e., rate of sea level rise) to customize the model.

The SLAMM Model performed by Warren Pinnacle Consulting, Inc. through the U.S. Department of the Interior and the U.S. Fish and Wildlife Service depicts a 0.5-meter sea level rise scenario. The potential impacts in this scenario affect marshes in the lower portion of the Watershed. Because the majority of the Watershed are undeveloped uplands, only a minimal amount of marsh area will be impacted based on model predictions. While some freshwater swamp habitats within the Watershed may be converted to salt marsh and open water habitats, the acreages would be minimal based on the higher topography and distance of the Watershed from the Gulf of Mexico. Areas of developed uplands include the City of Foley, the Town of Elberta, and the Glen Lakes and Graham Creek Estates Subdivisions.

6.5 Other Risk Scenarios

The NOAA Flood Exposure Mapper provides insight into potential impacts of a variety of flooding scenarios on Wolf Bay and the Wolf Bay Watershed. The Coastal Flood Hazard Composite takes into consideration high tide flooding, FEMA Flood Zones, and storm surge and sea level rise scenarios. While the lower portion of the Watershed is at low-to-moderate risk of impacts from sea level rise, the combination of these scenarios presents a more elevated risk, particularly to those developed properties in close proximity to the Wolf Bay shorelines. On the following Coastal Flood Hazard Composite Map (**Figure 6.5**), darker colors indicate higher risks of combined flooding risks from high tides, storm surge, and sea level rise.

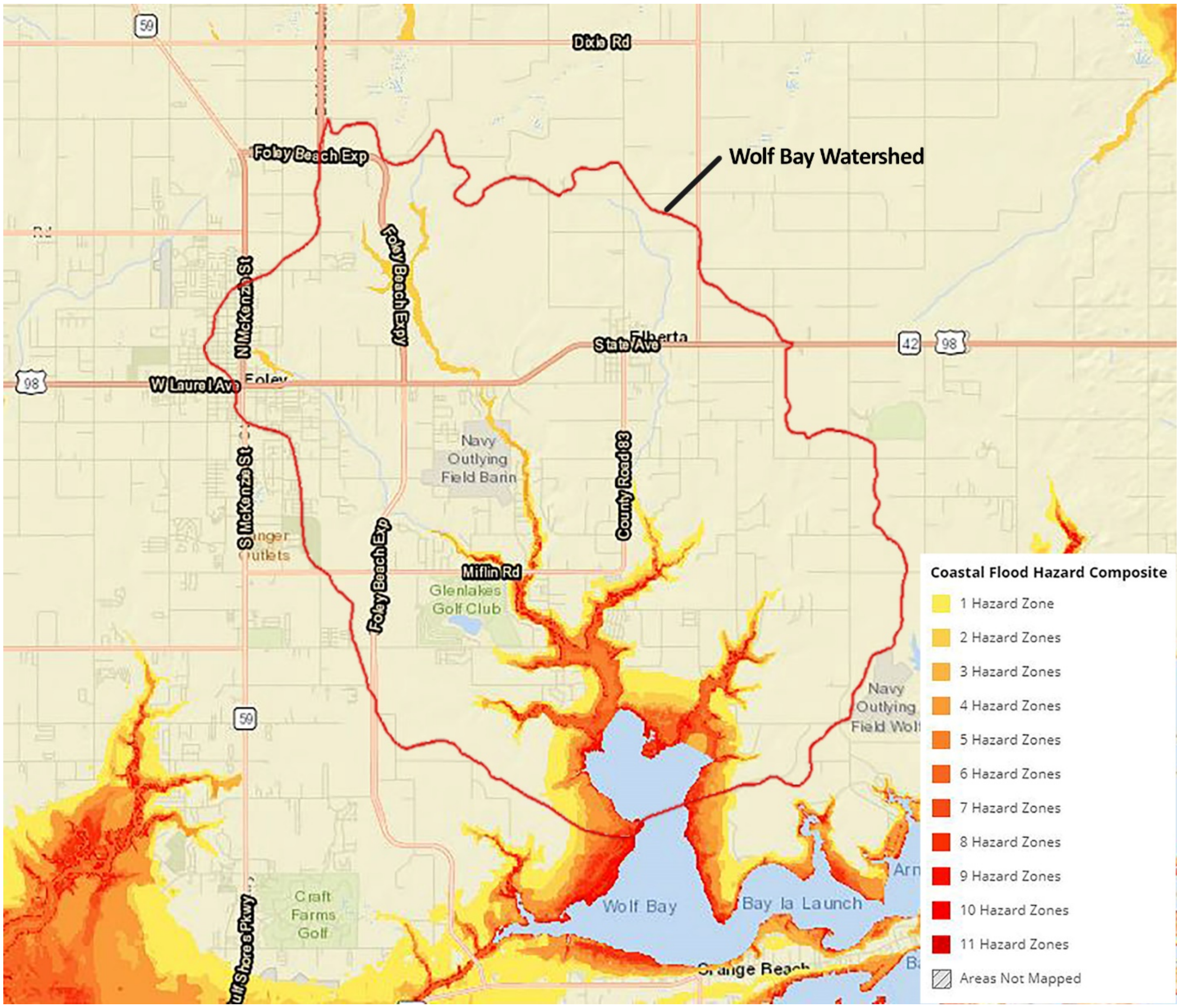

Figure 6.5 Coastal Flood Hazard Composite Map

In comparison, **Figure 6.6** shows developed lands and areas converted to development between 1996 and 2011. While the majority of the Watershed remains undeveloped or utilized for agricultural purposes, the pace of development in the Watershed increases the risk of vulnerability and exposure to a variety of climate change and flooding scenarios. As urbanization increases in the Watershed, so does the overall percentage of impervious surfaces and the potential for water quality and quantity issues in the Watershed.

Further exploration of the NOAA Flood Exposure Mapper by overlaying the coastal flood composite layer with development and development patterns reveals a scenario where future developments may be at risk, if not properly planned with respect to vulnerability scenarios.

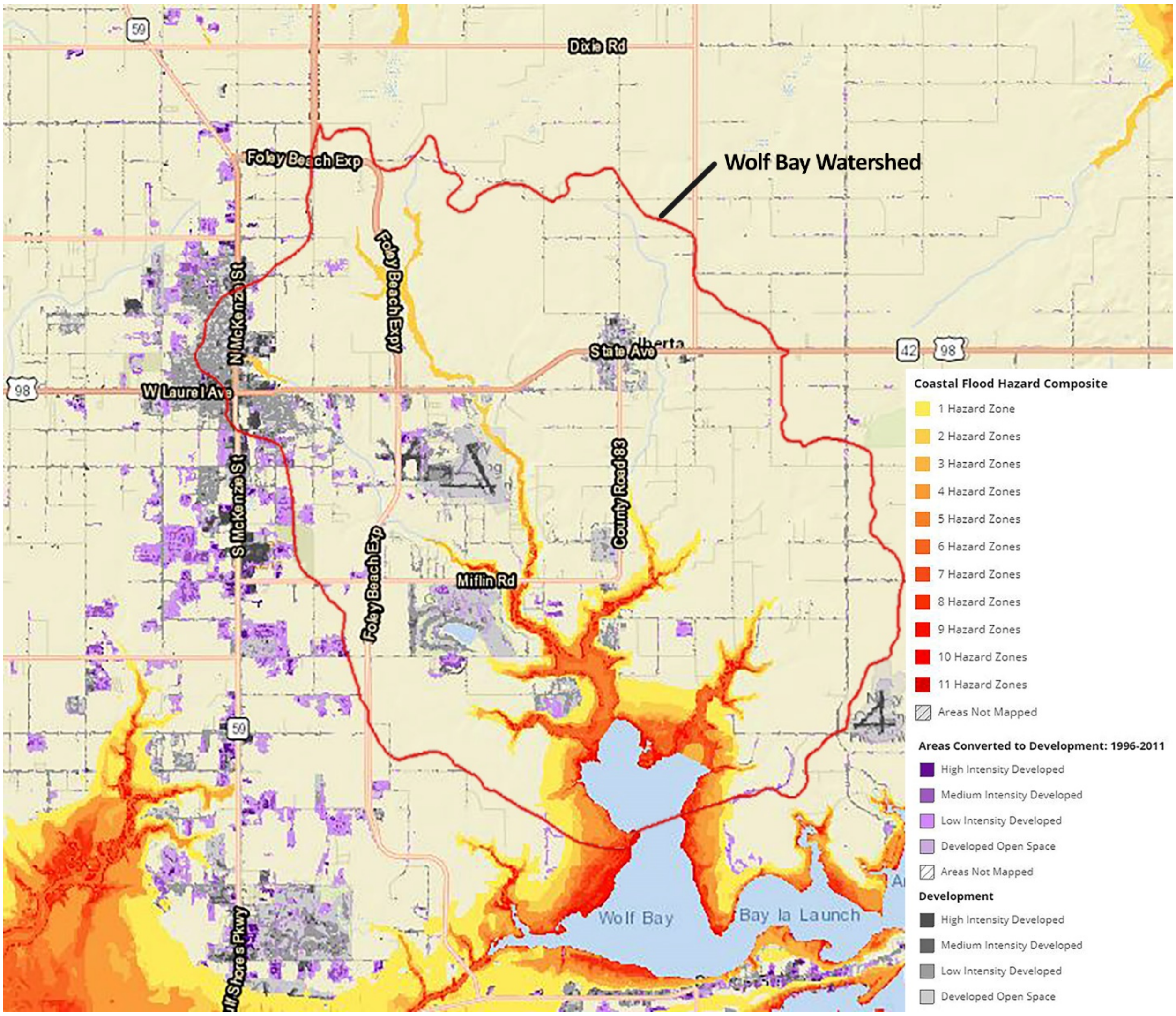

Figure 6.6 Developed Lands in Comparison to NOAA Flood Exposure Mapper

Sea level rise and resulting composite flooding also have potential to negatively impact natural areas, open space, and wetland areas. Through the current state of development in the Watershed, these undeveloped areas also have potential to mitigate impacts of flooding, storm surge, and sea level rise. As urbanization increases, efforts should be taken to protect and preserve natural areas, including wetlands, to maximize the benefit these features provide to minimize flooding and sea level rise impacts. **Figure 6.7** reflects natural areas and open space relative to composite flood risks and **Figure 6.8** reflects the wetlands potential for mitigation relative to the same composite flood risks.

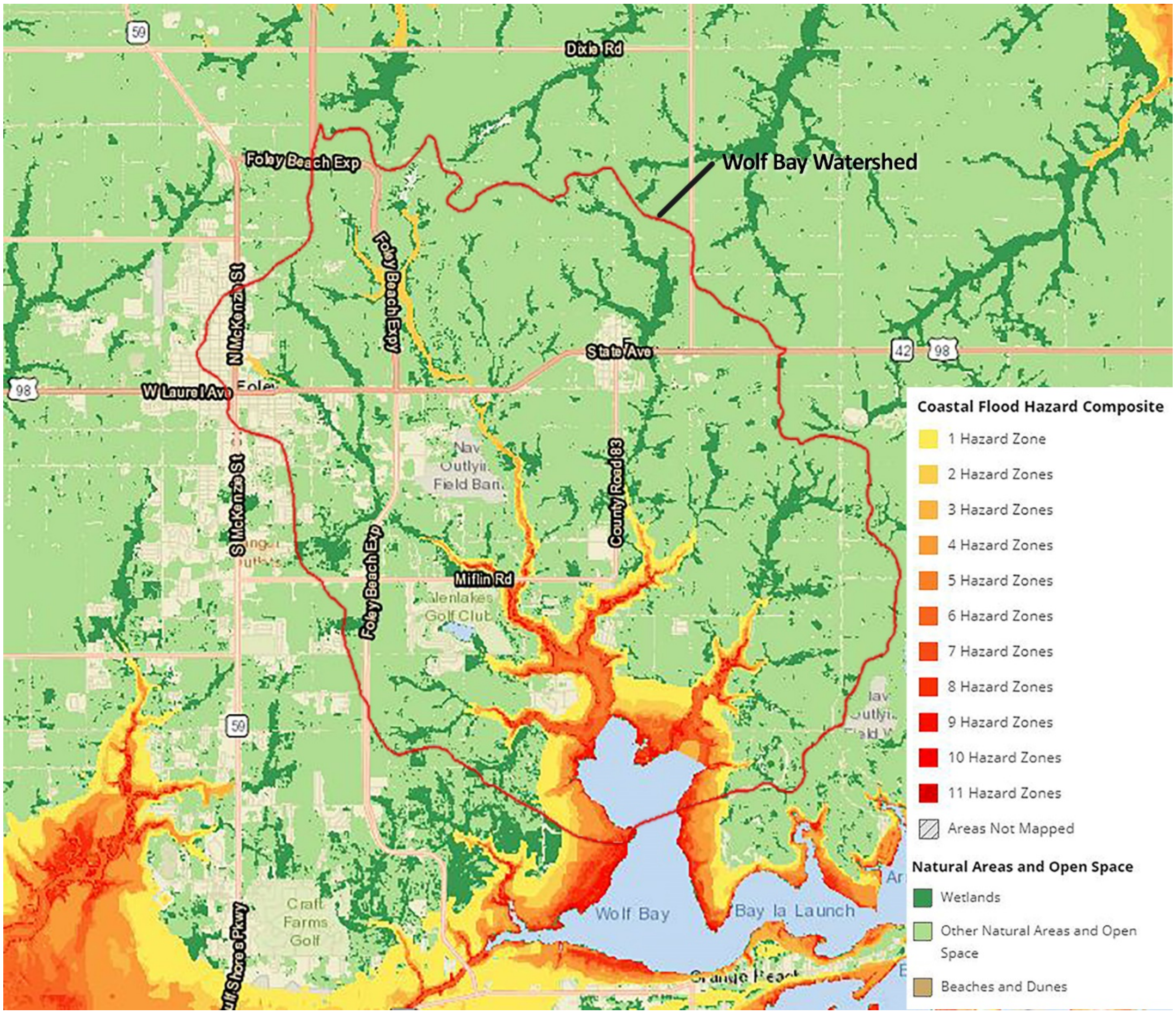

Figure 6.7 Natural Areas and Open Space Relative to Composite Flood Risks

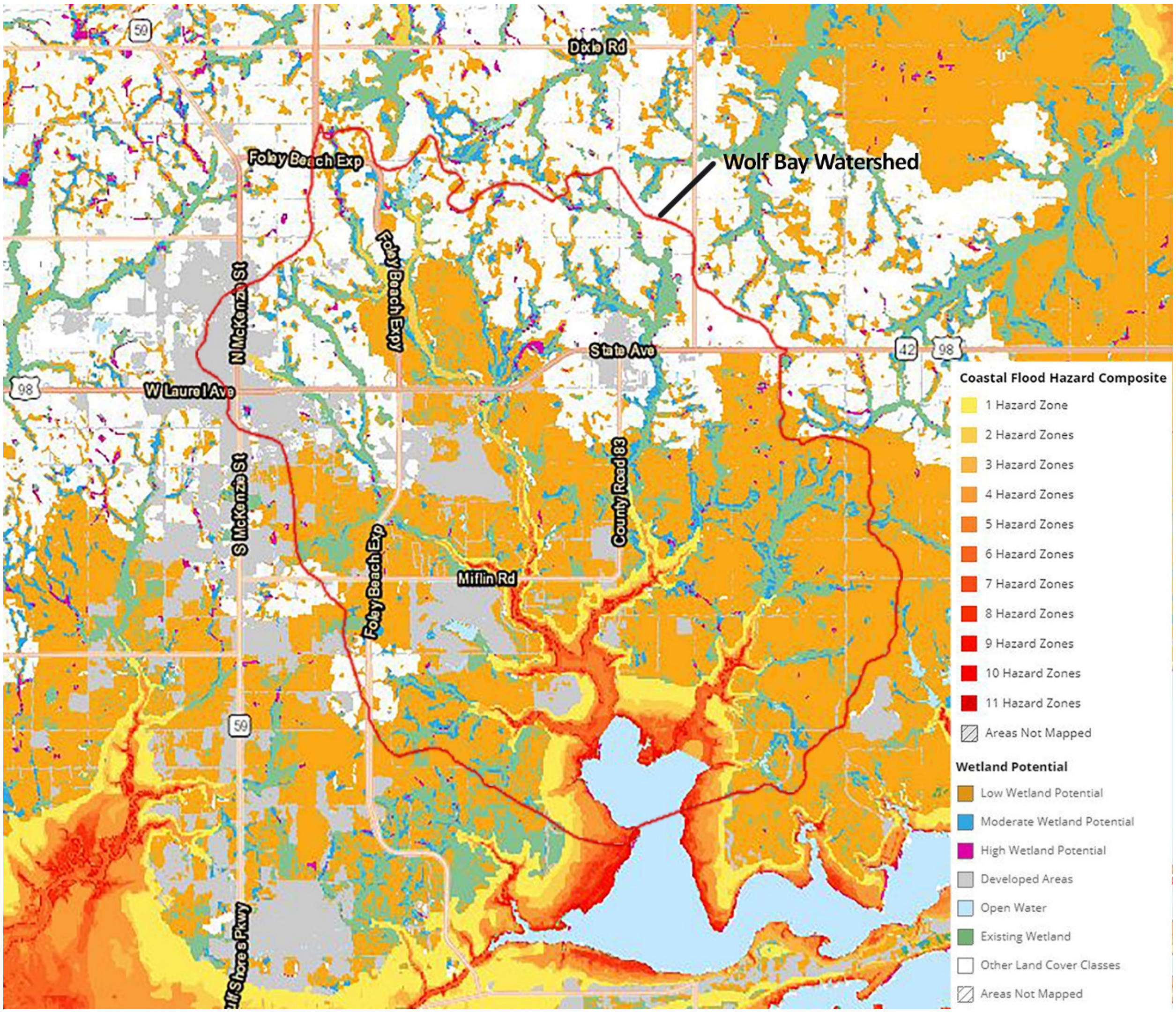

Figure 6.8 Flood Mitigation Potential for Wetlands

6.6 Coastal Resilience Index

The Coastal Resilience Index (CRI) was developed by the Mississippi–Alabama Sea Grant Consortium to provide communities with a tool to examine their relative resilience to hazard events that may also include the effects of sea level rise. The CRI exists as a series of topics within which communities rank themselves to determine potential resilience. The results of responses to these categories are then compiled to provide a relative indicator of community resilience. The results of the CRI examine seven categories of resilience that include:

- Critical Infrastructure,

- Critical Facilities,
- Transportation Systems,
- Community Plans,
- Mitigation Measures,
- Business Plans, and
- Social Systems.

A community's ranking in these seven categories indicates its relative resilience to natural hazards and, by default, to climate change and the effects of sea level rise. For the purposes of this Plan, a CRI was created for the City of Foley, the Town of Elberta, and the unincorporated portions of the Watershed and are included in **Appendix C** of this Plan. All three indices were based on a storm scenario that would include 6-8 inches of rain in a 24-hour period, a storm surge in excess of 12 feet at Perdido Pass, and a track that would take the storm directly through Perdido Pass and into Wolf Bay. The scenario also includes a landfall location west of Foley that would put the most heavily developed areas of the Watershed on the strong side of the storm. The following section addresses results of the CRIs for each area.

6.6.1 Foley

Due to a demonstrated planning capacity and well qualified and professionally certified staff, the City of Foley scored high on the CRI in all seven categories. Examples of elements contributing to a high score include participation in the FEMA Community Rating System (CRS) that serves to enhance the City's ability to prepare for flood events and also reduces flood insurance premiums for residents and businesses. Additionally, the City has a Certified Flood Plain Manager, a planner certified through the American Institute of Certified Planners (AICP), and certified building inspectors who implement the International Building Code for the City. The City also has a strong network of supporting social systems, including religious institutions, civic organizations, and an active Chamber of Commerce. Finally, the City does not appear to have critical infrastructure or facilities located in FEMA-designated flood plains or flood hazard areas.

6.6.2 Elberta

The Town of Elberta scored medium to high on the CRI. As with Foley, the Town does not appear to have critical facilities or infrastructure located in flood plains or flood hazard areas. However, the Town does not have the staff strength of Foley (lacking certified planners, certified flood plain managers, etc.). Additionally, the Town's social systems and community plans do not appear as robust in comparison to Foley. The Town's CRI ranks relatively highly and above medium.

6.6.3 Baldwin County

As with both Foley and Elberta, the unincorporated portions of Baldwin County within the Watershed do not appear to have critical facilities and infrastructure located in flood plains or flood hazard areas. The County does have good staff strength with certified planners and flood plain managers. As a result, the County scored highly in the CRI.

6.6.4 Coastal Resilience Index Summary

Generally speaking, the communities within the Watershed scored very well in the CRI. Per the CRI, a high ranking indicates that a community is well prepared for a storm event. In particular, if a community scores high in the critical infrastructure category (as all three did), then the community will probably not incur significant damage and can be functional with basic services in less than two weeks after an event.

6.7 Climate Change Management Measures

Local and regional responses to sea level rise generally fall into one of three primary categories: armoring, retreating, or adapting. Armoring strategies are those intended to physically armor the shoreline against rising sea levels. Retreating strategies are associated with policies related to "no-build" zones, deed restrictions, rolling easements, and other mechanisms designed to minimize impacts to the human and built environment. Adaptation strategies include measures such as elevation of structures and consideration of sea level rise into local and regional planning documents, such as comprehensive plans and local hazard mitigation plans. In determining specific pathways of response to sea level rise, it is rarely an "either-or" scenario but rather a decision process to determine which combination of pathways or strategies are most effective and sustainable for a given situation.

Retreating may also have the potential to raise legal issues related to Fifth Amendment rights and certain legal considerations related to common law and the Public Trust Doctrine. The Fifth Amendment to the U.S. Constitution states in part that “no person shall be deprived of life, liberty, or property without due process of law, nor shall private property be taken for public use without just compensation.” This “takings clause” of the Fifth Amendment brings to light sensitive issues as they relate to shoreline retreat, extension of shoreline buffers, and other legal mechanisms such as rolling easements. The Public Trust Doctrine is a legal principal taken from English Common Law. Its essence is that waters of the state are a public resource owned by and available to all citizens equally for purposes of navigation, commerce, fishing, recreation, and similar uses. Essentially, the Public Trust Doctrine limits public and private use of tidelands and other shorelands to protect the public’s right to use the waters of the state. Legal issues related to takings and public use rights are complex, and it is not the intention of this Plan to discuss in detail or clarify those issues as they relate to planning and mitigation strategies. Rather, this Plan seeks to provide a menu of potential mitigation, planning, and policy options to local and regional entities. Local governments seeking to enact policies or planning measures relating to taking of private land for public use or the Public Trust Doctrine should consult with legal counsel before enacting such measures.

The various options that exist for local and regional responses to sea level rise, including a “no-action” option must also be weighed within the contexts of sustainability, environmental sensitivity, local political feasibility, and fiscal feasibility. **Figures 6.9 – 6.12** depict the relative feasibility of different response options.

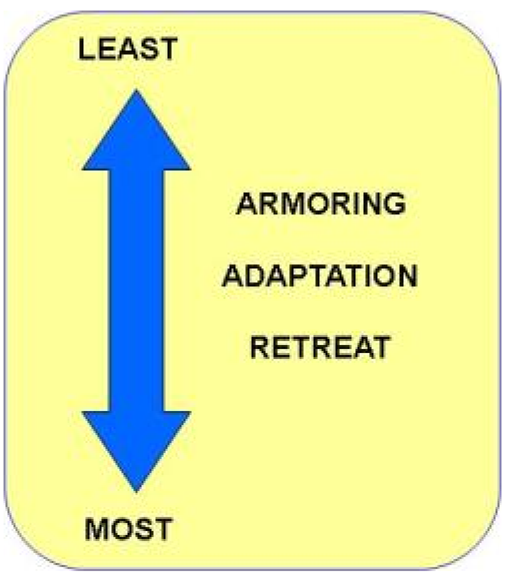

Figure 6.9 Response Pathways: Environmental Sensitivity

Figure 6.9 represents the relative environmental sensitivity of the three primary sea level rise response pathway approaches with armoring generally being the least environmentally sensitive and retreating options being the most environmentally sensitive. Exceptions to this may exist, depending on the particular strategy or set of strategies to be employed. Overall environmental sensitivity will be dependent on the particular ecosystem potentially impacted by a given strategy, materials employed in execution of the strategy, and the potential long or short-term nature of the strategy.

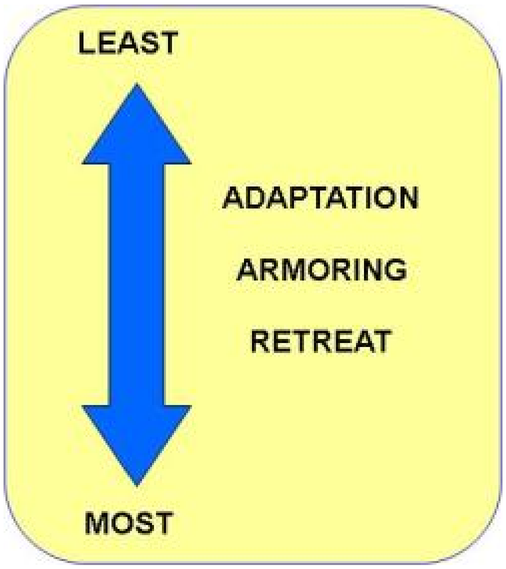

Figure 6.10 Response Pathways: Sustainability

Figure 6.10 illustrates the relative sustainability of the three primary sea level rise response pathways with adaptation being generally the least sustainable and options associated with the retreat pathway seen as the most sustainable. Exceptions to this illustration of relative sustainability will exist depending on the particular strategy or set of strategies to be employed.

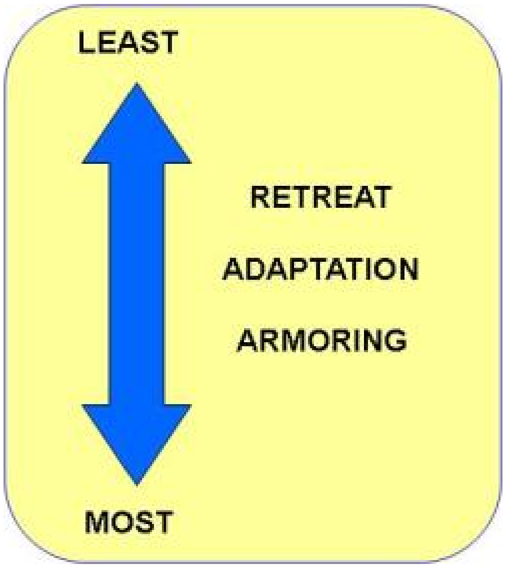

Figure 6.11 Response Pathways: Political Feasibility

Figure 6.11 illustrates the relative political feasibility of the three primary sea level rise response pathways. In general terms, options related to retreating from sea level rise are seen as the least politically feasible, and options related to armoring are seen as the most politically feasible. This illustration of political feasibility has a high potential for variability due to potential variations in local and state political climates, local stakeholder views on sea level rise and apparent risks, and local and state regulations governing implementation of various sea level rise response options.

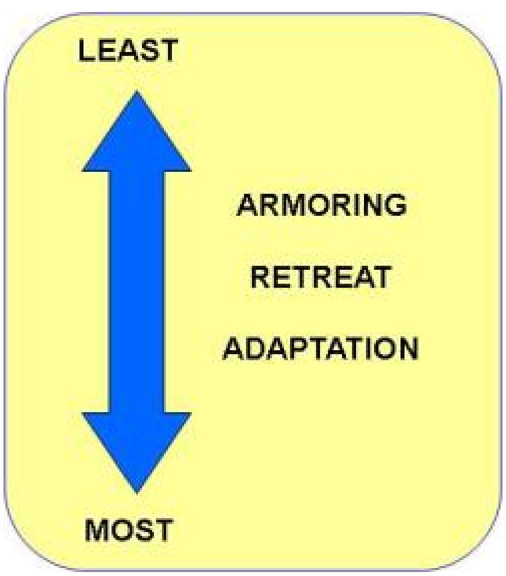

Figure 6.12 Response Pathways: Fiscal Feasibility

Figure 6.12 illustrates the relative fiscal or financial feasibility of the three primary sea level rise response pathways with armoring generally seen as the least fiscally feasible (or most expensive) long-term option and adaptation seen as the most fiscally feasible (or least expensive) long-term option. As with the other variables illustrated in **Figures 6.9 – 6.12,** some variation will exist with respect to fiscal feasibility of a given response option or set of options.

6.7.2 Armoring

Sea level rise mitigation measures and strategies related to armoring are generally engineer-designed structures or systems intended to hold back the sea and protect primarily man-made assets from impacts of increases in sea level. Examples include levees, groins, sea walls, and other hard structures. It is important to understand that living shoreline approaches, often used in tandem with more traditional shoreline stabilization methods, often fall into the "armoring" category of sea level rise responses. **Table 6.2** provides specific details of armoring practices that could potentially be deployed within the Wolf Bay Watershed.

Table 6.2 Armoring Strategies

Armoring Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Trap sand through construction of groins – a barrier-type structure that traps sand by interrupting longshore transport.	Maintenance of sediment transport.	Preserve coastal land/development; maintain shorelines.	Creates more natural shoreline than bulkheads or revetments; quick fix.	Can potentially trigger or accelerate erosion on the down drift side and loss of beach habitat.	$1,700 - $1,950/ LF
Install rock sills and other artificial breakwaters in front of tidal marshes along energetic estuarine shores.	Shoreline maintenance ("soft" measures").	Preserve coastal land / development; maintain water quality.	Naturally protect shorelines and marshes and inhibit erosion inshore of the reef; while promoting sediment deposition.	May not be sustainable in the long-term because breakwaters are not likely to provide reliable protection against erosion in major storms.	$125 - $200/ LF

Armoring Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Composite systems – Incorporation of elements of two or more methods (e.g. breakwater, sand fill, and planting vegetation.	Shoreline maintenance living shorelines).	Preserve coastal land / development.	Incorporates benefits of multiple systems; can address longer stretches of coastline.	Living shoreline approaches may require more maintenance over time.	$12 - $16/ LF
Harden shorelines with bulkheads – anchored, vertical barriers constructed at the shoreline to block erosion.	Shoreline Maintenance (“hard” measures).	Preserve coastal land / development.	Most common; simple materials used for construction; quick fix.	Loss of intertidal habitats; adjacent properties must be bulkheaded to maintain consistent shorefront	$100 - $200/ LF
Harden shorelines with revetments that armor the slope face of the shoreline.	Shoreline maintenance (“hard” measures).	Preserve coastal land / development.	Simple materials used for construction; quick fix.	Loss of intertidal habitats; often constructed poorly and lead to destabilization of banks, increasing erosion.	$115 - $180/ LF
Harden shorelines with breakwaters – structures placed offshore to reduce wave action.	Shoreline maintenance (“hard” measures).	Maintain water quality; preserve coastal land / development.	Employs materials that are locally available; creates good habitat for marshes and other calm water systems.	Down drift coast may be deprived of sediment, increasing erosion; loss of habitat.	$200 - $280/ LF

Armoring Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Headland control – reinforce or accentuate an existing geomorphic feature or create an artificial headland (e.g. geotextile tube).	Shoreline maintenance ("hard" measures).	Preserve coastal land / development.	Can be cost effective.	May reduce sediment supply to adjacent shores, increasing erosion; loss of habitat.	$150 - $180/ LF

6.7.3 Retreating

Sea level rise mitigation strategies involving retreat are typically policy-related measures that seek to prevent or minimize development in near shore areas of the coastline. Examples of retreat options include enhanced buffer zones, no-build zones, conservation easements, and rolling easements. Since these policies are typically associated with land use and land ownership rights, care should be taken in choosing options presented here. As previously mentioned, legal issues associated with Fifth Amendment rights and rights provided through the Public Trust Doctrine have the potential to be associated with these particular measures. **Table 6.3** provides a variety of options related to measures and strategies associated with the retreat option.

Table 6.3 Retreating Strategies

Retreating Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Allow coastal wetlands to migrate inland (e.g. through setbacks, density restrictions, land purchases).	Maintaining / restoring wetlands.	Preservation of habitat for vulnerable species; preservation of coastal land / development.	Maintains species habitats; maintains protection for inland ecosystems.	In highly developed areas, there is often little or no land available for wetland migration or could potentially be costly to landowners.	Costs are very relative based on land acquisition costs. Other costs (setbacks, density restrictions, etc.) are negligible.
Land exchange programs – owners exchange property in the floodplain for publicly-owned land outside of the floodplain (i.e. transfer of development rights).	Preservation of coastal land / development.	Preserves habitat for vulnerable species; maintain / restore wetlands.	Preserves open spaces; more land available to protect estuaries.	Program is voluntary; land must be available for development elsewhere.	Other than administrative costs, implementation costs are negligible.

Retreating Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Land acquisition program – purchase of coastal land that is damaged or prone to damage and reuse for conservation purposes.	Preservation of coastal land / development.	Preserve habitat for vulnerable species; maintain / restore wetlands.	Can provide a buffer to inland areas; prevents development on the land.	Can be cost prohibitive; land may not be available; voluntary.	Costs are relative based on site-specific land acquisition costs.
Create marsh by planting the appropriate species – typically grasses, sedges, or rushes – in the existing substrate.	Shoreline maintenance (Living shorelines).	Maintain water quality; maintain / restore wetlands; preserve habitat for vulnerable species; invasive species management.	Provides protective barrier; maintains and often increases habitat.	Conditions must be right for marsh to survive (e.g. sunlight for grasses, calm water) can be affected by seasonal changes.	$2.50 – $5.50/ sq. yard
Restrict or prohibit development in erosion zones.	Shoreline maintenance (Living shorelines).	Preserve coastal land / development; maintain / restore wetlands.	Allows for more land available to protect estuaries.	Will not help areas already developed; difficult to get all parties to agree; potential takings issues.	Other than administrative costs, implementation costs are negligible.
Increase shoreline setbacks.	Shoreline Maintenance (Living shorelines).	Preserve coastal land / development.	Protects coastal property in the long term and prevents development directly on the shoreline.	Will not help areas already developed; potential takings issues.	Other than administrative costs, implementation costs are negligible.
Retreat from, and abandonment of, coastal barriers.	Preservation of habitat for vulnerable species.	Maintain / restore wetlands.	May help protect estuaries, allowing them to return to their natural habitat.	Generally, not politically favored due to the high value of coastal property and infrastructure; potential takings issues.	Other than administrative costs, implementation costs are negligible.

Retreating Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Purchase upland development rights or property rights.	Preservation of habitat for vulnerable species.	Maintain / restore wetlands; maintain water quality.	Protects habitats downstream.	Costly; uncertainty about sea level rise leads to uncertainty in the amount of property purchased; similar to transfer of development rights.	Costs are relative based on site-specific land acquisition costs.

6.7.4 Adapting

Policies and strategies related to adaptation are those that provide some level of flexibility in policy, design, and implementation of strategies. Adaptation strategies include measures such as elevation of structures and including consideration of sea level rise into local and regional planning documents, such as comprehensive plans and local hazard mitigation plans. As previously mentioned, these strategies are not meant to be a "one size fits all" approach but rather a "treatment train" approach should be considered and adopted that uses one or more strategies working concurrently and in concert to address specific management goals. **Table 6.4** provides details on a variety of adaptation strategies.

Table 6.4 Adaptation Strategies

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Prohibit hard shore protection.	Maintain / restore wetlands.	Preserve habitat for vulnerable species; maintain sediment transport.	Allows for species migration.	Alternatives of bulkhead construction are more expensive and may be more difficult to obtain permits.	Other than administrative costs, implementation costs are negligible.
Incorporate wetland protection into infrastructure planning (e.g. transportation planning, sewer utilities).	Maintain / restore wetlands.	Maintain water quality; preserve habitat for vulnerable species.	Protects valuable and important infrastructure.		Other than administrative costs, implementation costs are negligible.
Identify and protect ecologically significant areas such as nursery grounds, spawning grounds, and areas of high species diversity (e.g. coastal preserves).	Maintain / restore wetlands.	Invasive species management; preserve habitat for vulnerable species.	Protecting critical areas will promote biodiversity and ecosystem services (e.g. producing and adding nutrients to coastal systems serving as refuges and nurseries for species).	Some areas / circumstances may require federal or state protection.	Other than administrative costs, implementation costs are negligible.
Trap or add sand through beach nourishment – the addition of sand to a shoreline to enhance or create a beach area.	Maintain sediment transport.	Preserve habitat for vulnerable species; preserve coastal land / development; maintain shorelines.	Creates protective beach for inland areas; replenishes sand lost to erosion; potentially creates new public access and tourism / recreation areas.	Periodic maintenance cycle required; potentially high costs to import beach material.	$15 - $20/ cubic yard

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Create a regional sediment management plan.	Maintain sediment transport.	Maintain water quality.	Preserves natural sediment flow and protects water quality of downstream reaches.	Improvements and plan recommendations may be costly.	Other than administrative costs, implementation costs are negligible.
Develop adaptive stormwater management practices (e.g. promoting natural buffers, adequate culvert sizing).	Maintain sediment transport.	Maintain water quality.	Preserves natural sediment flow and protects water quality of downstream reaches.	Improvements and retrofits may be costly.	Other than administrative costs, implementation costs are negligible.
Integrate coastal management into land use planning.	Preservation of coastal land / development.	Preserves habitat for vulnerable species; maintain / restore wetlands.	Potentially requires more state agency oversight; allows for conservation and management goals to be incorporated locally; allows for locally comprehensive coastal management in cooperation with state efforts.	May be difficult to have local and state agencies agree on specific plan elements; private property rights; current legislation is prescriptive but not required.	Other than administrative costs, implementation costs are negligible.

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Consider Integrated Coastal Zone Management – using an integrated approach to achieve sustainability and resilience.	Preservation of coastal land / development.	Preserve habitat for vulnerable species; maintain / restore wetlands; maintain water availability; maintain water quality; maintain sediment transport; maintain shorelines.	Considers all stakeholders in planning, balancing objectives; addresses all aspects of climate change.	Stakeholders must be willing to compromise; requires much more effort in planning.	Other than administrative costs, implementation costs are negligible.
Incorporate consideration of climate change and sea level rise impacts into planning for new infrastructure. (homes, buildings, water, sewer, streets, critical facilities, etc.	Preservation of coastal land / development.	Preserve habitat for vulnerable species; maintain / restore wetlands.	Engineering could be modified to account for changes in precipitation or seasonal timing of flows; siting decisions could take into account sea level rise.	Landowners may resist relocating away from prime coastal locations.	Other than administrative costs, implementation costs are negligible.
Strengthen rules that prevent the introduction of invasive species (e.g. enforce no discharge zones for ballast water).	Invasive species management.	Maintain / restore wetlands; preserve habitat for vulnerable species.	Prevents difficult and costly eradication of invasives by preventing their introduction.	May require state action; may be difficult to regulate.	Other than administrative costs, implementation costs are negligible.

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Expand the planning horizon of land use and comprehensive planning to incorporate longer climate predictions.	Preservation of habitats for vulnerable species.	Preserve coastal land / development.	Could inhibit risky development and prove protection for estuarine habitats.	Land use plans rarely incorporate hard prohibitions against development close to sensitive habitats and have limited durability over time; current legislation is prescriptive, not required.	Other than administrative costs, implementation costs are negligible.
Consider modifications to local Flood Hazard Prevention Ordinances to increase freeboard requirements.	Preserve coastal land / development.	Maintain water quality; protect life and property; increased resiliency.	Provide for additional protection of residential structures from higher tides, storm surges, flooding.	Will require local adoption; will increase costs of development in coastal zones and flood prone areas.	Other than administrative costs, implementation costs are negligible.
Consider incorporation of sea level rise and climate change impacts into local, regional, and state hazard mitigation plans.	Preserve coastal land / development.	Protect life and property; increased resiliency.	Enhances a proven and required planning mechanism; includes input from stakeholders.	Will require local adoption.	Other than administrative costs, implementation costs are negligible.
Incorporate risk-based land use planning into local comprehensive plans.	Preserve coastal land / development.	Protect life and property; increased resiliency.	Integrates natural hazards into local land use planning; potentially provides incentives for selection of alternative development sites.	Availability of alternate land for development; requires local adoption; current legislation is prescriptive, not required.	Other than administrative costs, implementation costs are negligible.

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
Integrate climate change and sea level rise impacts into due diligence for investment and lending.	Preserve coastal land / development.	Protection of life and property; increased resiliency.	Allows investors and asset managers to manage risks associated with real estate located in potentially impacted areas.	Will require cooperation among financial and real estate sectors.	Other than administrative costs, implementation costs are negligible.
For communities currently participating in FEMA's Community Rating System (CRS), consider program or policy changes that would specifically address Activity 430 – Credit for Higher Regulatory Standard, Activity 430 – Credit for Coastal A Zone Regulations, and Activity 610 – Credit for Flood Warning Systems.	Preserve coastal land / development;	Protection of life and property; enhanced resiliency.	Potentially increased premium discounts for National Flood Insurance policy holders; enhanced protection in flood prone areas.	Requires existing participation in the CRS system, Rating upgrades can potentially be expensive and time consuming.	Other than administrative costs, implementation costs are negligible.

Adaptation Strategy	Benefiting System	Secondary Management Goals Addressed	Benefits	Constraints	Relative Costs
For communities not currently participating in FEMA's CRS, consider enrollment in the program.	Preserve coastal land / development.	Protection of life and property; enhanced resiliency.	Potentially increased premium discounts for National Flood Insurance policy holders; enhanced protection in flood prone areas.	Application and enrollment in the program can be expensive and time consuming.	Other than administrative costs, implementation costs are negligible.

Chapter 7 Identification of Critical Issues and Areas

The critical issues and geographical areas described in this chapter were identified through multiple sources over the course of this project, including firsthand knowledge and expertise of the Wolf Bay WMP Steering Committee, as well as feedback from citizens who live, work and recreate within the Watershed. The WMP team also conducted field reconnaissance throughout the Watershed and analyzed research findings along with historic data to determine Watershed issues and the areas in which they occur.

7.1 Water Quality

Water quality is a broad term that can be measured by multiple indices and provides a means of qualifying how "healthy" a watershed may or may not be. Water quality was consistently listed by stakeholders in the Watershed as their most critical concern, due to its effect on recreation and usage by those who live and recreate within the Watershed. Maintaining or improving existing water quality is also important, as Wolf Bay is designated as an Outstanding Alabama Water. Several factors influencing water quality in the Watershed include:

- Nutrients
- Pathogens
- Litter
- Invasive Species
- Erosion and Sedimentation

7.1.1 Nutrients

Excessive nutrients in a body of water can degrade water quality by causing blooms of plants and algae that can deplete oxygen levels, degrade aquatic habitats for fish and wildlife, impair recreational usage and cause taste and odor problems in drinking water. Nutrients of concern within the Watershed are nitrogen and phosphorus. As discussed in Chapter 2, Cook (2017) found nitrogen levels that exceeded the ADEM reference concentrations in both Miflin and Sandy creeks. Both of their sub-watersheds are dominated by row crops and turf agriculture (**Figure 7.1**) which is a likely source of the excess nitrogen in these streams. Cook also noted that 10 of the 14 sites monitored throughout the Wolf Bay Watershed had phosphorous concentrations above the ADEM reference. The two highest levels of phosphorous were documented at sampling locations along Wolf Creek. It is unknown if these elevated phosphorus levels are attributed to runoff from urban, residential, or agricultural land use or a combination thereof.

Figure 7.1 Turf Operation in the Watershed

7.1.2 Pathogens

One critical concern raised during Steering Committee meetings was the presence of livestock within Hammock Creek, which could potentially lead to unsafe levels of *Escherichia coli* (*E. coli)*, a bacterial pathogen found in human and animal intestines and an indicator of pathogen pollution. Wolf Bay Watershed Watch (2017) reported that livestock had been removed from Hammock Creek, although Steering Committee members reported that the practice continues. Field reconnaissance verified the presence of cattle in a headwater tributary of Hammock Creek (**Figure 7.2)**. It should also be noted that wooded buffers along streams and tributaries can concentrate wildlife, leading to increased inputs of fecal coliform bacteria into the waterbody. Sampling conducted by Cook (2017) showed the highest concentrations of *E. coli* at two sampling points within Wolf Creek and one sampling point on Elberta

Creek (tributary to Miflin Creek). Cook concluded that the sampling numbers for the three locations were relatively low for surface water and most likely did not represent any particular pathogen point source.

Figure 7.2 Livestock Grazing Within Riparian Area of Hammock Creek Tributary

According to the Sewage Spill Explorer created by Mobile Baykeeper (www.mobilebaykeeper.org/sewage-spills) there have been 16 sanitary sewer overflows (SSOs) within the Watershed since 2016. Listed causes for these SSOs include broken sewer pipes, lift station failures, line blockages due to grease, and overflows due to heavy rainfall. Six of the SSOs within the Watershed occurred at the Riviera Utilities Wastewater Treatment Facility due to system overload caused by heavy rainfall and power outages.

7.1.3 Litter

Litter is an issue in any watershed, as it originates from numerous sources from which it is carried into waterbodies by stormwater runoff. Field investigations throughout the Watershed did not document unusually large concentrations of litter within any of the major stream systems. Litter found along banks in areas where people frequently gather, will likely make its way into the waterbody at some point.

Submerged items, such as tires and steel barrels, were observed in Sandy Creek in close proximity to some of the houses lining the banks. Common household refuse could be seen both in the channel and along the banks of Wolf Creek, which was previously listed as a potential problem area as shown **Figure 7.3** and **Figure 7.4**.

Figure 7.3 Litter in Wolf Creek

Figure 7.4 Trash Along Bank of Wolf Creek

7.1.4 Invasive Species

Non-native, invasive species can be extremely detrimental to wildlife habitats and ecosystem functions within watersheds. Invasive species are ideally suited to colonizing recently disturbed habitats, such as streams banks disrupted by new sediment deposited during flood conditions. Once established, these species are capable of out-competing native species and are costly to eradicate or control. Field investigations of the major streams in the Watershed revealed several species of aquatic and terrestrial invasive species.

Each of the major streams had some Chinese tallow found along the banks, particularly in more open areas of human settlement, **Figure 7.5**. Chinese tallow can be particularly problematic in coastal watersheds due to its ability to thrive in freshwater and saline soils. It is shade tolerant, flood tolerant and allelopathic making it ideally suited for invasion of stream banks within forested areas. Mature trees can produce 100,000 seeds per year which are spread by birds and water. Seeds remain viable in soil and leaf litter for two to seven years. Chinese tallow is capable of producing dense infestations through surface root sprouting (Miller et al., 2015).

Cogon grass was also found at almost every road or utility crossing along each stream, **Figure 7.6**. Cogon grass is particularly well adapted to road and utility crossings due to its ability to invade areas of open sunlight through wind-dispersed seeds and seeds transported by attaching to mowing and other equipment operating along these areas. Once established, the grass rapidly expands in a circular pattern through branching rhizomes that fill soils to a depth of 0.6 to 10 feet which excludes almost all other vegetation (Miller et al., 2015).

Alligatorweed was observed in Sandy Creek. Alligatorweed is problematic within watercourses due to its creation of mats on the water surface which can impede boat access. This weed can thrive in freshwater or slightly brackish water which makes it well suited for infestation of streams in the Wolf Bay Watershed. Alligatorweed occupies new areas by stem fragments moved by water and spreads rapidly by rooting at nodes. It produces deep mats that prevent other plants from germinating and will overtop other aquatic and upland plants (Miller et al., 2015).

Of all streams surveyed, Hammock Creek had the largest infestation of invasive species with Japanese climbing fern and Chinese privet being prevalent along the water's edge, **Figure 7.7**. Japanese climbing fern can climb up to 90 feet, forming dense mats that can smother shrubs and trees. Often found in open forests, the fern colonizes other vegetation through rhizomes and spreads to other areas by wind-dispersed spores that can also attach to clothing. Vines will die back in winter which provides a trellis for next year's growth.

Chinese privet is one of the most common invasive shrubs found in the Southeast. The shrub forms thickets up to 30 feet in height with long, leafy branches. Chinese privet is shade tolerant, making it highly suitable for bottomland hardwood forests bordering streams and wetland areas. This invasive shrub colonizes areas through abundant production of seeds that are consumed and dispersed by a wide variety of birds and other wildlife and then expands its infestation through root sprouts.

Figure 7.5 Chinese Tallow Tree Along Sandy Creek

Figure 7.6 Cogon Grass at Utility Crossing on Sandy Creek

Figure 7.7 Japanese Climbing Fern Along Hammock Creek

7.1.5 Erosion and Sedimentation

Erosion and sedimentation are naturally occurring processes within watershed systems. However, those processes can be exacerbated by increased runoff during rainfall events due to increased amounts of impervious surfaces and a lack of bank stability, caused by fast moving water and exacerbated by vegetation removal or other anthropogenic alterations along the stream bank.

Cook (2017) found that total sediment loads, which include both suspended sediments as well as bed sediment loads for each stream, were highest within Wolf Creek at the Doc McDuffie Road sampling location. Sediment loads in east and west tributaries of Sandy Creek were also notably high, but only half as high as the Wolf Creek site.

Field reconnaissance along the lower reaches of Wolf and Sandy creeks revealed bank instability and sloughing; the majority being associated with residential construction areas or areas lacking significant vegetation structure along the shoreline (**Figures 7.8** and **7.9)**. Several sediment bars were documented within the channel of Wolf Creek (**Figure 7.10**), although none were noted in the lower reach of Sandy

Creek. During investigations into the higher sediment loads found by Cook (2017) on the two unnamed tributaries to Sandy Creek, aerial photos showed a headcut on the western tributary potentially contributing to the sediment load. Also, a pond on the eastern tributary was breached, creating slope riling and unstable stream banks at the former pond location, also potentially contributing to sediment loads at the sampling point (see previous **Figures 5.7 and 5.8**).

Figure 7.8 Bank Sloughing Along Wolf Creek

Figure 7.9 Bank Failure at Residence Along Wolf Creek

Figure 7.10 Area of Sediment Deposition Within Wolf Creek

Both branches of Miflin Creek exhibited similar conditions with minimal bank erosion and some sediment deposition within the channels. Field personnel noted that Miflin Creek exhibited the clearest and deepest water of any creeks surveyed. Additionally, more fish, both in abundance and species, were visually observed in Miflin Creek compared to the other creeks in the Watershed. Hammock Creek exhibited the most bank erosion and instability in the reach north of CR 20 to the headwaters area. Numerous areas of bank failure were documented along this reach, leading to substantial sedimentation within the stream channel (**Figures 7.11 and 7.12**). Areas of overland flow outside of the stream banks were observed and likely the result of the erosion/sedimentation processes occurring within this area.

Figure 7.11 Bank Erosion/Sedimentation Within Hammock Creek

Figure 7.12 Bank Erosion Along Hammock Creek

7.2 Future Development

Baldwin County is one of the fastest growing areas in Alabama, and the Wolf Bay Watershed is one of the fastest growing areas in Baldwin County. Future development within the Watershed has potential to significantly impact the nature of stormwater management and water quality within the Watershed. While a significant percentage of the Watershed area is undeveloped or agricultural in nature, developments such as OWA in the eastern portion of the Watershed will likely continue to occur in response to increasing demands for tourism destinations within the County and the Watershed. Several large tracts of land along the Foley Beach Express in the northwest portion of the Watershed are currently listed for sale (see **Figure 7.13)**. Additionally, if the City of Orange Beach moves ahead with plans to construct a bridge connecting Orange Beach with the eastern portion of the Watershed, current undeveloped property has the potential to be targeted for development. These types of commercial and infrastructure developments do not necessarily translate to increases in population. However, they do contribute to increased impervious cover, traffic, and potential impacts to water quality. Given the potential for more of these developments to occur in the Watershed, it is imperative that the County, the City of Foley, and the Town of Elberta work to ensure that appropriate plans and regulations are in place to guide development in an appropriate manner.

Figure 7.13 Area of Potential Development

7.2.1 City of Foley

The City of Foley is the most urbanized area within the Watershed and has highest projected rate of population growth and the highest percentage of impervious cover. The City also has the Watershed's strictest stormwater regulations, which comprehensively address construction phase BMP requirements, post-construction stormwater requirements, coastal area resource protection, low impact development standards, and shoreline stabilization (where applicable). Additionally, the City's *Manual for Design and Construction Standards* requires specific standards for development activities as well as requiring implementation of low impact development standards. The City of Foley's estimated 2018 population was 18,928, representing a 140% increase since the 2000 census. As the City's population and level of development continue to increase, regulations pertaining to implementation of stormwater management

BMPs on a City-wide level will become increasingly necessary to ensure the City's growth does not adversely impact water quality in the Watershed.

7.2.2 Town of Elberta

In its current state, the Town of Elberta retains a small-town feel with a level of development relative to its population of 1,723 people based on the most recent census population estimate. However, the current population is in stark contrast to the 2000 population of 552 people (170% increase). Many of Elberta's ordinances, specifically those related to stormwater management, either cite by reference or mirror Baldwin County's ordinances. As with the City of Foley, it is important that Elberta continue to increase the level of regulation specific to stormwater management and water quality to ensure that the Town is prepared for future growth.

7.2.3 Baldwin County

Baldwin County will continue to experience significant population growth. From 2000 to 2020, population in Baldwin County increased 58.5%, with projected increases of 35% over the next 20 years. Significant population increases in Baldwin County and the Watershed will result in significant land use changes from agricultural and forested lands to developed uses. Current land use data indicates that undeveloped land uses represent approximately 78% of the total land area in the County. Projections for 2040 indicate a reduction of undeveloped land uses to 63%. This translates to an increase in impervious cover and related adverse impacts on water quality. As with the City of Foley and the Town of Elberta, Baldwin County should consider strengthening regulation related to stormwater management, water quality, new development and post-construction management within the County. The County should also consider enacting regulations to require Low Impact Development in a manner similar to the City of Foley's *Manual for Design and Construction Standards*.

7.3 Recreation

Boating access in the Watershed is lacking. The ability to access a watercourse by boat influences other recreational activities such as fishing and swimming. The private launch that historically provided access at the former site of the Wolf Bay Lodge is closed. The nearest public launches are Josephine Park in the Josephine community or Canal Park in the City of Gulf Shores, both located outside of the Watershed and with limited parking spaces that fill up very quickly. Additionally, obstacles to stream navigability were noted during field reconnaissance in the upper reaches of Wolf Creek, Sandy Creek, Miflin Creek, and Hammock Creek. Numerous log jams made it difficult to navigate each stream by boat (**Figure 7.14**).

Figure 7.14 Overhanging Trees Preventing Boat Access in Sandy Creek

Chapter 8 Management Measures

The Wolf Bay Watershed lies within one of the fastest growing regions of the entire southeastern United States. Growing populations have led to increased development, resulting in increased stress to the natural systems of the area. Excessive stormwater runoff due to increased impervious surface area; erosion and sedimentation resulting from runoff, construction, and changes in land use from rural to urban; litter issues; and invasive species are just a few of the issues currently facing the Watershed.

The management measures recommended in this chapter were derived from a combination of several inputs. A literature review was conducted at the beginning of the project to assimilate all available information regarding existing conditions in the Watershed and where problem areas historically occurred. Field reconnaissance was also conducted throughout the Watershed to document current conditions and where future issues might arise. Throughout this process, the Steering Committee, formed at the onset of Plan development, was consulted to gather information about observed conditions within the Watershed and identify priorities for conservation and management. Other Watershed stakeholders were also engaged through online and written surveys designed to identify management priorities.

8.1 Water Quality

As discussed in previous chapters, water quality is a broad term that reflects a combination of several parameters that are directly tied to the overall health of a watershed. The factors influencing water quality also affect the ability of stakeholders to utilize those waters for any number of uses. Because Wolf Bay is currently designated as an Outstanding Alabama Water, it is not only important to maintain water quality within the Watershed, but also to ensure future actions and land uses do not degrade the system. As discussed previously, the major factors influencing water quality within the Wolf Bay Watershed include:

- Erosion and Sedimentation
- Nutrients
- Pathogens

8.1.1 Erosion and Sedimentation

Sediment transport within a watershed is a natural ecological process. Sediment within a system can include particles carried by overland flow into stream channels after erosion of streambanks or geologic formations and transported and deposited through varying levels of stream flow. However, anthropogenic activities such as agriculture and development amplify these processes by exposing soils and decreasing infiltration rates by increasing impervious surfaces. Based on the 2016 NLCD impervious cover dataset, approximately 5,679 acres (16%) of the Watershed is covered by impervious surfaces. This number will continue to increase due to projected growth in the Watershed.

8.1.1.1 Agriculture

Agriculture encompasses approximately 35% of the land use within the Wolf Bay Watershed. Agricultural activities include row crops, sod, and livestock farming operations, which can significantly impact the amount of sediment entering a stream system if not managed properly. Improper agricultural practices, such as poorly located animal feeding operations, overgrazing, and plowing too frequently or at improper times, can contribute to excessive sediment loads entering surface waters. These adverse impacts can be avoided by using relatively simple management measures.

Agricultural buffers assume many forms, including contour buffer strips, field borders, filter strips, grassed waterways, riparian buffers, and wetlands. Regardless of the type of buffer used, all serve to slow runoff and allow time for infiltration through the soil profile, which can eliminate significant quantities of stormwater or irrigation runoff before it enters a waterway. This decrease in flow rate across an area also allows for sediments and other solid particles to fall out before reaching surface waters. Buffers also serve to stabilize streambanks further reducing erosion from areas directly adjacent to stream channels. Root systems of grasses, shrubs, and trees hold soils in place along field drainages, preventing rills and gullies from forming and contributing large amounts of sediment to adjacent waterways. Organic matter within buffer areas adjacent to streams also dissipates raindrop energy, protecting soil particles from becoming dislodged and transported across the landscape. The NRCS and Alabama Soil and Water Conservation District provide incentive programs to the agriculture community for incorporating agricultural buffer strips.

Livestock operations are found in the headwaters of the Miflin, Sandy and Hammock Creeks and have the potential to create erosion and sedimentation issues along streams. Livestock allowed to enter streams can create unstable streambanks by overgrazing vegetation that holds soils in place. Livestock allowed to enter stream channels for water can also displace bed sediments and increase turbidity, which can be detrimental to fish species and overall water quality. The use of exclusion fencing with a recommended distance of at least 30 feet from surface waters will prevent livestock from overgrazing within riparian and wetland areas, allowing appropriate vegetation to create a natural buffer strip between the pasture and the watercourse. Additionally, alternative water sources for livestock located away from naturally occurring surface waters allow animals to fully utilize their range and reduces impacts to streams.

Appendix D contains a copy of the NRCS Conservation Catalog for Alabama which contains detailed descriptions of various BMPs for agriculture.

The Natural Resources Conservation Service (NRCS) and Farm Service Agency offer numerous programs for public and private landowners. A brief description of relative programs appears below, and more information can be found in **Appendix E**.

- The Environmental Quality Incentives Program (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, air and related natural resources on agricultural land.
- The Conservation Stewardship Program (CSP) helps landowners build on existing conservation efforts while strengthening their farming operation.
- The Agricultural Conservation Easement Program (ACEP) provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits.
- The Emergency Watershed Protection Program (EWP) is a federal emergency recovery program that helps local communities recover after a natural disaster.
- The Regional Conservation Partnership Program (RCPP) promotes coordination of NRCS conservation activities with partners that offer value-added contributions to expand our collective ability to address on-farm, watershed, and regional natural resource concerns.
- The Watershed and Flood Prevention Program (WFPO) provides technical and financial assistance to States, local governments, and Tribes to plan and implements the protection and restoration of watersheds up to 250,000 acres.

As with any of the factors that degrade water quality and the associated management measures recommended to prevent them, education of stakeholders is vital to long-term success and implementation. Outreach to farmers and ranchers within the Watershed is vital to ensure water quality is protected while productivity is maintained. Management measure demonstration projects on local farms could increase their implementation throughout the Watershed.

Potential locations for agricultural buffers within the Wolf Bay Watershed and associated acreages can be found in **Table 8.1.** Potential locations for livestock exclusion fencing and locations for alternative water sources can be found in **Tables 8.2 and 8.3**, respectively. Potential locations for all agricultural BMPs within the watershed are illustrated in **Figure 8.1**.

Table 8.1 **Potential Locations for Buffers Within Agricultural Areas of the Wolf Bay Watershed**

Site No.	Description of Location	Acres	Latitude	Longitude
AB-1	Headwater of Wolf Creek	164	30.429982	-87.671793
AB-2	Headwater of Sandy Creek	89	30.441507	-87.660474
AB-3	Headwater of Sandy Creek	94	30.449948	-87.643315
AB-4	Headwater Tributary to Miflin Creek	110	30.432856	-87.610569
AB-5	Headwater of Miflin Creek	308	30.442681	-87.610904
AB-6	Headwater Tributary to Miflin Creek	89	30.400876	-87.577824
AB-7	Headwater Tributary to Miflin Creek	58	30.392460	-87.568102
AB-8	Headwater to Hammock Creek	47	30.396957	-87.555799
AB-9	Headwater Tributary to Hammock Creek	136	30.372257	-87.547044
AB-10	Headwater Tributary to Hammock Creek	264	30.369732	-87.539920

Table 8.2 **Potential Locations for Cattle Exclusion Fencing Within Agricultural Areas of the Wolf Bay Watershed**

Site No.	Description of Location	Length (ft)	Latitude	Longitude
CEF-1	Headwater of Sandy Creek	5,174	30.434796	-87.610401
CEF-2	Headwater of Sandy Creek	3,248	30.419298	-87.610663
CEF-3	Headwater of Miflin Creek	997	30.367275	-87.549170

Table 8.3 Potential Locations for Alternative Water Sources Within Agricultural Areas of the Wolf Bay Watershed

Site No.	Description of Location	Latitude	Longitude
AWS-1	Headwater of Sandy Creek	30.430041	-87.620014
AWS-2	Headwater of Sandy Creek	30.420302	-87.611999
AWS-3	Headwater of Hammock Creek	30.367529	-87.549064

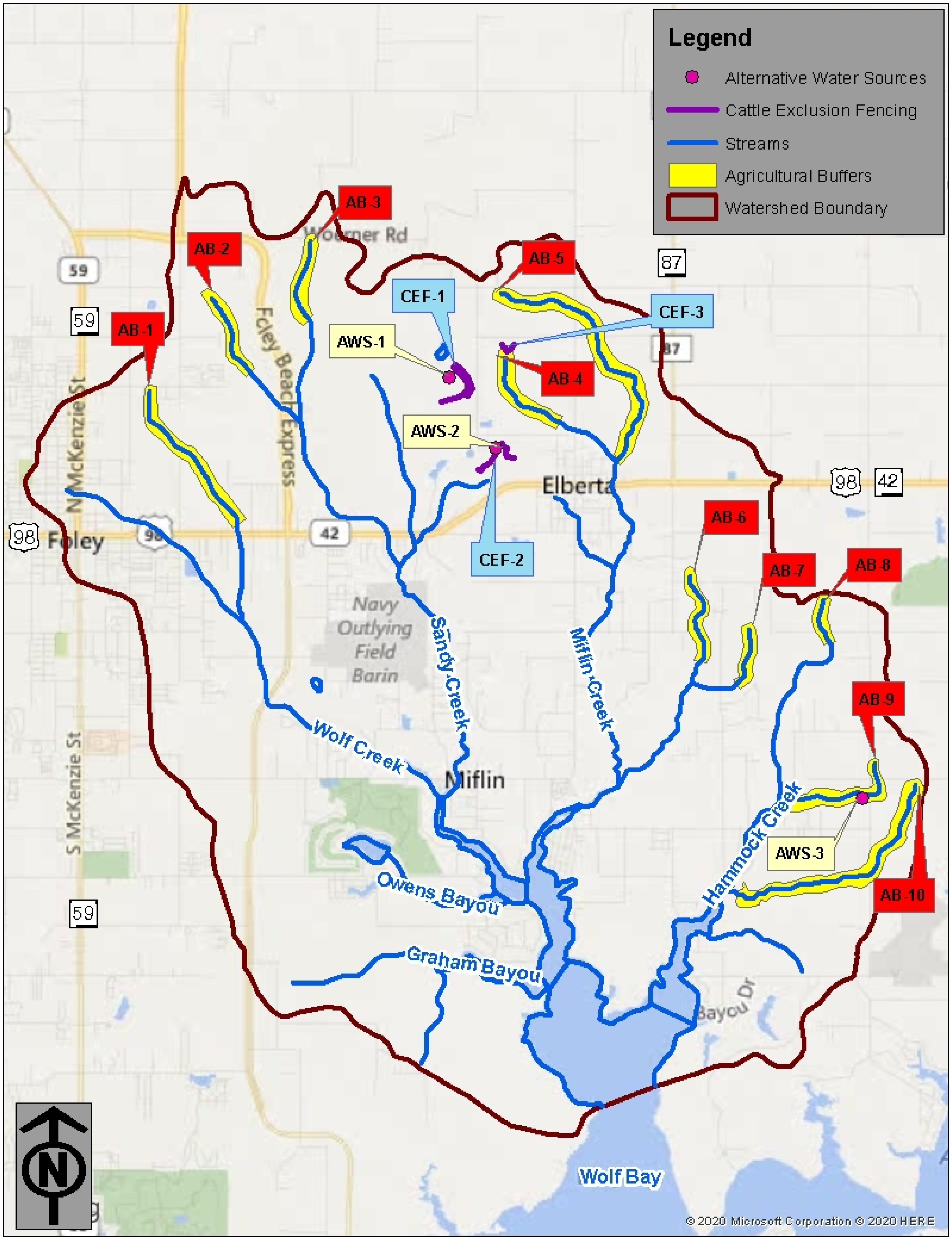

Figure 8.1 Potential Locations for Buffers Within Agricultural Areas Within Wolf Bay Watershed

8.1.1.2 Forestry

Approximately 39% of the Watershed is currently forested. While forestry practices do not typically contribute as much sediment to surface waters as construction or agriculture, effects can be significant without proper management. Removal of overstory trees combined with operation of logging equipment throughout an area can compact soils, expose them to erosive weather forces, and increase overland flow transporting sediment. Additionally, improper construction of logging roads and loading docks create erosion problems along slopes due to exposed soils. Stream crossings and use of logging equipment within riparian areas can also exacerbate channel erosion by compromising bank integrity if proper techniques are not utilized.

The use of recommended management measures for forest operations can significantly reduce the amount of soil transported into streams and other waterways within the Watershed. Streamside management zones act as vegetated buffers, intercepting stormwater runoff and allowing sediments to fall out before reaching watercourses. Water crossings utilizing culverts or temporary bridges also help to maintain bank stability and prevent erosion directly adjacent to a stream. Forest roads and loading decks should employ a series of broad-based dips, turnout ditches, and water bars to slow runoff and hold sediments in place. More detailed descriptions of forestry management measures can be found in the *Alabama's Best Management Practices for Forestry* handbook. This handbook can be accessed at http://www.forestry.alabama.gov/Pages/Management/Forms/2007_BMP_Manual.pdf and can also be found in **Appendix F**.

8.1.1.3 Unpaved Roads

Unpaved roads, if not properly constructed and maintained, have the potential to contribute large amounts of sediment into watercourses within the Watershed. Stabilization of these roads by paving most effectively prevents sediments from entering surface waters, but it leads to increased runoff which can affect sedimentation downslope. It is important to combine paved road surfaces with LID management measures allowing for stormwater infiltration adjacent to these impervious surfaces. For non-paved roads, incorporation of management measures into the designs can affect meaningful reductions on sedimentation impacting surface waters and wetlands in close proximity to these roads. Recommended management measures for non-paved roads include:

- Contouring of the road surface to disperse water into a vegetated swale and/or drainage outlet adjacent to the roadway.
- Use of stone or other aggregate material to provide a stable driving surface while holding soil in place.
- Application of drainage outlets that divert water into vegetated areas that serve as natural filters and allow runoff water to infiltrate the soil profile.

It is also important to remember that, over time, sediment can build up within swales or other holding areas, increasing the amount of flooding and sediment discharge. Periodic maintenance is necessary to maximize environmental benefits and keep road maintenance costs low. **Table 8.4** lists roads identified by the Steering Committee and through field reconnaissance within the Wolf Bay Watershed as candidates for paving and/or implementation of management measures. Roadway segments are listed in order of priority based on their proximity and potential impact to the headwaters of the Watershed. **Figure 8.2** identifies the map locations of these stretches of road within the Watershed.

Table 8.4 Unpaved Road Targets for Management Measure Implementation

Project ID	Road Name	Length (Miles)	Latitude	Longitude
RP-1	Woerner Road	1.2	30.444147	-87.602962
RP-2	Kleinschmidt Road	0.9	30.436165	-87.590658
RP-3	Bruhn Road	1.0	30.406877	-87.572472
RP-4	Breman Road	1.5	30.393321	-87.564641
RP-5	Roscoe Road	0.8	30.339496	-87.649473

Figure 8.2 Locations of Unpaved Road Segments Within the Wolf Bay Watershed

8.1.1.4 Construction

The Wolf Bay Watershed lies within one of the fastest growing areas of Alabama. As more development occurs within the Watershed, so does the potential for sediment inputs from poorly managed construction sites. Relative to size, the erosion and sediment input potential from construction sites is greater than that of any other land use due to the amount of exposed and disturbed sediment combined with the high rainfall totals observed in this region throughout the year.

While the City of Foley does have a post-construction BMP inventory, similar inventories should be developed for the Town of Elberta and Baldwin County. An inventory of post-construction stormwater BMPs is important to ensure that proper and routine maintenance and inspections are conducted on BMPs. It is also important for planning purposes to understand where coverage gaps may exist.

Given the historic and potential population and development growth rates in the Watershed, the following potential solutions are recommended:

- Baldwin County and the Town of Elberta should enact Low Impact Development (LID) /Green Infrastructure (GI) requirements similar to those that exist in the City of Foley's *Manual for Design and Construction Standards*. LID/GI requirements provide benefits to general public health, safety, and welfare while providing incentives to developers such as reduced lot sizes, lot lines, and setbacks.
- Baldwin County and the Town of Elberta should consider adoption of enhanced post-construction stormwater regulations to ensure any potential impacts from development and resulting increased imperviousness does not result in long-term adverse impacts to water quality.
- A comprehensive inventory of post-construction BMPs should be conducted throughout the Watershed. The inventory should include the type of BMP, date of installation, responsible party for maintenance, and an inspection of each BMP to ensure they are functioning properly.
- The proposed comprehensive inventory of post-construction BMPs should be used as part of a watershed-wide assessment of BMP needs to include retention basins, detention basins, and other types of BMPs that would provide long-term water quality benefits in the Watershed.
- Provide homeowner associations with educational material on stormwater detention pond maintenance.

Developer and contractor education are important management measures recommended for the Watershed. Informational brochures on construction BMPs should be provided early in the development process by the jurisdictional authority to education individuals on the benefits of properly implementing and maintaining these practices.

8.1.1.5 Stream Instability

Field reconnaissance and discussions with Watershed stakeholders were used to identify streams and tributaries exhibiting unstable banks or excessive sediment loads within the channels. These issues are likely caused by the excessive amounts of water moving through the streams due to reduced infiltration caused by impervious surfaces throughout the Watershed. Unfortunately, sediments from these streams and tributaries are transported to other regions of the waterway, causing downstream shoaling and reducing the capacity of that stream reach to carry water within streambanks. This creates overland flow situations that lead to property damage and further streambank instability.

Certain Watershed streams with reaches of bank instability have been identified as candidates for stream restoration activities to lessen in-stream sediment inputs and protect private properties from further erosion and degradation. In most cases, the most effective means of stabilizing streambanks is the reshaping of the bank combined with armament using rock or articulated concrete mats and the replanting of selected species of vegetation. In reshaping a streambank, the angle is reduced to eliminate undercutting and provides a gradient suitable for replanting. This reduces sloughing and promotes the establishment of vegetation that will maximize rooting depth and density which will stabilize riparian soils. Plants should be specifically chosen for their ability to thrive in riparian environments with specific soil and hydrology characteristics to ensure prolonged sustainability. Until vegetation is established, it is recommended that natural fiber matting be used to protect soil from runoff and dissipate raindrop energy which could lead to erosion.

Table 8.5 along with **Figure 8.3** identify locations for potential stream restoration projects that could protect properties and prevent further stream degradation.

Table 8.5 Locations Potential for Stream Restoration Projects in the Wolf Bay Watershed

Site No.	Description of Location	Stream Length (ft)	Latitude	Longitude
SR-1	Lower Wolf Creek stream/habitat restoration	300	30.370373	-87.623733
SR-2	Wolf Creek bank stabilization	700	30.375446	-87.635748
SR-3	Wolf Creek headwater/habitat restoration	3,800	30.380993	-87.655864
SR-4	Wolf Creek headwater/habitat stabilization	500	30.393585	-87.655605
SR-5	Sandy Creek headwater stabilization	1,175	30.421461	-87.628547
SR-6	Sandy Creek headwater/habitat restoration	1,600	30.416868	-87.620998
SR-7	Hammock Creek stream/habitat restoration	1,600	30.366057	-87.565365

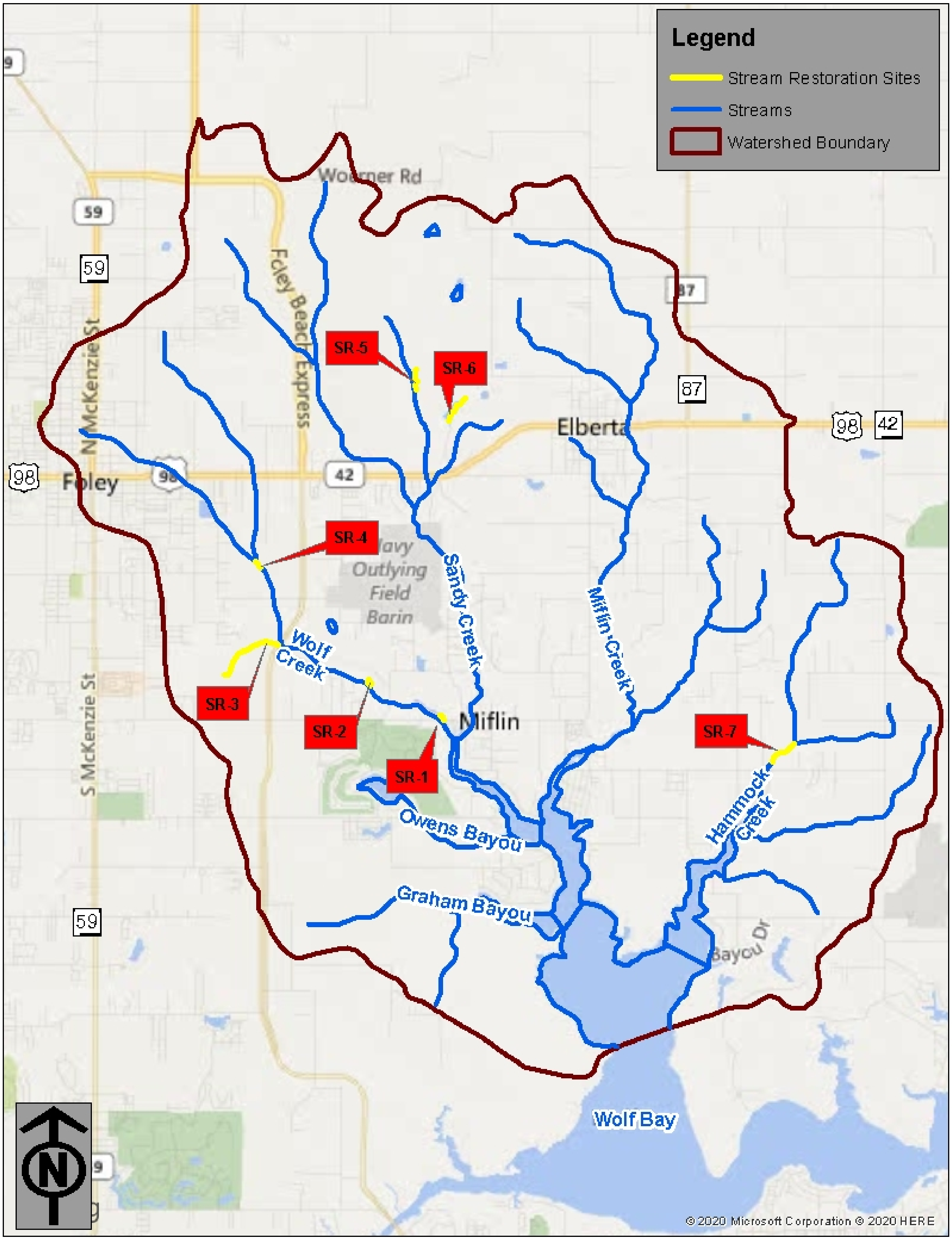

Figure 8.3 Potential Locations for Stream Restoration Projects in the Wolf Bay Watershed

8.1.2 Nutrients

Excessive nutrient inputs to streams and other waterbodies within the Watershed primarily result from fertilizers related to farming and landscaping associated with municipal recreation fields, golf courses, and residential dwellings. The use of fertilizers is a common practice to enhance agricultural productivity and produce more aesthetically pleasing landscapes. However, these fertilizers also have the potential of entering local watercourses, increasing nutrient levels (particularly nitrogen and phosphorous) within surface waters. Increased levels of these nutrients can lead to algal blooms, which can decrease dissolved oxygen levels available for fish and other aquatic species and increase turbidity, blocking sunlight necessary for submerged aquatic vegetation. Fortunately, there are simple steps that can be taken by farmers, municipal staff, commercial operators, and homeowners to drastically reduce amounts of fertilizer and nutrients entering streams.

The timing and amount of fertilization used on a crop or grassed area is extremely important in keeping excess nutrients from entering a water body. It begins with application of the proper amount of fertilizer for the type of vegetation and area being fertilized. Application rates are established to provide for the maximum uptake of nutrients by plants across a given area. Excessive amounts of applied fertilizer can leach through the soil profile and into groundwater or be transported to streams or other waterbodies by runoff before plants can utilize them. Application of precision fertilization techniques, whereby fertilizers are applied directly at the roots, of the plants also maximizes uptake by the plant and saves costs versus broadcast techniques. Applying fertilizers to saturated soils should always be avoided, as this increases the risk of overland transport via runoff.

The use of buffer strips of vegetation along field borders and drainage swales within agriculture fields can also prevent excess nutrients from entering streams. Buffer strips slow runoff and facilitate nutrient uptake by plants, as well as filtering through organic matter and the soil profile. Cover crops can also provide nutrient reduction benefits by reducing the amount of nutrients leaching through the soil profile and slowing overland flow of nutrients into surface waters.

As with many agricultural management measures, education programs and financial incentives for farmers play a key role in widespread implementation throughout the Watershed. The NRCS and Alabama Soil and Water Conservation District provide incentive programs to the agriculture community for incorporating agricultural buffer strips, conservation crop rotation, variable rate nutrient application, and precision agriculture. Workshops, targeted literature, and site visits from extension experts could go a long way in showing farmers and ranchers the benefits of conservation practices such as precision fertilization, buffer strips, and cover crops. Farmers are also reluctant to take land out of production for BMPs, so incentive programs are also vital to promote widespread implementation.

Golf courses and recreational fields operators should employee knowledgeable staff for nutrient application and incorporate monitoring on discharge areas for increased algal growth. Homeowners and landscape contractors can also benefit from information about the proper use and timing of fertilization. Simple steps, such as application at the recommended rate and removal of excess fertilizer from streets, sidewalks, and driveways, can prevent excess nutrients from entering waterways through stormwater drainage systems. Dissemination of information through local newspapers, garden clubs, and homeowner associations will help to raise awareness about downstream effects of improper fertilizer use.

8.1.3 Pathogens

Sandy Creek and Miflin Creek are currently listed on the draft 2020 Alabama 303(d) list of impaired streams due to unsafe levels of *Enterococcus faecalis* bacteria. The justification for this listing comes from data collected by ADEM from 2013 to 2015, where the Enterococci criterion was exceeded in five out of 16 samples in Sandy Creek and three out of 16 samples in Miflin Creek. The listing remains, despite Cook's (2017) study that found relatively low levels of *E. coli* in the Watershed streams (which is often directly linked to *Enterococcus faecalis*). Overall, the Wolf Bay Watershed has not historically shown significant levels of pathogens within the waters sampled by ADEM or in samples submitted by volunteers from Wolf Bay Watershed Watch. However, management measure implementation and outcomes should constantly be evaluated and to ensure pathogens do not become an issue of particular concern in the future.

Potential sources of pathogens within the Watershed can primarily be attributed to sanitary sewer overflows from the local wastewater treatment plant, discharges from rural septic systems, and livestock grazing operations. It is also worth noting pet waste from residential areas and wildlife waste from narrow vegetated areas directly adjacent to surface waters can also have effects on pathogen levels within Watershed streams.

Use of livestock exclusion fencing, alternative water sources, and vegetated buffer strips between pasture lands and waterbodies have proven extremely effective at preventing runoff of animal waste into surface waters. **Figure 8.4** shows unexcluded cattle within riparian areas of and with unrestricted access to a headwater of Sandy Creek. The use of exclusion fencing also prevents livestock from overgrazing riparian areas adjacent to streams and accessing stream channels. The excluded area is then allowed to revert to more natural vegetation, which serves numerous purposes in promoting water quality as discussed in previous sections. Additionally, the use of alternative water sources provides better water quality for livestock than stream watering and promotes better forage utilization across the property, leading to increased herd health and production. Reference **Figure 8.1** for a map of potential locations for agricultural BMPs that could aid in reducing pathogen inputs to surface waters within the Watershed.

Figure 8.4 Cattle within Riparian Area of Sandy Creek Tributary

Riviera Utilities, a local wastewater treatment plant, is currently permitted to discharge treated wastewater into Wolf Creek. Riviera is currently in the process of completing a major upgrade to their wastewater treatment facility which will reduce overflows from the plant during major rain events. Riviera is also in the process of replacing Gulftel Lift Station which is located on the east side of Hwy 59 just south of CR24. This project will reduce the potential for SSOs as well as increase capacity at the treatment plant during rain events. Other projects currently in the planning stages for Riviera Utilities include:

- Rehabilitation of 8.6 miles of aging sanitary sewer mains within the City of Foley. The goals of the project are to reduce accidental discharges of untreated/partially-treated wastewater into the Watershed; prevent exfiltration of wastewater into groundwater; and reduce wastewater treatment facility peak flows during rain events so that treatment processes are not overloaded and only high quality effluent is discharged into Wolf Creek.
- The construction of four Aquifer Storage Recovery (ASR) wells and the necessary transmission mains to connect the Class A reuse water from the Wolf Creek Wastewater Treatment Facility to the aquifer storage recovery wells for groundwater injection. The reuse water will then be stored and recovered for the irrigation needs of the area.

While much of the Watershed is connected to wastewater treatment systems, many of the more rural areas still rely on septic tank systems. Many of these systems are becoming aged and could possibly be leaking, thus contributing pathogens to the Watershed. Baldwin County would benefit from a septic tank inventory to establish a baseline of tank locations and potential sources of contamination. Education of county residents combined with enforcement of regulations related to septic systems should be a priority for County officials. Additionally, enforcement of unregulated septic systems should also be a priority throughout the County.

8.2 Invasive Species

Invasive species disrupt complex relationships formed by native plants and animals over thousands of years and disturb communities of plants and animals that rely on each other for existence. Through field reconnaissance, the invasive species most commonly observed within the Watershed were cogongrass, Japanese climbing fern, Chinese privet, alligatorweed, and Chinese tallow tree (**Figure 8.5**).

Figure 8.5 Chinese Tallow Tree Along the Bank of Sandy Creek

Understanding how to identify and map problem areas has been a long-standing goal of resource managers and is necessary to better manage the threats from invasive species within a watershed. Invasive species are a major threat to ecosystems due to their ability to spread rapidly, disrupt natural plant and animal communities, and even alter hydrology. Mapping of infested areas and monitoring the spread of these species through the Watershed would provide necessary information on how the area is being impacted. In order to provide a quantitative evaluation of invasive species within the Wolf Bay Watershed, a sampling strategy should be designed to document invasive species and the amount of colonization along major waterways within the Watershed. Subsequent to identifying problem areas, eradication policies and procedures should be implemented with the goal of restoring natural communities and functions within these ecosystems.

Eradication of invasive species within a target area is an obtainable goal if multiple modes of treatment are incorporated in control strategies. Applying a combination of techniques, including physical, chemical, and biological approaches, has proven to be the most effective strategy towards eliminating invasive species. Physical control includes variations of pulling, digging, mulching, and prescribed burning in both terrestrial and aquatic environments. Physical removal alone can be beneficial but has proven to be more effective when coupled with chemical treatment through various herbicide application techniques. The identification of invasive communities, their stage of growth, and the surrounding native species that may be affected by chemical application is key to the safe use of this method.

Management and protection of existing native communities is a priority when the goal is restoration of those communities. Replanting reference natural species following the eradication of invasive species helps to stabilize soils, provides cover for wildlife, and helps prevent other invasive species from reestablishing in the area.

While some invasives, such as Chinese tallow and alligatorweed, were not found in great abundance throughout the Watershed, it is important to understand how quickly these species can spread if not controlled. Invasive plants occupy disturbed areas and habitat edges due to lack of canopy coverage and exposed soils. Transportation corridors, utility rights of way, and riparian areas adjacent to streams, which are frequently disturbed, progress into invaded states more readily than natural areas. These areas, if left unchecked, serve as entryways for invasive species to spread and destroy natural habitats, forming more homogenous stands of invasive species. This makes the watercourses within the Wolf Bay Watershed particularly vulnerable to encroachment of invasive species.

Field investigators noted infestations of cogongrass along transmission line and county road rights of way throughout the Watershed. If not controlled, these areas could potentially spread to other portions of the Watershed. The need exists for establishment of a program dedicated to the control of cogongrass along right of ways managed by utility corporations and the county road department. A control program should be implemented by the managing company or agency to monitor and conduct periodic control measures to prevent cogongrass from spreading from these corridors into sensitive habitats such as riparian areas of the Watershed. Education and training of these entities in the value of equipment cleaning and inspection before transport will also help to control the spread from one area of the Watershed to another.

Management of invasive species within a watershed can often be difficult due to access to lands in private ownership. Providing educational outreach on management methods, including prescribe burning, to landowners is necessary to enable citizens to identify and subsequently remove invasive species on their properties before they multiply and spread. Outreach through local schools as well as through publications such as pamphlets and articles in newspapers will help raise awareness throughout the community about invasive species and the threats they pose.

8.3 Litter

Litter within the Wolf Bay Watershed comes from a variety of sources. Whether intentionally discarded on the ground, illegally dumped, or improperly handled at some point after containment, litter often makes its way into streams and other receiving waterbodies via overland flow or through the municipal drainage systems within the Watershed. Litter is the most visibly noticeable of all watershed impairments and has a direct impact on water quality, wildlife habitat, and recreational enjoyment.

Reduction of litter begins with education and awareness among those who live, recreate, work, and even pass through the Watershed. Making people aware of how trash eventually enters surface waters should be a continuous effort. Outreach to schools, businesses, homeowner associations, construction workers, and recreational users can pay dividends in educating people on how their actions can have a direct and noticeable impact on the health of the Watershed. Signage strategically placed where trash accumulates like roadways, boat launches, and fishing locations, is useful in raising awareness about the proper disposal of refuse. **Figure 8.6** shows potential locations for placement of signage designed to raise awareness about human impacts to the Watershed. Efforts should also be made to curtail illegal dumping in rural areas and impose harsh fines for violations. Additionally, community "clean-ups" among citizens and user groups can promote a sense of stewardship of the Watershed in addition to providing an immediate improvement on the landscape. Each year on the 3rd Saturday in September, the Alabama Coastal Cleanup is held. The current check-in site in the Watershed is located at the Wolf Creek Park. This community event is anchored by volunteers from the Wolf Bay Watershed Watch, City of Foley, Riviera Utilities, and the Boy Scouts of America.

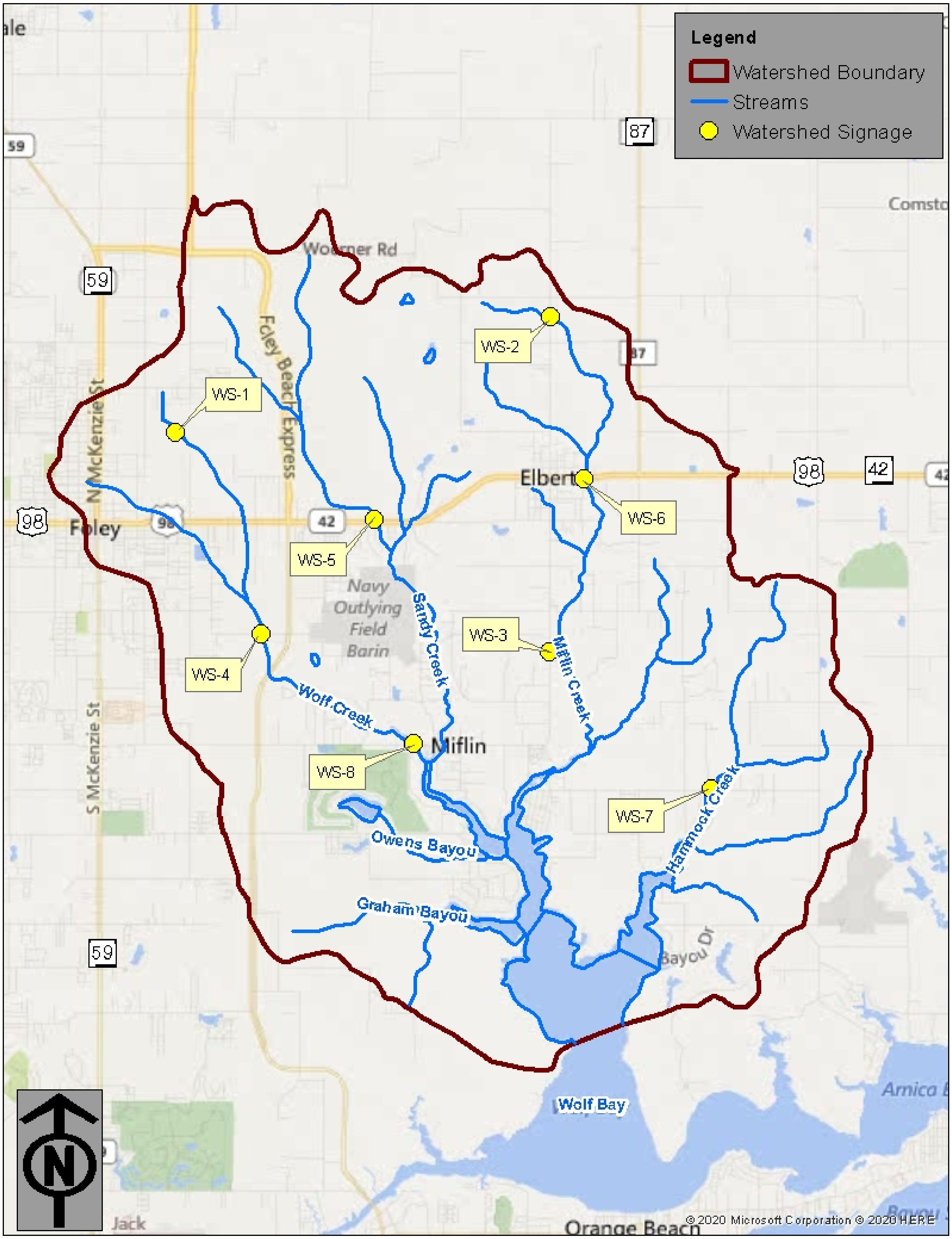

Figure 8.6 Potential Locations for "Watershed Awareness" Signage

In discussions with the Steering Committee, Wolf Creek was identified as an area of concern due to the amount of litter being observed. Litter traps were suggested as a means of removing trash that is ultimately transported downstream via Wolf Creek. These litter traps would be placed at strategic locations within tributaries to Wolf Creek and would collect litter before it makes its way into the Wolf Creek channel. The traps would require periodic cleanings to ensure proper function. The Steering Committee identified three potential locations for litter traps associated with Wolf Creek which are listed in **Table 8.6** and illustrated in **Figure 8.7**. An example of accumulated trash within Wolf Creek is shown in **Figure 8.8**.

Table 8.6 Steering Committee suggestions for litter trap locations along Wolf Creek

Site No.	Description of Location	Latitude	Longitude
LT-1	Wolf Creek at Pecan Street	30.404873	-87.666267
LT-2	Wolf Creek at Highway 98	30.406869	-87.669201
LT-3	Wolf Creek at Poplar Street	30.409243	-87.676309

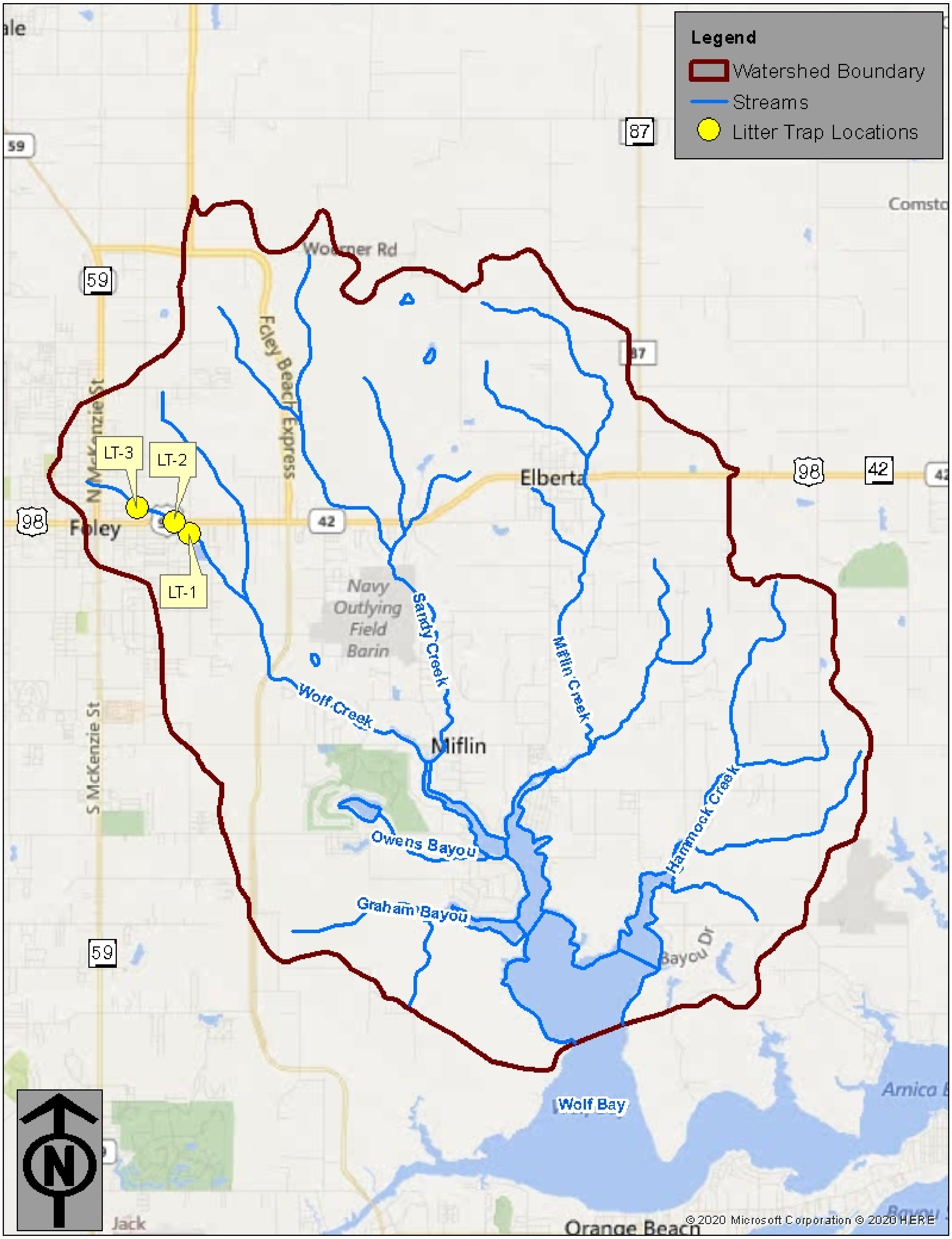

Figure 8.7 Potential Litter Trap Locations Along Wolf Creek

Figure 8.8 Litter in Wolf Creek

8.4 Conservation Land Acquisition and Recreational Access

Acquisition of conservation lands through direct purchase or easement programs is one of the best tools available to protect surface waters within a watershed. Riparian areas protected by trees and other vegetation provide excellent buffers between surface waters and other land uses. With the majority of residents within the Wolf Bay Watershed receiving their drinking water from groundwater sources, intact riparian areas can improve the quality of the groundwater and provide economic value through reduced costs for water treatment. Tracts of land set aside for conservation connect terrestrial and freshwater ecosystems and provide habitat for species of concern. Protecting these areas through acquisition and easement programs prevents future development and helps maintain the balance of natural systems throughout the Watershed. Conservation tracts also provide recreational opportunities like boating, fishing, and hiking, which can be critical to community economic development and provide stakeholders with a sense of ownership that further promotes wise stewardship of the Watershed's natural resources.

Table 8.7 lists tracts of land within the Watershed identified by the Steering Committee for potential land acquisitions for conservation. **Figure 8.9** illustrates those tracts within the Watershed.

Table 8.7 Locations for Potential Conservation Land Acquisitions

Site No.	Sub-Watershed	Acreage	Description
CLA-1	Sandy Creek/Wolf Creek	1,820	Nine adjacent parcels in the headwater areas of the Sandy Creek/Wolf Creek sub-watershed. These parcels front the Foley Beach Express to the west and are adjacent to U.S. Highway 98 to the south. As the area continues to develop, acquisition of these parcels would provide long term protection of the headwaters of Sandy Creek.
CLA-2	Sandy Creek/Wolf Creek	2.9	Parcel is directly adjacent to Wolf Creek Park. Would provide expansion of the park.
CLA-3	Sandy Creek/Wolf Creek	5.5	Parcel is located along Wolf Creek. Would provide water access to the public.
CLA-4	Miflin Creek	515	Eight adjacent parcels in the headwater areas of the Miflin Creek sub-watershed. Similar to the large cluster of parcels identified in the Sandy Creek/Wolf Creek sub-watershed, due to projected development, acquisition of these parcels would provide protection to Miflin Creek and associated headwater tributaries.
CLA-5	Graham Bayou	1,382	Seven adjacent parcels, approximately 1,382 acres, were identified as potential acquisitions in the Graham Bayou sub-watershed. These parcels are directly adjacent to the Graham Creek Nature Preserve, Graham Bayou, and Wolf Bay.

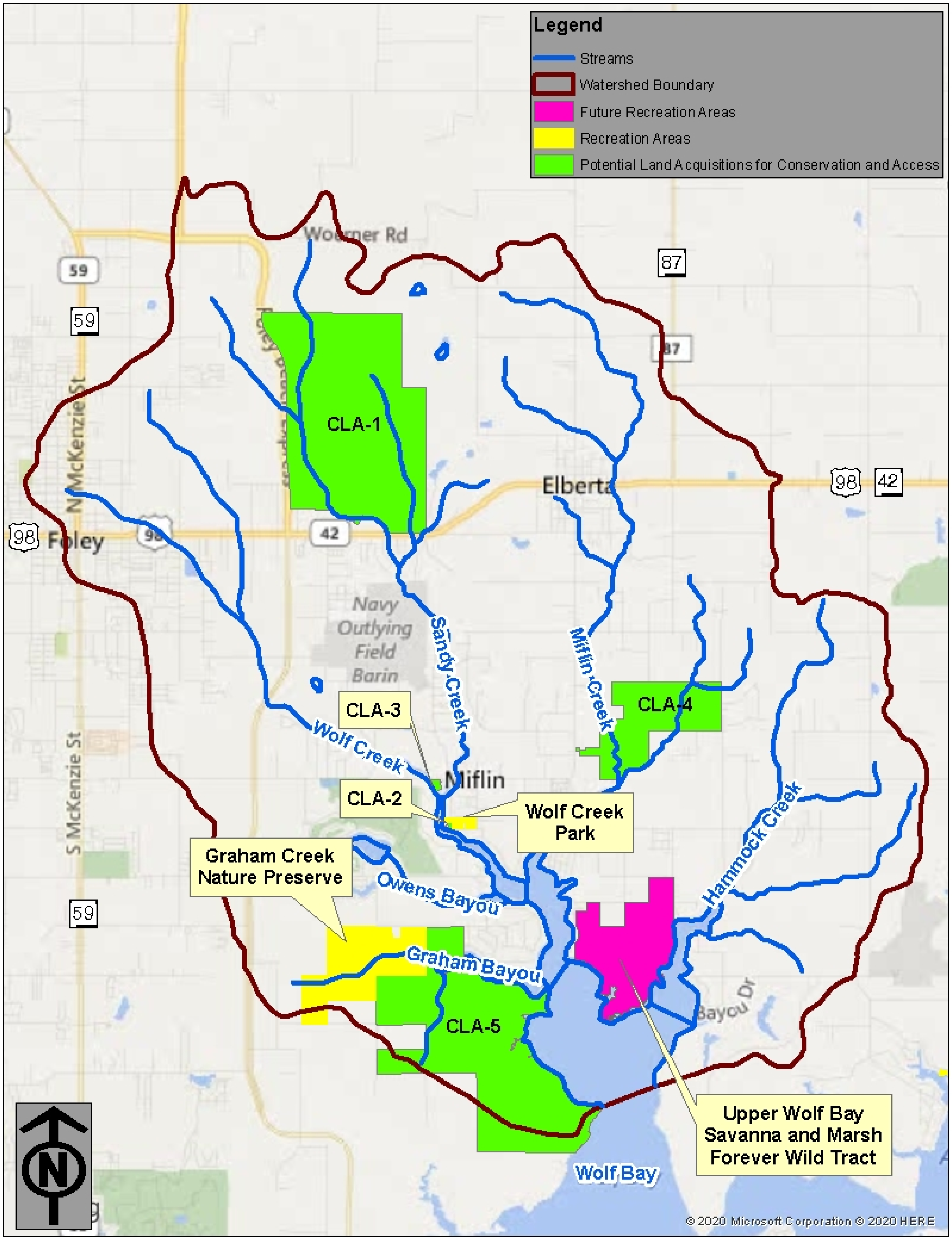

Figure 8.9 Locations of Potential Conservation Land Acquisitions Within the Wolf Bay Watershed

One of the most effective means of addressing water quality in a watershed is to ensure that residents in the watershed have access to recreational opportunities. The more residents take advantage of opportunities to enjoy natural resources in a watershed, the more respect and ownership they will feel for them. Recreational opportunities in the Watershed are very limited at this point, with a lack of public boat launches and limited opportunities for residents who do not own a boat.

The Watershed's premier access venue is the 484-acre Graham Creek Nature Preserve. The Preserve includes natural habitats and recreational features including canoe and kayak launches, hiking trails, picnic areas, an archery park, three-disc golf courses, and natural playgrounds. Wolf Creek Park offers recreational access with a canoe and kayak launch, fishing pier, and picnic areas.

In order to take full advantage of recreational opportunities in the Watershed, the following recommendations should be considered to enhance public access to the Watershed and associated natural resources:

- Develop of a series of blueway trails to include Wolf Creek, Miflin Creek, Graham Creek, and Hammock Creek, which each tie into Wolf Bay, would enhance public access and connection to the Watershed's natural resources. Appropriate planning should consider physical barriers, wayfinding, signage, and other elements necessary for a successful blueway system.
- Work with Alabama Forever Wild Land Trust to add appropriate recreational amenities to the Upper Wolf Bay Savanna and Marsh Forever Wild Tract.

8.5 Projects Previously Submitted for Deepwater Horizon Funding

Table 8.8 lists proposed projects that have been submitted through the various portals related to funding from the Deepwater Horizon Oil Disaster. The projects listed below were compiled from the Alabama Coastal Restoration website (www.alabamacoastalrestoration.org) and the NOAA Gulf Spill Restoration website (www.gulfspillrestoration.noaa.gov). Only projects that would directly affect improvements in water quality or ecosystem function were included in this list. Copies of summary sheets describing these projects are located in **Appendix G**.

Table 8.8 **Wolf Bay Watershed Ecosystem Restoration Projects Submitted for Deepwater Horizon Disaster Funding**

Project Name	Organization	Primary Classification	Estimated Cost
Wolf Creek Park Expansion	City of Foley	Ecological/Environmental	$325,000
Graham Creek Nature Preserve Expansion	City of Foley	Ecological/Environmental	$650,000
Nutrient Reduction Projects-Mobile and Baldwin Counties	U.S. Department of Agriculture	Ecological/Environmental	$6,000,000
Rehabilitation of Sanitary Sewer Mains – Foley, AL	Riviera Utilities	Restoration/Protection	$1,250,000
Long Bayou and Portage Creek Preservation and Enhancement	City of Orange Beach	Restoration/Protection	$14,273,000

Chapter 9 Implementation Strategies

Addressing management challenges within the Wolf Bay Watershed requires a pallet of management measures with varying scales and scopes, as described in Chapter 8. Successful implementation of these management measures calls for a clear and concise approach executed by a collaborative group of stakeholders, including community members and local, State, and federal agencies.

This chapter provides a strategy to address the critical issues and areas identified in the Watershed by prioritizing management measure recommendations, estimating associated costs, and presenting a two-phased (short-term and long-term) implementation approach to achieve success. Components for completing this WMP were reviewed during its preparation, and a checklist of these components is presented as **Appendix H**.

9.1 Watershed Management Task Force – Wolf Bay Watershed Watch

Successfully addressing the critical issues and areas identified in this WMP will require an entity who will champion watershed management and build off the momentum generated through developing the WMP. Many of the critical issues and areas extend beyond political and jurisdictional boundaries and will require the cooperation of landowners and the general public. Therefore, it is recommended that the Wolf Bay Watershed Watch (WBWW) assume primary responsibility of overseeing implementation of recommended management measures, many of which can be implemented simultaneously, and provide a platform for coordination on matters that affect local watershed conditions and natural and recreational resources. The Wolf Bay Watershed Watch currently has a Board of Directors representing various sectors of the Watershed. The Board meets monthly to discuss issues in the watershed; therefore, overseeing plan implementation would fit within their existing framework.

9.2 Phase One Implementation: Short Term

Feedback gained through stakeholder engagement and public outreach efforts stressed the need for short-term wins or tangible successes promptly following WMP adoption. This will help to nourish stakeholder confidence and build on the momentum generated through WMP development. Parallel with this need to capture early successes is the need to foster and harness interest in environmental stewardship of the Watershed. With these considerations in mind, management measures were grouped into two phases: short-term and long-term. The short-term management measures described in this section were chosen based on the likelihood of successful implementation within the next two years.

Table 9.1 describes each measure and provides rough order-of-magnitude cost estimates to implement each measure. The preparation of detailed cost estimates was not possible due to the conceptual level of planning that guided development of this WMP. These cost estimates are intended for preliminary budgetary consideration. A more detailed description of each recommended management measure is provided in Chapter 8.

Table 9.1 Short-Term Management Measures (0-2 Years)

Chapter/ Section	Management Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
Overall Watershed								
8.1.1.4	LID/GI and Post-Construction Requirements	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	Admin Costs
8.1.1.4	LID/GI and Post-Construction Education (Local Government Staff)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	Admin Costs
8.1.1.4	LID/GI and Post-Construction Education (Public)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$2,000/yr
8.1.1.4	Construction BMP Education (Public)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$2,000/yr
8.1.2	Nutrient Education (Local Government Staff)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	Admin Costs
8.1.2	Nutrient Education (Public)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$2,000/yr

Chapter/ Section	Management Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
8.1.2	Nutrient Education (Public)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$5,000/per subdivision
8.1.3	Invasive Species Education and Training (Local Government Staff and Local Utilities)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	Admin Costs
8.1.3	Invasive Species Education and Training (Public)	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$2000/yr
8.3	Watershed Signage	WS-1	Fern Ave	Sandy/Wolf	N/A	N/A	N/A	$100/sign
		WS-2	CR 83 North	Miflin Creek	N/A	N/A	N/A	$100/sign
		WS-3	CR 83 South	Miflin Creek	N/A	N/A	N/A	$100/sign
		WS-4	Doc McDuffie Rd	Sandy/Wolf	N/A	N/A	N/A	$100/sign
		WS-5	Hwy 98 W	Sandy/Wolf	N/A	N/A	N/A	$100/sign
		WS-6	Hwy 98 E	Miflin	N/A	N/A	N/A	$100/sign
		WS-7	CR 20	Graham Bayou	N/A	N/A	N/A	$100/sign
		WS-8	CR 20	Sandy/Wolf	N/A	N/A	N/A	$100/sign
Restoration and Protection								
8.1.1.4	Stream/Habitat Restoration (Engineering and Design)	SR-2	Wolf Creek	Sandy/Wolf Creek	700	N/A	N/A	$70,000
		SR-3	Wolf Creek	Sandy/Wolf Creek	3800	N/A	N/A	$380,000
		SR-4	Wolf Creek	Sandy/Wolf Creek	500	N/A	N/A	$50,000
Pathogen Monitoring								
8.1.1.5	Monthly Bacteriological Monitoring	MP-1	Sandy Creek	Sandy/Wolf Creek	N/A	N/A	N/A	$367/yr

Chapter/ Section	Management Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
		MP-2	Miflin Creek	Miflin	N/A	N/A	N/A	$367/yr
		MP-3	Hammock Creek	Graham Bayou	N/A	N/A	N/A	$367/yr
Access								
8.4	Blueway Signage	TBD	TBD	TBD	N/A	N/A	$1,300/sign	TBD

9.3 Phase Two Implementation: Long Term

Not all of the critical issues identified within this WMP can be addressed within two years of WMP adoption. Although some projects listed as long-term can be initiated within a two-year period, additional analysis, planning, data collection, design, etc. will push completion of project implementation beyond that range. **Table 9.2** summarizes recommended long-term management measures and includes rough order-of-magnitude cost estimates to implement each measure.

Table 9.2 Long-Term Management Measures (2+ Years)

Chapter/ Section	Mangement Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
Overall Watershed								
8.1.1.4	Comprehensive Post-Construction BMP Inventory	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$25,000
8.2	Invasive Species Control Plan	N/A	TBD	Sandy/Wolf, Miflin, Graham Bayou	TBD	TBD	TBD	TBD
8.1.3	Rehab of Sewer Mains in Foley	N/A	Wolf Creek	Sandy/Wolf	45,408	N/A	N/A	$1,250,000
8.1.3	Aquifer Recovery Storage Wells	N/A	Wolf Creek	Sandy/Wolf	N/A	N/A	N/A	$3,532,083
8.1.3	Septic Tank Inventory	N/A	N/A	Sandy/Wolf, Miflin, Graham Bayou	N/A	N/A	N/A	$30,000

Chapter/ Section	Mangement Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
Restoration and Protection								
8.1.1.1	Agricultural Buffer	AB-1	Wolf Creek	Sandy/Wolf	N/A	164	Low- $13,000/ac High- $30,000/ac	Low- $2.132M High - $4.92M
		AB-2	Sandy Creek	Sandy/Wolf	N/A	89	Low- $13,000/ac High- $30,000/ac	Low - $1.157M High - $2.67M
		AB-3	Sandy Creek	Sandy/Wolf	N/A	94	Low- $13,000/ac High- $30,000/ac	Low- $1.222M High - $2.82M
		AB-4	Miflin Creek	Miflin	N/A	110	Low- $13,000/ac High- $30,000/ac	Low - $1.43M High - $3.3M
		AB-5	Miflin Creek	Miflin	N/A	308	Low- $13,000/ac High- $30,000/ac	Low - $4.004M High - $9.24M
		AB-6	Trib to Miflin Creek	Miflin	N/A	89	Low- $13,000/ac High- $30,000/ac	Low - $1.157M High - $2.67M
		AB-7	Trib to Miflin Creek	Miflin	N/A	58	Low- $13,000/ac High- $30,000/ac	Low - $754,000 High - $1.74M
		AB-8	Hammock Creek	Graham Bayou	N/A	47	Low- $13,000/ac High- $30,000/ac	Low - $611,000 High - $1.41M
		AB-9	Hammock Creek	Graham Bayou	N/A	136	Low- $13,000/ac High- $30,000/ac	Low - $1.768M High - $4.08M
		AB-10	Trib to Hammock Creek	Graham Bayou	N/A	264	Low- $13,000/ac High- $30,000/ac	Low- $3.432M High - $7.92M

Chapter/ Section	Mangement Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
8.1.1.1	Cattle Exclusion Fencing	CEF-1	Sandy Creek	Sandy/Wolf	5,174	N/A	Low-$2.00/ft High-$2.40/ft	Low-$10,348 High - $12,417.60
		CEF-2	Sandy Creek	Sandy/Wolf	3,248	N/A	Low-$2.00/ft High-$2.40/ft	Low-$6,496 High - $7,795.20
		CEF-3	Miflin Creek	Miflin	997	N/A	Low-$2.00/ft High-$2.40/ft	Low-$1,994 High - $2,392.80
	Alternative Water Source	AWS-1	Sandy Creek	Sandy/Wolf	N/A	N/A	N/A	$6,000
		AWS-2	Sandy Creek	Sandy/Wolf	N/A	N/A	N/A	$6,000
		AWS-3	Hammock Creek	Graham Bayou	N/A	N/A	N/A	$6,000
8.1.1.4	Stream/Habitat Restoration (Engineering and Design)	SR-1	Wolf Creek	Sandy/Wolf	300	N/A	N/A	$30,000
		SR-5	Sandy Creek	Sandy/Wolf	1,175	N/A	N/A	$117,500
		SR-6	Hammock Creek	Sandy/Wolf	1,600	N/A	N/A	$160,000
		SR-7	Wolf Creek		1,600	N/A	N/A	$160,000
	Stream/Habitat Restoration (Construction)	SR-2	Wolf Creek	Sandy/Wolf	700	N/A	N/A	$700,000
		SR-3	Wolf Creek	Sandy/Wolf	3800	N/A	N/A	$3,800,000
		SR-4	Wolf Creek	Sandy/Wolf	500	N/A	N/A	$500,000
Conservation and Access								
8.4	Public Boat Launch		Wolf Creek	Sandy/Wolf	N/A	5.5	N/A	$1,600,000
8.4	Land Acquisitions	CLA-1	Sandy Creek	Sandy/Wolf	N/A	1,820	N/A	$9,100,000
		CLA-2	Wolf Creek	Sandy/Wolf	N/A	2.9	N/A	$325,000
		CLA-3	Wolf Creek	Sandy/Wolf	N/A	5.5	N/A	$1,600,000
		CLA-4	Miflin Creek	Miflin	N/A	515	N/A	$2,575,000

Chapter/ Section	Mangement Measure	Project ID	Potential Project Location	Sub-Watershed	Linear Feet (ft)	Acre (ac)	Estimated Cost per Unit	Estimated Total Cost
		CAL-5	Graham Bayou/ Wolf Bay	Graham Bayou	N/A	1,382	N/A	$8,564,000
BMPs								
8.1.1.3	Road Paving	RP-1	N/A	Miflin	6,336	N/A	$500,000/ 5280 ft	$600,000
		RP-2	N/A	Miflin	4,752	N/A	$500,000/ 5280 ft	$450,000
		RP-3	N/A	Miflin	5,280	N/A	$500,000/ 5280 ft	$500,000
		RP-4	N/A	Graham Bayou	7,920	N/A	$500,000/ 5280 ft	$750,000
		RP-5	N/A	Graham Bayou	4,224	N/A	$500,000/ 5280 ft	$400,000
8.1.1.5	Litter Traps	LT-1	Wolf Creek	Sandy/Wolf	N/A	N/A	N/A	$5,000 install/ $12,000 annual maint.
		LT-2	Wolf Creek	Sandy/Wolf	N/A	N/A	N/A	$5,000 install/ $12,000 annual maint.
		LT-3	Wolf Creek	Sandy/Wolf	N/A	N/A	N/A	$5,000 install/ $12,000 annual maint.

9.4 Accountability and Reporting

On a routine basis (e.g., annually), the WBWW should assess progress towards meeting WMP goals and objectives (see Chapter 1). Results of performance monitoring, as discussed in Chapter 12, should be used to assess whether specific management measures are addressing the critical issues and areas they were designed to address or whether adjustments are required. Additionally, the WBWW should develop criteria to judge success with input from stakeholders and the general public. On an annual basis, a report card should be prepared documenting accomplishments and success stories and reporting on conditions within the Watershed.

A regular reporting schedule is necessary to archive and track monitoring data and assess the overall success of management actions. Progress reports for the Watershed should be prepared and submitted to MBNEP. Reporting should be conducted on at least an annual basis, although interim reporting may be helpful in critical watershed areas or where more frequent monitoring is needed to track success of specific management actions. Annual reports should include at a minimum: a summary of watershed conditions including field results from monitoring and sampling activities, an update on the status of management measures implemented to date, and a summary of anticipated management measures to be implemented during the next 12 months.

Chapter 10 Regulatory Review

The implementation of best management practices (BMPs) recommended in the Wolf Bay WMP may be subject to a variety of federal, State, and local regulations. Many of these regulations are restrictive in nature and require a permits or other approvals for implementation of projects. Others are more permissive in nature, encouraging appropriate levels of innovation and the use of BMPs designed to improve environmental conditions. This chapter of the Wolf Bay WMP seeks to identify applicable regulations and identify regulatory overlaps, gaps, and any inconsistencies that may hinder implementation of the Plan's recommendations. This regulatory framework will outline the applicable federal, State, and local regulations, laws, and ordinances that relate to water quality, sediment and erosion control, coastal zone activities, wetlands, land development, and other land disturbance activities. In addition to regulations enforced through the U.S. Government and the State of Alabama, this chapter will also highlight local ordinances in Baldwin County, the City of Foley, and the Town of Elberta.

Table 10.1 provides a comprehensive overview of the applicable federal, State, and local regulations related to water resources. Regulatory requirements that govern activities in the Wolf Bay Watershed include:

- The Clean Water Act, 33 USC § 1251, et seq.
- The Coastal Zone Management Act, 16 USC § 1451
- The Alabama Water Pollution Control Act, Code of Alabama 1975 § 22-22-1
- The Alabama Water Quality Criteria, Code of Alabama 1991 § 336-6-10
- Construction Site Stormwater and State MS4 NPDES Program, Code of Alabama 1977 § 335-6-6
- The Alabama Watershed Management Authority Act, Code of Alabama 1991 § 91-602
- The Baldwin County Flood Damage Protection Ordinance
- The Baldwin County Subdivision Regulations
- The Baldwin County Zoning Ordinances
- The Baldwin County Stormwater Management Plan, NPDES Permit No. ALR040042
- The City of Foley Code of Ordinances
    - Chapter 4, Buildings, Construction and Related Activities
        - Article II: Flood Damage Prevention
        - Article III: Permits and Fees

        - Article VII: Lot Clearing and Weed Removal
        - Article VIII: Shoreline Construction Activities
    - Chapter 6.5, Environment
        - Article III: Erosion and Sediment Control
        - Article V: Illicit Discharges
        - Article VI: Environmental Permits Related to Land Disturbance
    - Appendix A, Zoning
    - Appendix B, Subdivision Regulations
- Town of Elberta Code of Ordinances
    - Chapter 8, Buildings and Building Regulations
    - Chapter 14, Floods
        - Article II: Flood Damage Prevention
    - Appendix A, Subdivision Regulations
    - Appendix B, Zoning

Table 10.1 Overview of Water-Related Regulations in the Wolf Bay Watershed

Regulation/Ordinance	Regulatory Authority	Jurisdiction
Federal Regulations		
Clean Water Act: §303(d) 1972	USEPA and ADEM • Impaired Waters List and TMDL Development/Implementation	Federal and State
Clean Water Act: §319 1972	USEPA and ADEM • Non-Point Source Management • Provides funding for local and state non-point source pollution programs	Federal and State
Clean Water Act: §401 1972	USEPA and ADEM • Provides for and requires state water quality criteria • Supported on the State level by ADEM Administrative Code 335-6-10	Federal and State
Clean Water Act: §402 1972	USEPA and ADEM • Establishes and regulates the National Pollution Discharge Elimination System (NPDES) which also includes the Municipal Separate Storm Sewer System (MS4)	Federal and State

Regulation/Ordinance	Regulatory Authority	Jurisdiction
Clean Water Act: §404 1972	USACE • Regulates the discharge of dredged or fill materials into waters of the U.S., including wetlands	Federal
Coastal Zone Management Act, 16 USC § 1451	NOAA, ADEM, and ADCNR • Management of the nation's coastal resources	Federal and State
State Regulations		
Alabama Water Pollution Control Act	ADEM • State of Alabama companion regulation to the CWA and includes water quality criteria, impaired waters, TMDLs, NPDES, etc.	State
Alabama Water Quality Criteria	ADEM • A subset of the Alabama Water Pollution Control Act that includes the 303(d) Impaired Waters List and TMDLs	State
NPDES Program	ADEM • A subset of the Alabama Water Pollution Control Act that includes MS4 permitting for local governments and other public entities	State
Alabama Coastal Zone Program	ADEM, ADCNR-SLD • ADEM – Permitting, monitoring, and enforcement • ADCNR-SLD – Planning and policy development	State
Alabama Watershed Management Authority Act	State of Alabama • Provides for the establishment and management of Watershed Management Authorities	State
Baldwin County Regulations		
Baldwin County Flood Damage Protection Ordinance	Baldwin County • Promote public health, safety, and welfare by minimizing losses due to flood conditions	Local

Regulation/Ordinance	Regulatory Authority	Jurisdiction
Baldwin County Subdivision Regulations	Baldwin County • Establishes regulations for development or expansion of subdivisions. • Applicable sections include • Article 5, Section 5.11 (Drainage Systems) • Article 5, Section 5.12 (Stormwater Detention/Retention Management • Article 5, Section 5.13 (Erosion and Sediment) • Article 5, Section 5.19 (Additional Regulations Applicable to Flood Prone Areas) • Appendix 2 (Stormwater Calculations and Submittal Requirements)	Local
Baldwin County Zoning Ordinances	Baldwin County • Intended to protect health, safety, and welfare by encouraging the appropriate use of lands and natural resources. • Applicable Sections include: • Article 11 (Conservation Developments) • Article 13, Section 13.4 (Utilities (including wastewater)) • Article 13, Section 13.5 (Sewage Treatment Plants) • Article 13, Section 13.11 (Stormwater Management) • Article 13, Section 13.12 (Erosion Control) • Article 17 (Landscaping and Buffers)	Local
City of Foley Code of Ordinances		
Chapter 4, Buildings, Construction and Related Activities	City of Foley • Regulates building construction including lot development and other land disturbing activities and also includes provisions for flood damage prevention	Local
Chapter 6.5, Environment	City of Foley • Generally referred to as the Erosion and Sediment Control Ordinance and addresses erosion and sediment control, illicit discharges, and permits for land disturbance activities	Local
Appendix A, Zoning	City of Foley • Provides for the orderly growth and development and encourage the most advantageous use of land and resources	Local
Appendix B, Subdivision Regulations	City of Foley • Established standards and procedures for development of new or expansion of existing subdivisions.	Local

Regulation/Ordinance	Regulatory Authority	Jurisdiction
Manual for Design and Construction Standards	City of Foley • Includes provisions for conservation areas, Low Impact Development (LID) techniques, and Green Infrastructure (GI) in development and redevelopment	Local
Town of Elberta Code of Ordinances		
Chapter 8, Buildings and Building Regulations	Town of Elberta and Baldwin County • Elberta adopted the Baldwin County Building Regulation by reference.	Local
Chapter 14, Floods	Town of Elberta • Promote public health, safety, and welfare by minimizing losses due to flood conditions	Local
Appendix A, Subdivision Regulations	Town of Elberta • Established standards and procedures for development of new or expansion of existing subdivisions.	Local
Appendix B, Zoning	Town of Elberta • Provides for the orderly growth and development and encourage the most advantageous use of land and resources	Local

In addition to the above matrix that outlines a wide variety of regulatory mechanisms potentially affecting the Wolf Bay Watershed, the matrix presented in **Table 10.2** reviews specific stormwater regulations affecting the Watershed. The stormwater matrix below was derived from the South Alabama Stormwater Regulatory Review Report (2018) and includes an overview of stormwater regulations from the federal to the municipal level. The matrix also provides a good example of regulatory overlap and illustrates the level of regulation delegated from the federal level to the state level and ultimately to the local level. Typically, it is incumbent upon the local governments (counties and municipalities) to fill in regulatory gaps that potentially affect the local landscape and specific issues found at the local government level.

Table 10.2 **Mobile Bay National Estuary Program: South Alabama Stormwater Regulatory Requirements, January 2018**

Regulatory Category	US EPA	ADEM	Baldwin County	City of Foley	Town of Elberta
Construction Phase BMPs Requirements	Yes	Yes	Yes	Yes	Yes
Design Standards	Not specified	AL Handbook	AL Handbook	AL Handbook	Not specified
BMP Design Storm	2yr-24hr	2yr-24hr	Not Specified	Not Specified	10/25-year
Site Size	>1 acre	>1 acre	Any	>/= 500 ft^2 / 1/2 acre	>1 acre

Regulatory Category	US EPA	ADEM	Baldwin County	City of Foley	Town of Elberta
Stabilization Time	Immediate/14 days	Immediate/13 days	10 or 13 days	Immediate	14 days
Site Inspections	1 per week or per 2 weeks + 1/4" Rain	State-Random / Con. 1/month +3/4" rain	Yes	City-Random / Contractor - "regular"	City-Random / Contractor - "regular"
BMP Repair/Maintenance Time	Immediate/7 days	5 days	Not Specified	2 Days	Not specified
Non-compliance Reporting	Yes	Yes	No	No	No
Buffer Requirement	50'	Yes - 25'	No	30' Wetland / 50' Waterway	5' - 30' Wetland / 25' Waterway
Post Construction Stormwater Requirements	No	No	Yes	Yes	Yes
Stormwater Quality	No	No	No	Yes - Treat First Flush (1.25")	No
Stormwater Quantity	No	No	Yes-Considers timing	Yes	Yes
Design Storm	N/A	N/A	2 - 100 yr.	2 - 100 yr.	25 year
Site Size	N/A	N/A	Any	500 $ft.^2$	Varies 1 - 10 acre
Routine Inspection	N/A	N/A	No	Annual by City	No
Maintenance	N/A	N/A	Developer/Owner	Owner	Landowner
Reporting	N/A	N/A	No	No	No
Calculation Method	N/A	N/A	NRCS	Various	Rational Method
Coastal Area Resource Protection	Yes	Yes	No	Yes	No
Wetland/Stream Buffer	50 ft.	25 ft.	N/A	30' Wetland / 50' Waterway	5' - 30' Wetland / 25' Waterway
Permit Requirement	Yes - USACE	Yes	N/A	USACE/ADEM	USACE/ADEM
Low Impact Development	No	No	No	Yes	No
Development Size	N/A	N/A	N/A	N/A	N/A
Impervious Cover	No	No	No	N/A	N/A
On-Site Retention	No	No	No	Yes - 1.23"	N/A
LID Standards	No	No	No	LID Handbook	N/A

Regulatory Category	US EPA	ADEM	Baldwin County	City of Foley	Town of Elberta
Impediments to LID	N/A	N/A	N/A	No	N/A
Shoreline Stabilization	N/A	Yes	No	Yes	Yes
Piers and Bulkheads	N/A	Yes	N/A	Yes	Yes
Living Shorelines	N/A	No	N/A	No	Optional
MS4 Permit Coverage	N/A	N/A	ALR040042	No	No

10.2 Overview of Applicable Laws, Regulations, and Ordinances

10.2.1 Federal Regulations

Several federal agencies and regulations manage and govern activities in the nation's wetlands, groundwater, freshwater, and coastal resources. Most of these programs are managed through the United States Army Corps of Engineers (USACE), the United States Environmental Protection Agency (USEPA), and National Oceanic and Atmospheric Administration (NOAA). In forthcoming sections, we will discuss regulatory overlaps. Many of these overlaps occur through a top-down regulatory approach that begins at the federal level and extends to the state and sometimes even the local level. Federal regulations relative to this Plan and designed to protect water quality and regulate activities in the nation's waters are provided below.

10.2.1.1 Federal Water Pollution Control Act and the Clean Water Act

The most notable set of regulations addressing water quality and aquatic resource protection are found in the Federal Water Pollution Control Act (FWPCA) of 1948, amendments to the Act in 1972, and the Clean Water Act (CWA) amendments to the FWPCA enacted in 1977. The original FWPCA was the first major law to address water pollution in the U.S. However, by the 1970's two-thirds of the nation's lakes, rivers, and coastal waters were unsafe for fishing or swimming. The 1972 and 1977 amendments were extensive and wide-ranging and accomplished the following:

- Established a system to regulate pollutant discharges into waters of the U.S.
- Granted the USEPA authority to implement water pollution control programs.

- Retained existing requirements to set water quality standards for all contaminants in surface waters.
- Prohibited the discharge of a pollutant from a point source into navigable waters unless the discharger obtains a permit under the law's provisions.
- Funded the construction of wastewater treatment facilities.
- Recognized the importance of planning when addressing critical issues caused by non-point source pollution.

Within the CWA are a number of sections particularly pertinent to watershed planning and coastal resources. These sections are outlined below.

10.2.1.2 Clean Water Act §303(d) 1972

Section 303(d) of the Clean Water Act provides for establishment of water quality criteria and requires states to maintain a listing of impaired waters. Section 303(d) also requires that Total Maximum Daily Loads (TMDL) be established for impaired waters. A TMDL establishes the allowable loading of a given pollutant that a receiving water can handle without an increase of impairment for that specific pollutant. Typically, once a TMDL is established for a particular stream segment, it is removed from of the 303(d) list.

10.2.1.3 Clean Water Act §319 1972

Section 319 provides grant funding to states, territories, and tribes to support a variety of water quality initiatives including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, watershed planning, and monitoring to assess the success of nonpoint source implementation projects. As a funding source, it is less regulatory and more of an assistance program. However, since it directly addresses water quality issues, it bears mention in this section of the Wolf Bay Plan.

10.2.1.4 Clean Water Act §401 1972

Section 401 of the CWA determines that a federal agency may not issue a permit to conduct activities that may result in a discharge into waters of the U.S. without a state or tribal entity issuing a Section 401 water quality certification verifying or waiving compliance with existing water quality requirements.

Section 401 is supported on the state level in Alabama by the Alabama Department of Environmental Management (ADEM) Administrative Code 335-6-10. Section 401 is an important tool that allows states to protect water quality within their borders in collaboration with federal agencies. Section 401 seeks to provide for a robust state role in the federal permitting process but also places limitations on how that role is implemented within the federal construct of the CWA.

10.2.1.5 Clean Water Act §402 1972

Section 402 of the CWA established and regulates discharges under the National Pollution Discharge Elimination System (NPDES). Under NPDES, USEPA grants permits for a number of land disturbance and discharge activities, including concentrated animal feeding operations, publicly owned treatment works, combined sewer overflows, construction, and sanitary sewer overflows. The program also established the Municipal Separate Storm Sewer System (MS4), that provides permits to local governments and other entities and regulates the management of non-point source pollutants, commonly referred to as stormwater runoff.

10.2.1.6 Clean Water Act §404

Section 404 authorizes a permitting process specific to activities that may impact jurisdictional wetlands and is designed to ensure protection of the nation’s wetlands. Section 404 includes specific guidance relative to discharges of dredge or fill materials into waters of the U.S. Section 404 specifically established the USACE as the primary permitting authority to issue permits and to oversee permitted activities. The program also requires that all 404 permitted activities be consistent with state water quality standards and coastal program requirements that may exist.

10.2.1.7 Coastal Zone Management Act 16 USC §1451

The Coastal Zone Management Act (CZMA) was borne of a congressional recognition that continued growth in the nation’s coastal zones presents challenges with respect to protection of natural areas and water quality within the coastal zones. The CZMA includes three primary programs: the National Coastal Zone Management Program, the National Estuarine Research Reserve System, and the Coastal and Estuarine Land Conservation Program. The CZMA program seeks to balance competing land and water issues through state coastal management programs. The program also provides matching funds to state and local governments to purchase threatened coastal and estuarine lands or to obtain conservation easements. The Act provides for NOAA to have primary management responsibility of the program.

10.2.2 State Regulations

The majority of federal regulations previously discussed are delegated to the states to administer, providing the states enact and implement equivalent state statutes and programs. For the State of Alabama, the majority of regulations related to the environment and water quality are administered through ADEM. With the exception of the CZMA, the regulations discussed below are applicable statewide.

10.2.2.1 Alabama Water Pollution Control Act

The Alabama Water Pollution Control Act is the state equivalent of the federal CWA and prohibits discharges of pollutants to state waters without a permit. It also lays the foundation for the state's authority to implement a variety of water quality programs as discussed below.

10.2.2.2 Alabama Water Quality Certification

As a subset of the Alabama Water Pollution Control Act, the Water Quality Certification Program dictates that permit applications must be filed with and approved by the state to ensure dredged or fill materials will not cause or contribute to a violation of water quality standards. These standards are also communicated by the state through a 303(d) Impaired Waters Report and published TMDLs.

10.2.2.3 National Pollution Discharge Elimination System Program

This program is the state delegate program of Section 402 of the CWA and establishes a permitting program for discharge of pollutants to waters of the U.S. ADEM administers this program through its Water Quality Program. ADEM characterizes facilities discharging pollutants based on the size and type of facility and level of treatment required prior to discharge. Generally, larger facilities such as sewage treatment plants are authorized to discharge under individual permits, while smaller facilities such as construction sites receive authorization under a general permit.

The program also includes the NPDES Municipal Separate Storm Sewer System (MS4). This program issues permits to large municipalities, urban areas, entities with high population densities such as a university, and most departments of transportation (DOTs). MS4 permits require that covered entities develop and implement a Stormwater Management Program Plan that includes the following six minimum measures:

- Public Education and Outreach on Stormwater Impacts
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Management
- Post Construction Stormwater Management
- Pollution Prevention and Good Housekeeping for Municipal Operations

MS4 permits may require stormwater or stream monitoring for stream segments included in the state's 303(d) list or with an approved TMDL. The programs typically encourage low impact development and implementation of green infrastructure practices. The MS4 permits also require submittal of an annual report of activities and accomplishments related to the six minimum measures to be submitted to ADEM. Most MS4s operate under a general permit. However, some non-municipal MS4s such as DOTs have opted for coverage under an individual permit.

10.2.2.4 Alabama Coastal Area Management Program

This program is administered by ADEM with the Alabama Department of Conservation and Natural Resources (State Lands Division) providing additional support and planning oversight. The Alabama CZMA provides the statutory basis for the Alabama Coastal Area Management Program. The Program is designed to "promote, improve, and safeguard the lands and waters located in the coastal areas of the State through a comprehensive and cooperative program designed to preserve, enhance, and develop such valuable resources for the present and future well-being and general welfare of the citizens of the State". The Program regulates and permits development activities of greater than five acres that have potential to impact wetlands. The Program also regulates and permits shoreline stabilization, docks and piers, construction on beaches or dunes, and other similar activities impacting coastal resources.

10.2.2.5 Alabama Watershed Management Authority Act

This program is not regulatory; however, it does provide a statutory basis for creation of Watershed Management Authorities. The general intent of the Act is to allow for the establishment of Watershed Management Authorities whose purpose is to protect and manage the watersheds of the State. Through the Act, Watershed Management Authorities may be formed in any watershed in the State. Their primary purpose is to develop and execute plans and programs relating to water conservation and usage; flood prevention; flood control; water pollution control; wildlife habitat protection; agricultural and timberland protection; erosion prevention; and control of erosion, flood water, and sediment damages within the watershed.

10.2.3 Local Government Regulations and Ordinances

Three local government entities exist within the Wolf Bay Watershed: Baldwin County, the City of Foley, and the Town of Elberta. Each of these entities have a variety of regulations and ordinances that regulate development in the Watershed and are designed to protect water quality and natural resources in the Watershed. Many of the ordinances enacted by the local governments are similar. However, they do have varying levels of detail with respect to requirements and implementation of the ordinances.

The State of Alabama is a “Dillon’s Rule” State. Under Dillon’s Rule, a municipal government has the authority to act only when:

1. The power is granted in the express words of the statute, private act, or charter creating the municipality.
2. The power is necessarily or fairly implied in, or incident to the powers expressly granted; or
3. The power is one that is neither expressly granted nor fairly implied from the express grants of power but is otherwise implied as essential to the declared objects and purposes of the municipality.

Thirty-one states in the U.S. employ Dillon’s rule to all municipalities. Another eight states apply Dillon’s rule to only certain municipalities. The remaining states employ home rule, with the exception of Florida, which applies home rule to everything except taxation.

10.2.3.1 Baldwin County

10.2.3.1.1 Baldwin County Flood Damage Protection Ordinance

The overarching goal of the Baldwin County Flood Damage Protection Ordinance is to minimize losses due to flood conditions. Through this ordinance, the County regulates construction and development in the floodplain to ensure buildings are protected from flood damage. Baldwin County participates in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS). The CRS program includes incentives for NFIP communities to implement more stringent floodplain standards than those normally required by the NFIP. The CRS program rewards these efforts with discounts on flood insurance premiums. Baldwin County currently has a CRS rating of a Class 6, which results in a 20% reduction in flood insurance premiums for properties located within a FEMA designated Special Flood Hazard Area (SFHA). Additionally, the County has flood damage prevention requirements specific to properties located within SFHAs that are coastal in nature, including the Coastal High Hazard VE Zone and the Coastal High Hazard AE Zone.

10.2.3.1.2 Baldwin County Subdivision Ordinance

The Baldwin County Subdivision Ordinance (August 2019), establishes regulations for development or expansion of subdivisions. A number of provisions of the Ordinance are specific to water quality and protection of natural resources. These include:

- **Article 5, Section 5.11 (Drainage Systems):** This section provides for minimum design standards for drainage systems in subdivisions and requires that stormwater drainage systems be separate from and independent of any sanitary sewer systems.
- **Article 5, Section 5.12 (Stormwater):** This section requires developments that will produce an increase in stormwater runoff to include stormwater management facilities as part of the development. It also requires detailed engineering calculations that include historical runoff, and proposed development runoff. The section requires that post-development runoff be equal to or less than pre-construction conditions for two, five, 10, 25, 50, and 100-year storm events. Subsection 5.12.2 (3) provides for specific requirements for subdivisions developed within the Wolf Bay Watershed and requires that subdivisions proposed in the Wolf Bay Watershed be modeled according to the Wolf Bay Watershed Study Model (Hydro Engineering Solutions, 2013 and 2020).
- **Article 5, Section 5.13 (Erosion and Sedimentation):** This section imposes requirements on persons engaged in land disturbance activities to incorporate planning and implementation of

effective erosion and sediment controls. The provision includes construction requirements and requirements for protection of adjacent properties.

- **Article 5, Section 5.19 (Additional Regulations Applicable in Flood Prone Areas):** This section, by reference, enforces the County's Flood Damage Protection Ordinance by requiring all subdivisions within or containing FEMA designated SFHAs to comply with the Flood Damage Ordinance and be consistent with the need to minimize flood damage to the development itself and to minimize future flood damages to adjacent properties.
- **Appendix 2 (Stormwater Calculations and Submittal Requirements):** Appendix 2 requires subdivision design engineers to submit a design narrative summarizing the assumptions, calculations, and results of the design for the entire project including:
    - A design narrative summary,
    - Evaluations of pre and post differential runoff,
    - Evaluations of required retention/detention ponds,
    - Pond routing calculations in legible tabulated form,
    - Inlet and gutter details,
    - Culvert pipe details, and
    - Open channel drainage system details.

10.2.3.1.3 Baldwin County Zoning Ordinance

The Baldwin County Zoning Ordinance is intended to protect health, safety, and welfare by encouraging the appropriate use of lands and natural resources in the County. As with the Subdivision Ordinance, specific sections of the Zoning ordinance are intended to be protective of water quality and natural resources. These include:

- **Article 11 (Conservation Developments):** The intent of this section is to "promote flexibility of design to promote environmentally sensitive and efficient use of the land to preserve in perpetuity unique or sensitive natural resources such as groundwater, floodplains, wetlands, streams, steep slopes, woodlands, and wildlife habitat". The Conservation Development Article is a perfect example of a regulation that is permissive in nature. By allowing for unified control of the development, allowing for clustered development on less sensitive lands, and by waiving minimum lot and yard sizes, this Article encourages conservation and protection of sensitive lands. The Article includes a number of flexible standards providing that the design allows for:

  - Improved site design,
  - Protection of natural features within the development,
  - Maintenance of harmony with neighboring land uses,
  - Promotion of the objectives and purpose of the master plan with respect to protection of natural resources, and
  - Promotion of the intent and purpose of the Article.

- **Article 13, Section 13.4 (Utilities including wastewater):** This section requires that developments include provisions for proper wastewater collection and transmission, including provisions for septic tanks. The section requires submission of a utility plan illustrating plans and specifications for proposed water supply, sewage disposal, refuse collection, fire protection, and other utilities.
- **Article 13, Section 13.5 (Sewage Treatment Plants):** This section requires that on-site sewage treatment plants utilize the best available technology and provide, at a minimum, tertiary treatment.
- **Article 13, Section 13.11 (Stormwater Management):** Section 13.11 requires that a Stormwater Management Plan be developed for all major projects. The plan must be prepared by an engineer licensed in the State of Alabama and must be submitted in conjunction with an application for a land use certificate. The section also ensures that reasonable provisions for the proper handling of surface drainage are incorporated into the development's design.
- **Article 13, Section 13.12 (Erosion Control):** The purpose of this section is to further the maintenance of safe conditions by preventing and controlling water pollution, erosion, and undesirable sediment transfer. It also seeks to protect natural areas such as spawning grounds, fish and wildlife habitats, and other natural systems. The section outlines specific design principles, design criteria, and erosion and sediment control requirements. The section requires development, submittal, and implementation of an erosion control plan for both small (less than 1 acre) and large projects (greater than 1 acre).
- **Article 17 (Landscaping and Buffers):** This section outlines requirements for on-site landscaping and buffers between adjacent properties. The section outlines provisions for tree protection and provides recommended native species for development of new on-site landscaped and buffered areas.

10.2.3.2 City of Foley Code of Ordinances

The City of Foley maintains a comprehensive code of ordinances, many of which are directly related to land development and include provisions for protection of water quality and natural resources. This section will outline specific chapters and articles of the City of Foley code of ordinances that are relevant to this WMP.

10.2.3.2.1 Chapter 4: Buildings, Construction, and Related Activities

Chapter 4 of the Foley Code of Ordinances outlines provisions, policies, and procedures for development within the City. Chapter 4 outlines specific permitting processes and includes regulations relative to flood prone areas, design and construction standards, lot clearing, and shoreline construction activities.

Article II seeks to protect human life and health, to minimize damage to public facilities and infrastructure from flood events, to maintain a stable tax base by providing for sound use and development in flood prone areas, to minimize expenditure of public funds for costly flood control projects, to minimize the need for rescue and relief efforts during flood events, to minimize prolonged business interruptions; and to ensure that potential home buyers are notified that a given property is in a flood area.

The Article requires issuance of a permit from the City for development in FEMA designated SFHAs and includes a series of general and specific standards designed to reduce or minimize risk of development in SFHAs. Examples of standards include a requirement that structures within a SFHA be elevated so the lowest finished floor is one foot above the base flood elevation (BFE). The article also includes variance procedures and other processes for relief of the general and specific standards. However, relief from these standards requires stringent engineering controls and illustration of design elements that will minimize the impacts of flooding.

Article VIII references USACE, ADCNR, and ADEM regulations specific to development and improvements on State-submerged lands. The article includes provisions for application for and issuance of permits for development and repair of riparian structures, including piers, docks, boathouses, retaining walls, and bulkheads. Issuance of permits for these activities requires an inspection by the City's Environmental Department and establishes standards for shoreline protection associated with the aforementioned development activities.

10.2.3.2.2 Chapter 6.5: Environment

Chapter 6.5 contains four key articles, including Article III: Erosion and Sediment Control, Article IV: Heritage Tree Preservation, Article V: Illicit Discharges Ordinance, and Article VI: Environmental Permits Related to Land Disturbance.

Article III outlines provisions for permits related to development activities that have potential to contribute to erosion and sediment transfer. The Article requires a permit for land disturbing activities that uncover more than five hundred square feet of ground and requires submission of an erosion and sediment control plan outlining specific BMPs designed to minimize erosion and sediment transfer. The Article also outlines specific design requirements related to clearing and grading, erosion control, sediment controls, protection of waterways and water courses, and construction site access.

Article IV identifies specific species of heritage trees to be protected and preserved during land disturbance and other construction activities. The Article includes provisions for permitting of removal of heritage trees, inclusion of heritage trees in submitted site plans, and provision for replacement of removed heritage trees.

Article V is the City's Illicit Discharge Ordinance. The ordinance applies to all lands within the corporate limits of the City and is intended to regulate the contribution of pollutants to the MS4, to prohibit illicit connections and discharges to the MS4, and to establish the City's legal authority to conduct inspections and monitor as necessary to enforce the provisions of the ordinance. Article V includes specific discharge prohibitions and suspension of MS4 access. Additionally, it includes provisions for discharge monitoring, protection of waterways and watercourses, required notification of spills and discharges, and enforcement.

Article VI outlines processes and procedures required by the City to obtain a permit for land disturbance activities. The stated purpose of the Article is to provide minimum standards to ensure effective stormwater management, drainage management, tree protection and restoration, and construction of BMPs for land disturbance activities affecting more than five hundred square feet of land. The Article outlines specific BMP plan requirements, including a landscape plan and tree survey of proposed development sites.

10.2.3.2.3 Appendix A: Zoning

The purpose of the City's Zoning Ordinance is to promote the public health, safety, morals, and general welfare of the citizens by providing for orderly development and growth of the City; by avoiding congestion of public streets; by conserving life, property, and natural resources; and allowing for and encouraging the most advantageous use of land and resources for the public good. The ordinance is organized into 25 articles, the most relevant of which are discussed here.

Article X, Section 10.2: Landscaping, and Buffer Requirements requires buffering where necessary to provide separation between abutting lots, particularly between abutting lots with differing or conflicting uses. The ordinance encourages the use of vegetative buffers, which provides benefits for stormwater management and control of non-point source pollutants.

Article XIX, Section 19.2: Open Space and Preservation Districts allows for establishment of open space and preservation districts that may include public parks, playgrounds, hiking and nature trails, wildlife sanctuaries, nature preserves, canoe, kayak, and boat launches, and other similar uses.

10.2.3.2.4 Appendix B: Subdivision Regulations

The City of Foley Subdivision Regulations establish policies and procedures for development of new or modifications to existing subdivisions. The regulations stipulate requirements for drainage, sewage disposal, retention ponds, and land stabilization. The ordinance also addresses development near or adjacent to floodways and requires specific setbacks for developments near floodways. Additionally, the regulations address general flooding and flood hazard areas, wetlands, and the need for permitting of developments in these areas in similar fashion to the City's Flood Damage Prevention Ordinance.

10.2.3.2.5 Manual for Design and Construction Standards

The City of Foley's *Manual for Design and Construction Standards*, enacted as Ordinance 17-2029-ORD, provides standards for a variety of construction related activities. Most notably for the purposes of this Chapter, it provides specific standards for acquisition and maintenance of conservation green space and conservation easements. The ordinance also provides standards for and requires the use of LID and GI practices in development and redevelopment. Section 4.6 of the *Manual for Design and Construction Standards* calls for the design and integration of LID techniques to promote the health, safety, and general welfare of the community. The ordinance also requires close collaboration between the design engineer and the City's Engineering and Environmental Departments to ensure that LID practices are designed on a site-specific basis and that specific LID techniques and practices provide the optimum solutions for the site in question.

Specific design requirements include a provision that stormwater management practices retain the first 1.25" of stormwater and allows this standard to be achieved through infiltration, evapotranspiration, and the use of retention or detention BMPs. The ordinance also requires the engineering design to utilize hydraulic and hydrologic analysis to demonstrate that any post-development increases in discharge from a two-year storm be infiltrated on site. Additionally, any redevelopment activities that modify over 30% of the site valuation achieve the capture and retaining of the first 1.25" of runoff through LID and GI practices.

10.2.3.3 Town of Elberta Code of Ordinances

In similar fashion to the City of Foley, the Town of Elberta maintains and enforces a Code of Ordinances generally designed to regulate a variety of activities in the Town, including land development, building construction, flood prone areas, zoning, and subdivision development.

10.2.3.3.1 Buildings and Building Codes

Elberta has adopted the County's building codes by reference. As such, the provisions for Elberta's building codes are identical to Baldwin County's.

10.2.3.3.2 Chapter 4, Article II: Flood Damage Prevention

The Town of Elberta's Flood Damage Prevention Ordinance is very similar to Foley's and is intended to protect human life and health, to minimize damage to public facilities and infrastructure from flood events, to maintain a stable tax base by providing for sound use and development in flood prone areas, to minimize expenditure of public funds for costly flood control projects, to minimize the need for rescue and relief efforts during flood events, to minimize prolonged business interruptions, and to ensure that potential home buyers are notified that a given property is in a flood area.

The Article requires issuance of a permit from the Town for development in FEMA-designated SFHAs and includes a series of general and specific standards designed to reduce or minimize risk of development in SFHAs. Examples of standards include a requirement that structures within a SFHA be elevated so the lowest finished floor is one foot above the BFE. The article also includes variance procedures and other processes for relief of the general and specific standards. However, relief from these standards requires stringent engineering controls and illustration of design elements that will minimize the impacts of flooding.

10.2.3.3.3 Appendix A: Subdivision Regulations

The Town of Elberta's Subdivision Regulations provide for the orderly development of new subdivisions and modification of existing subdivisions. The ordinance addresses the orderly placement of streets, lots, and other elements of subdivisions and addresses drainage and other elements critical to this Watershed Management Plan.

Article 3 – Definitions: This Article references floodplains, floodways, and other FEMA designated SFHAs. Users should cross-reference the Town's Flood Damage Prevention Ordinance for specific requirements for developments encroaching in flood prone areas.

Article 5, Section 5.7 – Drainage: This Article provides general policies and design standards for drainage associated with subdivisions developed within the Town of Elberta. As with other design elements, the Town requires submission of a subdivision plat that illustrates planned drainage improvements to include surface and subsurface drainage systems and dedication of common areas to be used for stormwater management and drainage such as retention basins. The ordinance requires that drainage systems for all subdivisions be designed to accommodate flows from at least a 25-year frequency design storm.

Article 5, Section 5.8 – Erosion and Sedimentation: This Article imposes requirements on persons engaged in land-disturbing activities requiring planning and implementation of effective sediment controls for subdivision development sites. The ordinance requires that an erosion and sediment control plan be a part of the construction plans to be filed with the Town prior to beginning any construction activities. The ordinance also states that when conflicts exist between federal, state, or local laws, the more restrictive provision applies. Section 5.8 outlines basic control objectives, including identification of critical areas, limitations on exposed areas at any one time, limitations on the time of exposure, minimization of stormwater runoff and sediment transfer during construction, and permanent protection of downstream stream banks and channels. The ordinance applies to all subdivision developments comprising more than one acre.

Article 5, Section 5.9 – Stormwater Detention: This Article indicates that subdivision developments producing an increase in the amount of stormwater runoff be required to construct stormwater detention ponds or other approved types of detention devices or structures. The ordinance also provides detailed design criteria for detention structures. Also significant is the provision that responsibilities for maintenance of such structures and facilities remain with the developer throughout the construction process and until the Town accepts the subdivision improvements in their entirety.

Article 7 – Required Improvements: Article 7 outlines a number of improvements required by subdivision developers, including streets, curbs and gutters; sidewalks; water and wastewater systems; utilities; and drainage common areas. Specifically, the requirements for drainage common areas address subdivisions that are traversed by a watercourse, drainageway, or stream and requires the establishment of drainage rights-of-way conforming to the lines of the watercourse at a minimum of 15 feet in width to allow for public maintenance when necessary.

10.2.3.3.4 Appendix B: Zoning Ordinance

As with other zoning ordinances, the Town of Elberta's is intended to promote public health, safety, and welfare by ensuring proper use of land within the Town and that incompatible uses are minimized.

Article VIII, Sections 7.6 and 7.7: This Article's sections address surface drainage and erosion and sediment control and are generally consistent with provisions included in the Town's Subdivision Ordinance. More specific provisions are outlined in later sections of the Ordinance.

Article VIII, Section 8.13 – Flood Hazard Areas: This Article references the FEMA Flood Insurance Rate Maps for Baldwin County.

Article XI – Erosion and Sediment Control: This Article goes beyond the Town's Subdivision Ordinance by outlining provisions for erosion and sediment control for all developments with land disturbance activities greater than one acre. Article XI outlines basic control objectives, standards, and provisions for submission of erosion and sediment control plans, as well as processes for review of submitted plans.

10.3 Regulatory Overlap

Regulatory overlap is evident in the delegation of regulatory implementation authority from the federal to the state level, and in some cases to local (municipal and county) authorities. A good example of regulatory overlap is the NPDES MS4 Program. The regulations begin on the federal level, with states receiving permitting authority from USEPA and continues to local authorities through permits issued from ADEM. Regulatory overlap does not appear to be a significant issue with respect to the development and implementation of the Wolf Bay WMP. However, it does illustrate the need for consistent coordination and communication between USEPA, ADEM, and local authorities to ensure that regulations are applied consistently across varying jurisdictional levels. Regulations discussed in this chapter are often referred to as "minimum standards," meaning that states and local authorities have the authority to establish more stringent standards to ensure that priorities at these governmental levels are clearly addressed through the regulations.

10.4 Regulatory Gaps

One regulatory gap that appears to be consistent among all three local authorities is the absence of a strong post-construction provision relative to stormwater runoff, erosion, and sediment controls. While all three entities address standards for retention/detention structures in subdivisions, we did not identify regulations that address the same for all types of development activities. This is due in part to the absence of a strong post-construction standard on both the federal and State levels. Therefore, it becomes incumbent upon local entities to fill regulatory gaps to protect water quality and other natural resources from direct and indirect impacts associated with development and redevelopment.

10.5 Recommendations and Opportunities

Our review of the local regulatory environment indicates that the level of regulation for each of the three local authorities appears to be appropriate, given the scale and level of development currently being experienced. From our research and review of the regulatory environment in the Wolf Bay Watershed, we observed what appears to be an appropriate level of regulation, particularly with respect to local authorities.

However, given the County's rapid rate of growth, all local authorities should comprehensively review regulations specific to natural resource protection to ensure that future developments are implemented in ways that protect the Watershed's bountiful natural resources. Outside of the City of Foley, we see opportunities for regulatory provisions that encourage and incentivize the use of LID and GI practices. These incentives can be incorporated into local zoning and subdivision ordinances, as well as local building codes. Opportunities to reduce impervious cover in new developments can also be included in these ordinances through parking lot ratios, requirements for buffers and percentages of green space, and landscaped areas in new developments.

Baldwin County and the City of Foley both participate in the FEMA Community Rating System (CRS). Baldwin County is at a Class 7, Foley is at a Class 8, and Elberta is not currently enrolled in CRS. We recommend that Baldwin County and Foley seek to improve their current CRS Class and that Elberta strongly consider participating in CRS. One activity that can greatly improve Baldwin County's and Foley's ratings is development and implementation of a FEMA compliant Watershed Master Plan. A Watershed Master Plan differs from a Watershed Management Plan in that it focuses on water quantity, establishes baseline flooding conditions, and projects changes in flooding conditions based on potential future developments.

All local authorities should consider implementation of environmental courts into the county or municipal court systems. Environmental courts separate specific environmental violations from traditional municipal courts and can address violations related to development codes, litter, property maintenance, and enforcement of local stormwater (MS4) regulations. Examples of successful environmental courts in Alabama include Mobile County, the City of Birmingham, and the City of Montgomery.

It is also recommended that Baldwin County and the Town of Elberta adopt an ordinance similar to the City of Foley's *Manual for Design and Construction Standards*. Adoption of a similar ordinance would allow the County and Elberta to proactively address stormwater, drainage, and water quality issues as growth and increases in impervious cover continue to affect water quality in those two jurisdictions.

Baldwin County, the City of Foley, and the Town of Elberta would a benefit from communicating on a regular basis in an effort to coordinate actions and regulatory changes related to stormwater management on a watershed scale across municipal and political boundaries. Monthly meetings of the Plan Lower Alabama Now (PLAN) group (of which each is an active member) could provide opportunities for updates and coordination. Each should consider adoption of a consistent post-construction stormwater ordinance to ensure that regulations affecting development activities continue to have a positive impact on water quality once construction on a site is complete. It is our recommendation that the model originally developed in 2013 by Hydro Engineering Solutions serve as a guide when updating regulations and approving new development throughout the Watershed. This model was reevaluated in 2020 using data from a September 2018 rainfall event which produced 5 inches of rain within a ten-hour period. It was determined from this event that the previously calibrated Wolf Bay model from 2013 provided similar results for timing and peak discharge (Hydro Engineering Solutions, 2020).

Additionally, several communities in Alabama have "stand-alone" post-construction ordinances including:

- Jacksonville: https://www.jacksonville-al.org/wp-content/uploads/2019/05/POST_CONSTRUCTION_STORMWATER_MANAGEMENT_ORDINANCE_No_O_592_17.pdf;
- Alabaster: https://www.cityofalabaster.com/DocumentCenter/View/2685/Ordinance-181001-075-Stormwater-Management-Post-Construction-PDF;
- Helena: http://www.cityofhelena.org/Sites/Helena/Documents/City%20Ordinances/Ord%20859-18%20Stormwater.pdf.

When the State of Alabama, through ADEM, drafts its next State MS4 permit, the State should consider a heightened emphasis on post-construction stormwater regulations and standards to ensure that all regulated MS4s within the State are basing their ordinances on a consistent set of standards.

Chapter 11 Financing Alternatives

The funding of projects and activities on a watershed scale can be a complex process. Watershed boundaries do not follow municipal jurisdictions; therefore, successful implementation of the management measures described in Chapter 8 depends on the long-term commitment of significant financial resources and cooperation between local, county and state governments, non-profits, utilities, as well as the surrounding communities.

A variety of federal, state, and local funding sources, along with public-private partnerships, should be considered to fund implementation of management measures. Leveraging multiple funding opportunities simultaneously will maximize the implementation potential of the WMP. Ultimately, success will be linked to the degree of coordination and level of financial resources available.

Some of the financial structures described in the following sections will be applicable across the entire Watershed, while others will only be useful within certain areas and apply to particular management measures. Many of the financing alternatives will require public-private partnerships between landowners and sponsors, such as local governments, utilities, or civic/non-profit organizations.

11.1 Funding and Regional Planning

Multi-organizational partnerships that incorporate stakeholders across all sectors in the Watershed are effective because of their ability to strengthen local capacity and eliminate duplicative efforts. Because a structure is needed to guide multi-stakeholder initiatives, it is imperative that a WMTF be created to see common goals across multiple entities come to fruition. A cooperative approach allows entities such as governments, non-profits, utilities, and the public to come together to collaborate on project funding, as well as implementation. Aligning efforts and increasing program efficiency requires: 1) a common agenda, 2) shared measurement system, 3) mutually reinforcing activities, 4) continuous communication, and 5) backbone support organizations. **Table 11.1** presents entities that should be considered in the financial planning and implementation process for projects in the Watershed.

Table 11.1 Organizations to be Included in Financial Planning and Implementation

Alabama Coastal Foundation	Alabama Department of Conservation and Natural Resources	Alabama Department of Environmental Management
Alabama Department of Public Health	Alabama Department of Transportation	Alabama Forestry Commission
Alabama Forest Resources Center	Alabama Water Watch	Alabama Wildlife Federation
Auburn University Marine Extension and Research Center	Baldwin County-Alabama Cooperative Extension	Baldwin County Commission
Baldwin County Health Department	Baldwin County Public Schools	Baldwin County Soil and Water Conservation District
City of Foley	Dauphin Island Sea Lab	Geological Survey of Alabama
Gulf Coast Ecosystem Restoration Council	Mobile Bay National Estuary Program	National Fish and Wildlife Foundation
National Oceanic and Atmospheric Administration	National Science Foundation	Riviera Utilities
Southeastern South Aquatic Resources Partnership	The Nature Conservancy	Town of Elberta
University of South Alabama	USDA, Forest Service	USDA, Natural Resource Conservation Service
US Army Corps of Engineers	US Environmental Protection Agency	US Fish and Wildlife Service
US Geological Survey	US National Park Service	Wolf Bay Watershed Watch

11.2 Financial Strategy

11.2.1 Federal Funding Programs

The United States government provides numerous sources of funding, usually through grants, loans and revenue sharing, that may be used by municipalities and non-profits to conduct studies and construct projects related to watershed protection, stream restoration, and storm water management. Attempting to combine multiple federal funding sources for one single project can be problematic and is often not permissible.

11.2.1.1 U.S. Environmental Protection Agency

The USEPA administers grant money to state and local governments to support collaborative partnerships to protect and restore the nation's water resources. Financial support for non-point source and pollution control measures, including Section 319 (non-point source management) and Section 106 (water pollution control) are provided by the USEPA. In addition, the USEPA Gulf of Mexico Program helps fund environmental education, habitat restoration, coastal resilience and water quality improvements. More information on these grants and other USEPA grant opportunities is discussed further in **Appendix E**.

11.2.1.2 National Oceanic and Atmospheric Administration

NOAA is another federal agency that provides financial resources to conserve and manage coastal and marine ecosystems. The Marine Debris Removal Program grant and the Marine Debris Prevention, Education and Outreach grant are two provided by NOAA that can support litter reduction efforts. The Community-Based Restoration Program leverages local resources and promotes community involvement in habitat restoration activities. See **Appendix E** for more information regarding NOAA-specific funding resources.

11.2.1.3 U.S. Department of Agriculture, Natural Resources Conservation Service

Funding opportunities for all rural producers and riparian landowners in the Watershed are provided by the U.S. Department of Agriculture, Natural Resources Conservation Service in Bay Minette. These programs include the Baldwin County Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP), Emergency Watershed Protection Program (EWP), Regional Conservation Partnership Program (RCPP), Watershed and Flood Prevention Operations Program (WFPO) and Agricultural Conservation Easement Program (ACEP). These programs provide applicants with financial assistance to address erosion control, soil quality, grazing lands, forestry/wildlife heath, irrigation water management, and invasive species control. The Baldwin County District Conservationist works with agricultural producers to determine specific qualification and levels of financial assistance available within each program. **Appendix E** presents additional information about EQIP, CSP, EWP, WFPO, and ACEP.

11.2.1.4 Alabama Gulf Coast Recovery Council

The Alabama Gulf Coast Recovery Council was created with the passage of the Resources and Ecosystems Sustainability, Tourists Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act of 2012 to administer funds received from civil penalties from the 2010 *Deepwater Horizon* oil spill. The Council can designate RESTORE funds to WMP projects that restore and protect natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, and coastal wetlands of the Gulf Coast region. More information on RESTORE funds can be found in **Appendix E**.

11.2.2 State Funding Programs

The following section presents funding sources provided by the Alabama Department of Conservation and Natural Resources and the Alabama Department of Environmental Management. The funding provided by these State entities is typically used to implement water quality, coastal resiliency, emergency preparedness, and conservation-based projects.

11.2.2.1 Alabama Coastal Area Management Program

The Alabama Coastal Area Management Program (ACAMP) was approved by NOAA in 1979 as a part of the National Coastal Zone Management Program. The ACAMP provides annual funding opportunities related to coastal planning. The program is intended to assist local government planning agencies in providing education and addressing coastal habitat protection, wetland protection, and coastal nonpoint source pollution control measures.

11.2.2.2 Clean Water State Revolving Fund

The Clean Water State Revolving Fund (CWSRF) is a low interest program intended to finance public water and wastewater infrastructure improvements and stormwater/non-point source projects. For example, a municipality might consider financing streambank restoration and buffer projects by securing a CWSRF loan. Financial resources provided by the State of Alabama are also covered in **Appendix E**.

11.2.3 Private Funding Programs

The National Fish and Wildlife Foundation, created by Congress in 1984, is a nonprofit organization that works with both public and private sectors to protect and restore the nation's fish, wildlife, plants, and habitats. Several WMP implementation projects have already been funded by NFWF throughout Baldwin County through the Gulf Environmental Benefit Fund with monies derived from criminal penalties related to the *Deepwater Horizon* oil spill. The Five Star Urban Waters Program is intended to fund shoreline erosion, streambank stabilization, and stormwater runoff projects. The Gulf Coast Conservation Grants

Program supports conservation projects that preserve threatened coastal ecosystems. These NFWF grants provide invaluable opportunities to craft cross-sector conservation partnerships in the Watershed.

Other notable grant resources include the Healthy Watersheds Consortium Program and the Gulf of Mexico Alliance's Gulf Star Program. **Appendix E** presents a full list of private, and private/public partnership funding resources.

11.2.4 Funding of Local Stormwater Programs

In 2010, the Baldwin County Commission proposed a stormwater referendum to address water quality and drainage issues. Despite the Commission's effort to manage stormwater at the watershed scale, residents strongly opposed the new plan. The referendum was unpopular among voters and became referred to locally as the "rain tax" plan. Despite local criticism, watershed-scale stormwater management is a growing trend throughout the United States. Stormwater drain fees, property taxes, general funds, and special assessment districts are just a few examples of regional funding mechanisms that have successfully financed stormwater initiatives in other areas of the country. These options should be considered as viable alternatives for financing a regional stormwater program in south Baldwin County.

11.2.5 Listing of Previously Discussed Resources

Table 11.2 lists financial resources discussed above, as well as additional resources that could support implementing management measures recommended in the WMP. Four different funding categories are presented in the table: (1) financial assistance, (2) technical assistance, (3) water quality monitoring and (4) information and education. Additional information on funding sources and website links are located in **Appendix E**.

Table 11.2 Listing of Potential Funding Sources and Descriptions

Funding Source	Description	Type	Actions Funded
Alabama Coastal Area Management Program	Annual Grant Program	State	Financial Assistance, Water Quality Monitoring
Alabama Department of Environmental Management	Section 319 Grant Funds	State	Financial Assistance, Water Quality Monitoring
	Clean Water SRF		
Department of the Interior	Land and Water Conservation Fund	Federal	Financial Assistance
Alabama Gulf Coast	RESTORE Act	Federal	Financial

Funding Source	Description	Type	Actions Funded
Recovery Council			Assistance
National Oceanic and Atmospheric Administration	Community-based Marine Debris Removal	Federal	Financial Assistance
	NOAA Marine Debris Prevention, Education and Outreach Partnership Grant	Federal	Financial Assistance, Information and Education
	NOAA Gulf of Mexico Bay-Watershed Education and Training (B-WET) Program	Federal	Financial Assistance, Information and Education
	RESTORE Act Science Program	Federal	Financial Assistance
	FY2020 Broad Agency Announcement	Federal	Financial Assistance, Information and Education
	Environmental Literacy Grants	Federal	Financial Assistance, Information and Education
	Community-based Restoration Program	Federal	Financial Assistance, Technical Assistance
National Science Foundation	Environmental Engineering and Sustainability Program	Federal	Technical Assistance, Water Quality Monitoring
USDA, Natural Resource Conservation Service	Environmental Quality Incentives Program	Federal	Financial Assistance, Technical Assistance, Water Quality Monitoring
	Conservation Stewardship Program	Federal	Financial Assistance, Technical Assistance
	Emergency Watershed Protection Program	Federal	Financial Assistance, Technical Assistance
	Watershed and Flood Prevention Operations Program	Federal	Financial Assistance, Technical Assistance
	Agricultural Conservation Easement Program	Federal	Financial Assistance, Technical Assistance
USEPA	106 Grant Funds (Water Pollution Control)	Federal	Financial Assistance, Water Quality Monitoring
	National Wetland Program Development Grants	Federal	Financial Assistance, Technical Assistance, Water Quality Monitoring

Funding Source	Description	Type	Actions Funded
	Source Water Protection Grants	Federal	Information and Education, Financial Assistance, Water Quality Monitoring
	Urban Water Small Grants	Federal	Technical Assistance, Water Quality Monitoring
	Gulf of Mexico (and the Gulf of Mexico Partnership Gulf Guardian Awards)	Federal	Financial Assistance, Water Quality Monitoring
USFWS	Partners for Fish and Wildlife	Federal	Financial Assistance, Technical Assistance
	Coastal Program	Federal	Financial Assistance, Technical Assistance
	National Coastal Wetlands Grant	Federal	Financial Assistance
	Boating infrastructure Grant Program (Tier 2-National)	Federal	Financial Assistance
	Boating infrastructure Grant Program (Tier 1-State)	Federal	Financial Assistance
	Natural Resource Damage Assessment, Restoration and Implementation	Federal	Financial Assistance
	State Wildlife Refuge Partnership	Federal	Financial Assistance
	Urban Wildlife Refuge Partnership	Federal	Financial Assistance, Information and Education
	National Fish Habitat Action Plan	Federal	Financial Assistance, Technical Assistance
Conservation Alabama Foundation	Watershed Management Plan Outreach Grant Program	Private-Public Partnership	Information and Education
US Endowment for Forestry and Communities, Inc.	Healthy Watersheds Consortium Grant Program	Private-Public Partnership	Financial Assistance, Technical Assistance, Water Quality Monitoring
Gulf of Mexico Alliance	Gulf Star Grants Program (1-Coastal Resiliency, 2-Data and Monitoring, 3-Education and Engagement, 4-Wildlife and Fisheries)	Private-Public Partnership	Information and Education, Financial Assistance, Water Quality Monitoring

Funding Source	Description	Type	Actions Funded
Cornell Douglas Foundation Grants	Cornel Douglas Foundation Grants	Private	Financial Assistance, Information and Education
The Home Depot	Community Impact Grants Program	Private	Financial Assistance
The Kresge Foundation	Environmental: (1-Climate Resilience in Coastal Cities and Regions, 2-Sustainable Water Resource Management in Changing Climate)	Private	Financial Assistance
Gulf of Mexico Research Initiative	RFP - IV	Private	Financial Assistance
Gulf Research Program	Capacity Building Grants	Private	Information and Education
Legacy Partners in Environmental Education	Environmental Education Grants	Private	Financial Assistance, Information and Education
National Education Association Foundation	Captain Planet Foundation Grants for the Environment	Private	Financial Assistance, Information and Education
National Environmental Education Foundation	Everyday Capacity Building Grants	Private	Financial Assistance, Information and Education
NFWF	Conservation Partners Program	Private	Technical Assistance, Information and Education
	Gulf Environmental Benefit Fund	Private	Financial Assistance
	National Wildlife Refuge Friends Program (project specific grants)	Private	Financial Assistance, Information and Education
	Five Star & Urban Waters Restoration Program	Private	Financial Assistance, Information and Education, Water Quality Monitoring
	Gulf Coast Conservation Grant Program	Private	Financial Assistance

Chapter 12 Monitoring

A watershed monitoring program is an integral component of a WMP. It not only evaluates the water quality (physical, chemical, and biological) of the waterbodies within the Watershed but also assesses specific watershed characteristics (i.e., riparian corridors and land use/land cover) that may be related to water quality observations. It also provides a quantitative method by which to evaluate successes and failures of implemented management measures. The Wolf Bay Watershed monitoring program should utilize the guidance set forth in the *Mobile Bay Subwatershed Restoration Monitoring Framework* prepared by the Science Advisory Committee: Monitoring Working Group in 2015.

12.1 Monitoring Parameters

Based on literature reviews, field reconnaissance, Steering Committee input, and public input gathered during the development of this WMP, the following water quality parameters (physical and chemical) and watershed characteristics are recommended to be monitored.

12.1.1 Standard Field Parameters

Standard field parameters are physical characteristics (abiotic factors) of water which should be measured each time sampling is conducted. These parameters include water temperature, specific conductivity, dissolved oxygen, alkalinity, hardness, and pH. Standard field parameters can serve as indicators of watershed health, while providing a context for interpreting other measured or observed field data. These parameters are correlated with one another, as well as biological factors within the system, and have important influences on the overall watershed.

12.1.2 Turbidity

Turbidity is a physical characteristic that measures water clarity based on the amount of sediment or other materials suspended in the water. Elevated turbidity levels can degrade watershed conditions by disrupting primary production (plant and algal growth) and adversely impacting the health of fish and other aquatic organisms. Turbidity typically increases following rain events because loose sediments are transported to waterbodies by storm runoff. Therefore, targeted measurements of turbidity can be a good indicator of non-point sources and may help to identify areas where improvements or additional management measures (such as stream restoration or installation of buffer strips or retention basins) are needed.

12.1.3 Nutrients

Unlike standard field parameters and turbidity, nutrient concentrations cannot be easily measured in the field. Chemical analysis of water samples is performed at facilities with appropriate laboratory instrumentation to determine the presence and concentration of specific nutrients in a water sample. When elevated nutrient concentrations are discovered at specific sampling locations, evaluation of adjacent land use and land cover can be conducted to determine potential sources, such as agriculture, lawns, or septic sewer outfalls. Existing water quality data indicates that elevated nitrogen and phosphorus concentrations are both a concern in some locations in the Watershed.

12.1.4 Pathogens

Sandy Creek and Miflin Creek were recently placed on the draft 2020 Alabama 303(d) list for pathogens (Enterococcus). High pathogen concentrations pose a public health risk and, for this reason, can result in restricted uses of waterways (such as swimming or fishing). Enterococcus is a strain of bacteria that originates in the guts of humans and other animals and is typically used as an indicator for pathogens in water. Pathogen concentrations peak immediately after rainfall events, because they are usually carried to waterbodies via stormwater runoff. Pathogen monitoring data can help identify certain types of sources, such as agriculture or faulty septic systems, and may guide decision makers in determining where improvements or additional management measures (such as buffer strips) are needed. Pathogen concentrations are measured by collecting water samples in the field for incubation in a laboratory to quantify bacterial growth. Pathogen concentrations cannot be easily measured in the field.

12.1.5 Erosion and Sedimentation

Erosion and sedimentation within watershed streams can be measured by collection of water samples which can then be filtered. Remaining sediments are dried and weighed for analysis and comparison. Grab samples during and immediately after storm events are used to determine if streams are impaired by sediment issues. The amount of soil loss or accretion can also be measured by the use of stationary erosion stakes which illustrate the amount of soil lost or gained around the stake over a period of time. Areas of measurable erosion and sedimentation were identified through the WMP process in Wolf Creek between the Foley Beach Express and Swift Church Road and at Doc McDuffie Road, in two unnamed tributaries of Sandy Creek north of Highway 98, and in Hammock Creek north of County Road 20. It is recommended that total suspended solids (TSS) be monitored in addition to turbidity in the vicinity of these identified areas.

12.1.6 Invasive Species

Although not abundantly present, invasive species have been identified as an issue in the Watershed. While quantitative assessments of invasive species throughout the Watershed may not be feasible, sampling teams should make visual assessments of the presence of invasive species during routine water quality sampling activities. These observations should be documented in field notes and photographed when possible. Sampling teams should be trained in the identification of the four major invasive plants (cogongrass, Chinese tallow, Chinese privet, and alligator weed) that are known to occur, as well as other species which may occur.

12.1.7 Litter Monitoring

While litter can be difficult to quantify, sampling teams should make visual observations during routine water quality sampling to generally assess litter conditions at various points throughout the Watershed. These observations should be documented in field notes and photographed when possible. Litter monitoring may also help identify areas within the Watershed that should be targeted for future action.

Another option for documenting trash amounts and locations throughout the Watershed is through the Escaped Trash Assessment Protocol (ETAP). ETAP was created by the Trash Free Waters Program of the EPA to provide a uniform method to collect data on trash types, amounts, and what areas pose the greatest risk to humans and wildlife. Groups such as the WBWW can upload data to a publicly available database and a summary report will be generated. This data helps to identify trends over time as well as mitigation and source reduction measures. Groups can add features to the methodology to address the types of data they want to produce, such as certain item types or volume of trash collected. More information on the program and program protocols can be found at https://dpa730eaqha29.cloudfront.net/myedmondsnews/wp-content/uploads/2018/07/Reference-Manual_ETAP-June-2018.pdf

12.2 Sample Collection Locations

The Wolf Bay Watershed is unique when compared to adjacent watersheds in that it currently has an established water quality monitoring program. The program employs both municipal and citizen volunteer sampling locations. According to the Alabama Water Watch (AWW) website, there are currently three sampling locations actively being monitored by the city of Foley and eight sites being monitored by members of the Wolf Bay Watershed Watch (**Table 12.1)**. Based on data gathered through literature reviews, field reconnaissance, and collaboration with members of the Steering Committee, six additional sites have been identified for sampling. **Table 12.2** provides information for each of the newly identified monitoring sites. **Figure 12.1** illustrates the sampling locations.

Table 12.1 Sample Collection Locations

AWW Site Code	Current Sampling Group	Latitude	Longitude	Current Sampling Parameters	Recommended Additional Sampling Parameters
4012016	City of Foley	30.409623	-87.676263	Standard Parameters and Turbidity	
4012027	City of Foley	30.388458	-87.652879	Standard Parameters, Turbidity and Nutrients	Total Suspended Solids
4012047	City of Foley	30.344697	-87.623978	Standard Parameters, Turbidity and Bacteria	
4012022	Wolf Bay Watershed Watch	30.36321	-87.567792	Standard Parameters, Turbidity, and Nutrients	Bacteria
4012062	Wolf Bay Watershed Watch	30.363962	-87.602255	Standard Parameters, Turbidity, and Nutrients	Bacteria
4012061	Wolf Bay Watershed Watch	30.363933	-87.620412	Standard Parameters, Turbidity, and Bacteria	
4012020	Wolf Bay Watershed Watch	30.355732	-87.610053	Standard Parameters, Turbidity, and Bacteria	

AWW Site Code	Current Sampling Group	Latitude	Longitude	Current Sampling Parameters	Recommended Additional Sampling Parameters
4012028	Wolf Bay Watershed Watch	30.406977	-87.630185	Standard Parameters, Turbidity, and Bacteria	Nutrients
4012063	Wolf Bay Watershed Watch	30.355784	-87.627068	Standard Parameters and Turbidity	Nutrients
4012060	Wolf Bay Watershed Watch	30.3711	-87.619028	Standard Parameters, Turbidity, and Bacteria	
4012042	Wolf Bay Watershed Watch	30.325373	-87.587554	Standard Parameters, Turbidity, and Bacteria	

Table 12.2 Recommended Additional Sampling Locations

Recommended Sites	Latitude	Longitude	Recommended Sampling Parameters
Unnamed Tributary to Sandy Creek	30.406836	-87.626341	Standard Parameters, Turbidity, and Total Suspended Solids
Unnamed Tributary to Sandy Creek	30.406583	-87.624872	Standard Parameters, Turbidity, and Total Suspended Solids
County Road 83 at Elberta Creek	30.423199	-87.598111	Standard Parameters, Turbidity, Bacteria, and Nutrients
Highway 98 at Miflin Creek	30.414399	-87.591348	Standard Parameters, Turbidity, Bacteria, and Nutrients
County Road 95 at Tributary to Hammock Creek	30.368244	-87.548332	Standard Parameters, Turbidity, Bacteria, and Nutrients
Wolf Creek at Swift Church Road	30.37348	-87.63258	Standard Parameters, Turbidity, and Total Suspended Solids

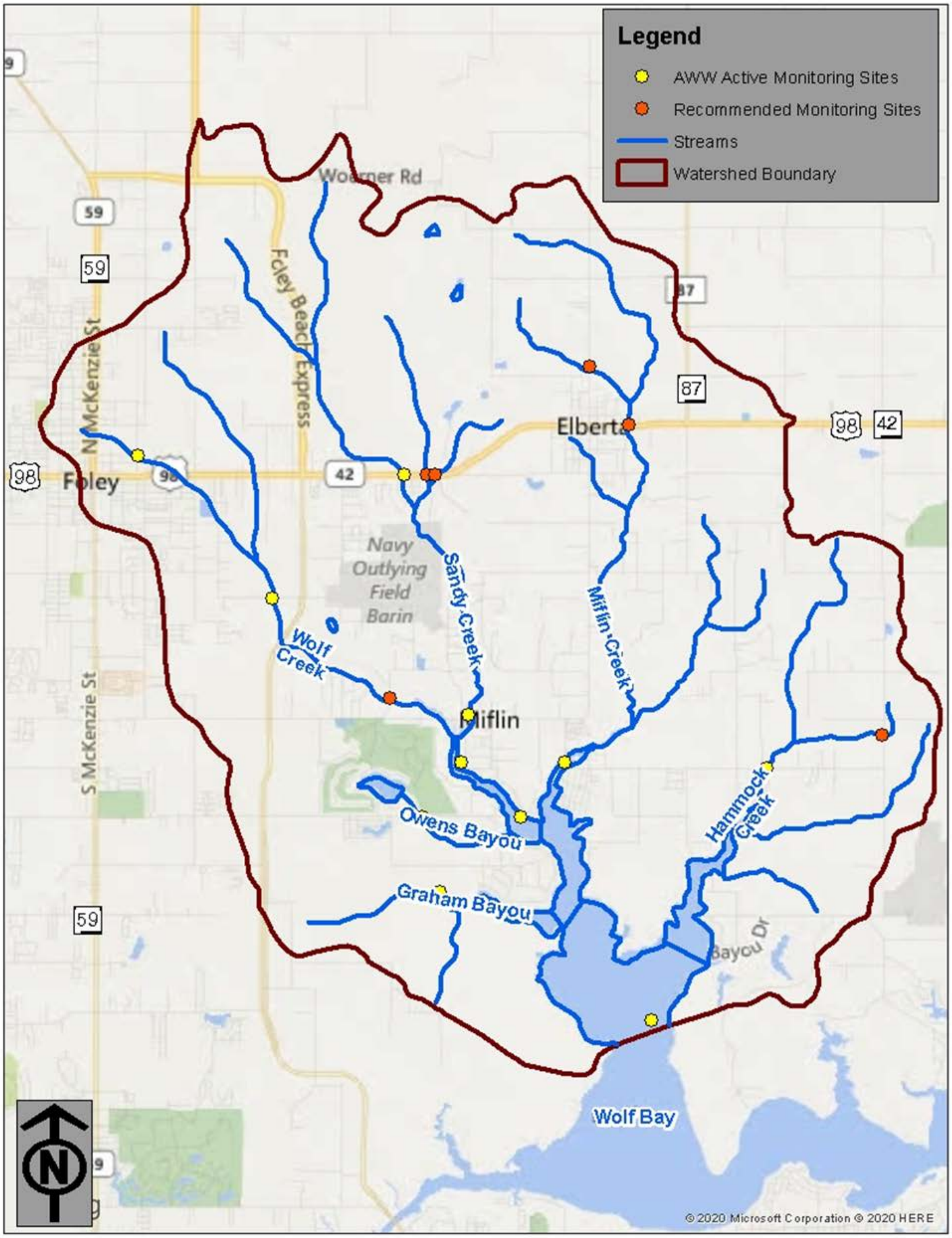

Figure 12.1 Active and Proposed Sample Collection Locations

12.3 Monitoring Program Approach and Schedule

Because water quality parameters and watershed characteristics are affected by many factors and can change quickly, annual or quarterly sampling may not be sufficient to track changes and monitor overall trends. It is important to note that each sampling data point represents a snapshot of watershed conditions at a certain point in time. A larger data set will provide context for each data point and help to identify outliers that may not be representative of overall watershed conditions. It is recommended that sampling be conducted at each of the designated sample collection locations on an at-least monthly basis. This sampling schedule should be sufficient to accurately monitor trends in water quality parameters and watershed characteristics without being overly burdensome for sampling teams or cost prohibitive for managers.

12.4 Citizen Volunteer Monitoring

The Wolf Bay Watershed Watch began volunteer water quality monitoring in the Watershed in 1998. Much of the data collected through this effort was instrumental in Wolf Bay being declared an OAW by ADEM and the USEPA in 2007. In recent years, the number of active water quality monitoring volunteers has declined, and data collected has not been consistent. In an effort to revive the program, the WBWW (**Figure 12.2**) is working to recruit local schools and community groups to adopt sampling locations that were previously monitored or that have been identified in this Plan. Citizen participation in water quality monitoring will not only enable successful implementation but will also establish a sense of community ownership within the Watershed.

Figure 12.2 Wolf Bay Watershed Watch Group Logo

12.5 Adaptive Management

Adaptive management will be implemented to maximize the effectiveness and efficiency of implemented management measures. Adaptive management should consist of an annual review of sampling data and comparison of watershed conditions against goals and objectives identified in this WMP. This review and comparison will allow decision makers to evaluate the success of implemented management measures and recommend changes or additional management measures needed to achieve stated goals and objectives. Adaptive management will ensure that implementation strategies are constantly being evaluated and updated, based on the best available science, and adjusted according to changing watershed conditions. Adaptive management will also ensure that staff time and funding resources are used in the most efficient way possible to produce measurable results.

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